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Air Quality at Sonamarg - A Tourist Hill Station in Kashmir Valley, India

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Abstract

The present study was undertaken to determine the ambient air quality with respect to suspended particulate matter (TSPM), respirable suspended particulate matter (PM_{10}), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) at Sonamarg- a tourist hill station in Kashmir valley. The ambient air quality at three different station namely Sonamarg town, Thajwas and Baltal was monitored from July to December in 2009. All the pollutants were measured with a sampling duration of 1 hour. The results showed high concentration of pollutants in summer months which correspond with peak tourist activity. The highest concentration of pollutants was recorded at Baltal site, while least values were observed at Thajwas site. TSPM and PM_{10} are chief air pollutants in the area, however, the values of NO_2 and SO_2 were well within the limits as set by EPA at all the sites. It can be concluded that tourist inflow, vehicular density, roadside dust, and burning of coal and fuelwood on a large scale are the main sources of air pollutants in this area.

Key Words: Ambient; SPM; PM_{10}; Sonamarg

Introduction

Air pollution has a great impact on human health, climate change, agriculture, and the natural ecosystem (Decker *et al*., 2000; Mayer *et al*., 2000; Molina and Molina, 2004). Air pollution has emerged in the past few decades as the most crucial problem to mankind. However, the magnitude of air pollution effects varies across cities and countries (Lin and Lee, 2004; Namdeo and Bell, 2005). Currently, in India, air pollution is widespread in urban areas where vehicles are the major contributors and in a few other areas with a high concentration of industries and thermal power plants (Reddy and Ruj, 2003; Majumdar *et al*., 2010). Concern about air pollution in urban regions has received increasing importance worldwide, especially pollution by gaseous and particulate matter (Salam *et al*., 2008; Cachier *et al*. 2005). However, there is scarce information related to air quality in rural areas or tourist hill stations.

A great deal of attention has focused on particulate matter (PM) pollution due to their severe health effects, especially fine particles. Several epidemiological studies have indicated a strong association between elevated concentrations of inhalable particles and increased mortality and morbidity (Samet *et al.,* 2000; Katsouyanni *et al.,* 2001; Analitis *et al.,* 2006). Gaseous pollutants have major negative impacts on health. They also play an important role in environmental changes and changes in atmospheric chemistry. SO_2 and NO_2 form acids through different chemical reactions in the atmosphere, and these acids are subsequently deposited on land and ocean surfaces as acid rain. Numerous studies and the lack of effective policies reveal that air pollution continues to threaten public health (Medina *et al*., 2009).

The State of Jammu and Kashmir located in the north-western Himalaya is experiencing increase in the air pollution levels since last decade due to increase in transportation and industrial activities. Tourism is the Jammu and Kashmir is the largest retail industry. Although tourism was once thought of as a "smokeless" industry with few, if any, environmental impacts, recognition of its potential for adverse impacts are growing (Davies and Cahill, 2000). The number of tourists visiting the State has increased from 6.80 thousand tourists in 1951 to 524.12 thousand tourists in 2008 (Directorate of Tourism, J&K, 2007-2008). Most tourism-related air pollution comes from automobiles (Andereck, 1993). However, work on air quality in Kashmir valley has received little attention (Jehangir *et al*., 2010) and no information exists on the air quality of sensitive area like tourist hill resorts. The present study was therefore conducted in the Sonamarg valley of Kashmir Himalaya located on the Srinagar-Leh national Highway, which is famous tourist hill resort and base camp for Amarnath pilgrims.

Material and Methods

Ambient air quality was monitored from July to December during 2009 at three sites in Sonamarg valley for priority parameters Total suspended particulate matter (TSPM), Respirable suspended particulate matter (PM_{10}), Nitrogen dioxide and Sulphur dioxide. In selection of sampling points, the priority was given to populated areas, sensitive area and National highway. The three sampling stations, namely, Main Bazar Sonamarg (Site I), Thajwas Wildlife Sanctuary (Site II) and Baltal (Site III) were selected for the study (Fig 1). The description of the sampling sites is shown in Table 1. The climate of area is very bracing, but the rainfall is frequent though

not heavy. Summers (May to October) are bit warm and pleasant with cool atmosphere and climate. Average temperature is around 14°C. Winters (November to April) are chilly with temperature goes down to subzero levels. The Sonamarg valley remains open for public only from April to December but the peak tourist flow occurs from June to September as it is one of the base camps for the annual Hindu pilgrimage to Amarnath holy cave. The number of pilgrims visiting Holy Amarnath Cave has increased from merely 7 thousand in 1965 to a peak flow of around 5 lakh in 2008 (Directorate of Tourism, J&K, 2007-2008). Besides pilgrims a large number of local and foreign tourists visit Sonamarg mainly during summer months. Further due to its location on Srinagar-Leh National Highway, Sonamarg is an important destination for vehicles before their journey to Ladakh and Srinagar regions.

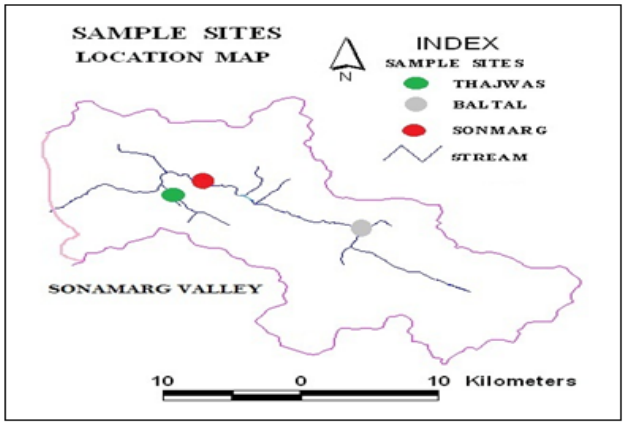

Fig. 1. Map of study area showing position of sampling sites

Air quality parameters, TSPM, PM_{10}, SO_2 and NO_2 were monitored by using High Volume Respirable Dust Sampler (Envirotech Instrument APM 460NL). The sampling instrument was set up 3 meters above ground and hourly values for all pollutants were measured at each site. The particulate matter (PM_{10}) collected on fibre glass filter was determined by weighing the filter before and after exposure to ambient air. Total suspended particulate matter (TSPM) was determined from the sum of PM_{10} and particles larger than PM_{10}. The mass of PM larger than PM_{10} was determined from the initial and final weight of the dust Cup Vial. The collected samples (Fibre glass filter) were properly stored and placed in vacuum desiccators and transported to the laboratory for analysis. The samples of nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) were collected in glass impingers using sodium arsenate and sodium tetrachloro-mercurate absorption solutions respectively. NO_2 in the samples was determined using Jacob and Hochheiser (1958) modified method, while SO_2 was determined using the modified West and Gaeke (1956) method. Samples were kept in a refrigerator until analysis to minimize volatilization.

Table 1. Characteristics of three monitoring stations at Sonamarg

Location	Site No.	Description	Altitude	Latitude	Longitude
Main Bazaar Sonamarg	I	Located in residential and commercial area.	2,705m	34^0 18' N	75^0 15'E
Thajwas	II	Located in Thajwas wildlife sanctuary surrounded by forest area.	2,617m	34^0 17' N	75^0 12'E
Baltal	III	Located on Srinagar-Leh National Highway near base camp of Amarnath Pilgrims.	2,850m	$34^0$15'N	75^0 24'E

Results and Discussion

The concentrations of various parameters like TSPM, PM_{10}, SO_2 and NO_2 analyzed at 3 stations during June to December are shown in Fig 2. The three stations chosen for the study which varied in terms of tourist inflow, transportation, nearness to the road and residential and commercial activity varied significantly with respect to concentration of air pollutants. The TSPM concentration ranged from 36 to 1209µg/m^3, 10 to 470µg/m^3 and 50 to 1250 µg/m^3 at site I, II and III respectively, while PM_{10} values ranged from 30 to 295

µg/m^3 at site I, 15 to 260 µg/m^3 at site II and 25 to 265 µg/m^3 at site III during the study period. The NO_2 concentration varied from a minimum of 5 µg/m^3 at site II to a maximum of 55 µg/m^3 at site III. Similarly, SO_2 recorded a minimum of 6 µg/m^3 at site II and a maximum of 55 µg/m^3 at site III.

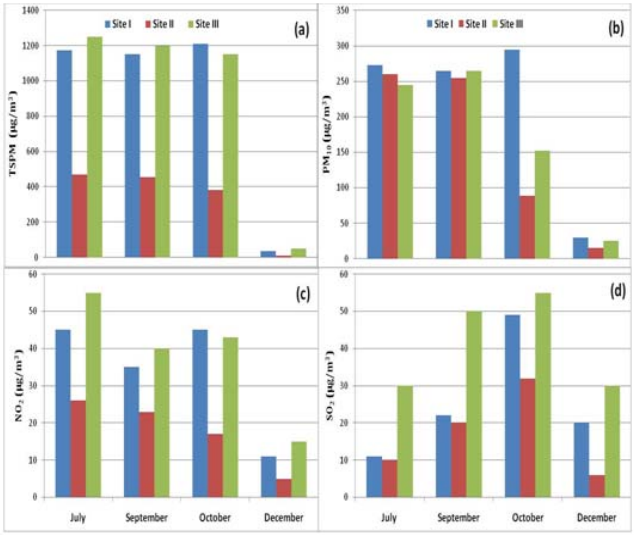

Figure 2. Variation in TSPM(a), PM_{10}(b), NO_2(c) and SO_2(d) at different sites during the study period

Concentration of air pollutants was highest in summer months (July-October), which correspond with peak tourist activity and high vehicular density, while least concentration was recorded during the month of December as an outcome of absence of vehicular traffic due to the closure of the Srinagar-Leh National highway and also on the account of the wash-out of the air pollutants by snowfall. However, higher levels of air pollutants in the month of October despite having lower vehicular density and tourist activity may be attributed to the burning of coal by the local people and the military camps in the cold weather conditions and frequent windblown dust as well as due to prevalence of anti-cyclonic conditions, resulting in little dispersion or dilution of pollutants (Reddy and Ruj, 2003).

Table 2. Mean values (µg/m^3) of TSPM, PM_{10}, SO_2 and NO_2 compared with USEPA (2010) and NAAQS (CPCB, 2006)

S. No.	Parameter (µg/m^3)	Site I	Site II	Site III	Total Mean ± Standard deviation	USEPA Standards	NAAQS Standard Sensitive areas
						1 Hourly values	24 hourly values
1	TSPM	892	329	913	711±331	-	100
2	PM_{10}	216	155	172	181±31	-	75
3	NO_2	34	18	38	30±11	188 µg/m^3	30
4	SO_2	25	17	41	28±12	196 µg/m^3	30

The mean concentration of TSPM, PM_{10}, NO_2 and SO_2 at 3 stations along with 24 hourly National ambient air quality standards (NAAQS) and 1 hourly Unites States Environmental protection agency (USEPA) guidelines in ambient air are presented in Table 2. The mean concentration of TSPM, NO_2 and SO_2 was highest at site III, while mean concentration of PM_{10} was highest at site I. The lowest mean values of all the air pollutants were recorded at site II. Highest values of TSPM, NO_2 and SO_2 at site III is due to its location on National Highway with heavy movement of traffic. Further, coarse and fine soil dust being presumably associated with dust re-suspension by road traffic and wind (Almeida *et al*., 2007) and high density of diesel vehicles may have also contributed to high values of air pollutants at this site. The higher levels of PM_{10} at site I may be attributed to high vehicular density, presence of road side markets and unplanned road side

parking leading to conjunction of traffic and blowing of dust particles on road sides by moving vehicles (Cohen, 1998). Vehicular emission is the dominating source of PM_{10} along the road sides (Kukkonen *et al*., 2001; Sharma *et al.,* 2006). However, lower concentration of air pollutants at site II is due to its location in the Thajwas Wildlife Sanctuary having restricted vehicular movement, least tourist activity and presence of dense forest cover.

Most of the guidelines do not specify hourly standards for TSPM and PM_{10}. However, when compared to 24 hourly guidelines of NAAQS, all the sites crossed the permissible limits set for TSPM and PM_{10} in ambient air for sensitive area. Although these values cannot be compared with 24 hourly standards as 1 hourly value tend to be higher, yet they give significant indication of increasing air pollution at Sonamarg tourist hill station. However, according to USEPA guidelines (2010), the permissible level of NO_2 and SO_2 on hourly basis in ambient air is 188 µg/m^3 and 196 µg/m^3 respectively. The values of NO_2 and SO_2 were well below the 1 hourly EPA standard limits at all sites. Further, the NO_2 and SO_2 values were also well within the 24 hourly limits set by NAAQS for sensitive areas.

Conclusions

Air pollution from tourist transportation has impacts on the global level, and it can contribute to severe local air pollution. The study showed increase in concentration of air pollutants during peak tourist activity. Tourist inflow, vehicular density, roadside dust, and burning of coal and fuelwood on a large scale are main sources of air pollution in the Sonamarg tourist hill station. PM_{10} and TSPM are the chief air pollutants in this area posing health risks either alone, or in combination with other pollutants, therefore there is an urgent need to monitor TSPM and PM_{10} levels and frame strategies to control the same.

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