Environmental Pollution Sources and their Apportionment to Ambient Environment: A GIS-based Study of Solan District

(Preliminary Report)

Submitted
to
Himachal Pradesh State Pollution Control Board, New Shimla

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November 2012

Table of Contents

List of Tables

List of Figures

Chapter 1

Introduction

1.0 Background

Industrialization is on the increase and so is the environmental pollution due to emissions and waste generation from industries and other sources. Since the carrying capacity of the environment is not unlimited and some areas or ecosystems are more susceptible to adverse environmental impacts than others, the unplanned and haphazard location of industries might substantially increase the risk to the environment. Environmental planning is a proven tool for reducing the impacts from such risks. However, this tool has seldom been used in India. Proper siting of newly planned industries and industrial estates is a strong pollution preventive instrument that ensures environmental soundness of the industrial development. It is the site that ultimately determines which water bodies might be affected by effluent discharged by an industry, which air-shed might be affected by air-pollutants or which ecosystem might be harmed. Site selection based on environmental criteria with the objective of minimizing adverse environmental impacts is, therefore of vital importance.

In light of the above environmental issues, the Himachal Pradesh State Pollution Control Board (HPSPCB) has sponsored a study to IIT Kanpur (IITK) for Solan district (Figure 1.1) that will cover environmental pollution sources inventory (air, water and hazardous waste), dispersion of pollutants, drainage of wastewater discharges and fate of pollutants,

apportionment of pollution sources in ambient environment and short and long term plans for restoration of environmental quality. This report is the first preliminary report that is detaining the results of air sampling in terms of parameters listed in National Ambient Air Quality Standards (NAAQS) for the entire Solan district (at 25 locations) with emphasis on Baddi industrial area.

1.1 Need for the Study

The Solan district (Figure 1.1) is the most industrialized district in HP. The district is covered by catchment area of three important rivers Satluj, Yamuna and Ghagar. There are approximately 2500 small scale industries and approximately 150 large and medium scale industries in Solan district (http://www.msmedihimachal.nic.in/solan.html). Many of the pharmaceutical industries have moved to the district. The area is rich with minerals and other natural resources and has attracted several industries. The Oil and Natural Gas Commission has selected a point in Ramshahr Mohan for exploration, and other industries include Meakin Brewery, Thapar Paper Mills Sidharta Textile, Fertilizers, Wool Processing and Hypon Carbons and Him chemicals. In addition, steel re-rolling mills are also functioning in the district.

The source activities for air pollution in the Solan district can be broadly classified as: transport sector (motor vehicles), commercial activities, industrial activities, domestic activities, institutional & official activities and fugitive sources. Under commercial activities, diesel/ kerosene generators are the most prevailing sources for air pollution in Solan district. For transportation, mostly public transport (buses) and private diesel tempos are used.

Baddi is considered as major industrial hub in Solan. In addition to industrial and automobile pollution, there is a significant emission from domestic cooking using cheap

fuels like wood, coal, biomass etc. Clusters of small and medium scale industries are also responsible for the air pollution. In most of the institutions and offices, the diesel generators are used at the time of power failure. Unlike other cities, at several locations, garbage burning is a common practice; it can be an important contributor to air pollution. The road condition in the town is quite bad as roads are broken, poorly maintained and partially paved surfaces and it is observed that movements of vehicle may cause non-exhaust road dust emission in a significant amount.

1.2 Objective and Scope of Study

The project aims to achieve the following objectives:

Survey, Assessment and Monitoring

- Assessment of pollution load to river and water bodies from direct sources such as domestic and industrial sources as well as non-point sources based on uses of fertilizers, insecticides, pesticides and disposal of hazardous waste. This assessment will be used for preparation source and parameter specific of water pollution and air pollutant source inventory.
- Monitoring of water quality from routine parameters (e.g. BOD, SS, COD, TDS, pH, MPN, oil and grease etc), trace organics, trace metals and toxic compounds will be taken up by HPSPCB.
- Air quality monitoring of all pollutants included in the revised national air quality standards (http://www.cpcb.nic.in/National_Ambient_Air_Quality_Standards.php) will be taken up by HPSPCB.

- Information related to population, domestic cooking, drainage map etc will be prepared based on secondary data.
- Inventory of hazardous waste and their disposal will be carried out.

Modeling

- Water quality modeling of DO-BOD, MPN, sediment oxygen demand (SOD), nitrogen (TKN, NO3-N, NO2-N), phosphorous and other pollutants have been undertaken using software such as QUAL2E or statistical techniques for simulating the transport and transformation of the pollutants will be undertaken.
- Air dispersion modeling, (e.g. Industrial Source complex (ISC ST3) model, AERMOD) and receptor model for source apportion studies (e.g. USEPA, CMB 8.2) will be undertaken to ascertain source receptor linkages or develop cause effect relationship. HPPCB will provide the metrology data.
- The other areas of modelling include hydraulic model studies for river training and assessment and management of combined sewer overflows.

Technology

- Specific technological options and planning will be suggested for the study area.

Human and Ecological Risk Assessment

- The pollutant exposure assessment, risk assessment, management and risk communication will be undertaken for the population.
- Remote Sensing and GIS – All the data storing, retrieval, presentation etc. will be done on GIS platform using ARC GIS 9.2 or higher.

1.3 Project Initiation and Field Sampling

The project was started on March 15, 2012. After a preliminary visit to the study area and to the HPSPCB Head Quarters, the field work was undertaken during May 14-June 20, 2012. It included extensive sampling for air quality at 25 locations and water quality sampling at 70 locations in the Solan district. Some of the analysis was completed in situ during the field sampling and for other parameters samples were brought to IITK for analysis on sophisticated instruments.

Numerous data, information and maps were also collected while on field to undertake the exercise of GIS-based digitization of maps and data storage. The current report presents the task completed and efforts being made to complete the study which require more information from HPSPCB and other institutions in HP.

Fig 1.1 Map of Solan District

Chapter 2

Methodology

2.0 General

Ambient air sampling has been carried out at 25 locations in Solan. The duration of air sampling was three days at each site. The water samples were collected from 70 locations along with the team of HPSPCB. The duration of water sampling is one day grab sample at each site. Finalization of sites was done in consultation with HPSPCB. The traffic data was collected at four locations in Baddi. The parking lot survey was done at Baddi and Nalagarh cities to assess the type of vehicles on the roads, their make and model to accurately assess the emission from the vehicles.

2.1 Methodology

2.1.1 Air

It was considered appropriate that twenty five sites in Solan district can represent typical land use patterns. It has been ensured that at all sites, there is a free flow of air without any obstruction (e.g. buildings, trees etc.). In view of the safety of the stations, public buildings (institutions, police stations, hospitals, electric substations, etc) were considered as better choices as sampling locations. The land uses that are covered includes, background, commercial, residential, industrial and commercial cum residential. The air quality sampling stations have been categorized based on the predominant land use pattern (Table 2.1). Ambient air was characterized for particulate matter of aerodynamic diameter of 10µm (PM_{10}), particulate matter of aerodynamic diameter of 2.5µm ($PM_{2.5}$),

Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), Organic Carbon (OC), Elemental Carbon (EC), Ammonia (NH_3), Ions, Elements, Volatile Organic Compounds (VOCs), Poly Aromatic Hydrocarbons (PAHs), Carbon Monoxide (CO) and Ozone (O_3). The air quality sampling was conducted for three days continuously at each location (Fig 2.1).

Table 2.1 Sampling Sites and their Descriptions

S.No	Sampling Location	Site Code	Description of the site	Type of sources
1	Buranwala	AQS1	Industrial area	Industries, domestic cooking, DG sets, vehicles, road dust, garbage burning.
2	Industry Department Near Fire Brigade Office	AQS2	Industrial cum Commercial area	Industries, domestic cooking, DG sets, vehicles, road dust, garbage burning, restaurant.
3	Ayurvedic Dispensary Barotiwala	AQS3	Industrial area	Industries, domestic cooking, DG sets, vehicles, road dust, garbage burning.
4	Housing Board Phase 2	AQS4	Residential area	Domestic cooking, vehicles, road dust.
5	MC Nalagarh	AQS5	Commercial cum residential area	Domestic cooking, DG sets, vehicles, road dust, garbage burning, restaurants.
6	MC Building	AQS6	Commercial cum residential area	Domestic cooking, DG sets, vehicles, road dust, garbage burning, restaurants.
7	Housing Board Phase 3	AQS7	Residential area	Domestic cooking, vehicles, road dust.
8	Thana	AQS8	Industrial area	Industries, domestic cooking, DG sets, vehicles, road dust, garbage burning.
9	Homeland City Mall	AQS9	Commercial area.	Domestic cooking, DG sets, vehicles, road dust, garbage burning, restaurants.
10	BBNDA Rest House	AQS10	Agricultural area	Domestic cooking, road dust, garbage burning.
11	Katha (Mahabir Mill)	AQS11	Industrial area	Industries, domestic cooking, DG sets, vehicles, road dust, garbage burning.
12	Morepan	AQS12	Industrial area	Industries, domestic cooking, DG sets, vehicles, road dust, garbage burning.
13	Malpura (Panacea Biotec)	AQS13	Industrial area	Industries (mainly pharma), domestic cooking, DG sets, vehicles, road dust, garbage

				burning.
14	Khera	AQS14	Industrial cum residential area	Industries, domestic cooking, DG sets, vehicles, road dust, garbage burning, restaurant.
15	Bhatain (TVS Nalagarh)	AQS15	Industrial cum residential area	Industries, domestic cooking, DG sets, vehicles, road dust, garbage burning, restaurant.
16	Lodhimajra (Marico)	AQS16	Industrial area	Industries, domestic cooking, DG sets, vehicles, road dust, garbage burning.
17	NRTC (Parwanoo)	AQS17	Industrial area	Industries, domestic cooking, DG sets, vehicles, road dust, garbage burning.
18	Parwanoo Office	AQS18	Residential area	Domestic cooking, vehicles, road dust.
19	Chambaghat (Solan)	AQS19	Mixed Use	Industries, domestic cooking, DG sets, vehicles, road dust, garbage burning, restaurant.
20	Solan Town (SP Office)	AQS20	Residential area	Domestic cooking, vehicles, road dust.
21	Darlaghat Town (Police Station)	AQS21	Residential area	Domestic cooking, vehicles, road dust.
22	Darlaghat Mining (Rathoh)	AQS22	Mining cum residential area	Mining, domestic cooking, vehicles, road dust
23	Arki Town	AQS23	Residential area	Domestic cooking, vehicles, road dust.
24	Kasauli	AQS24	Residential area	Domestic cooking, vehicles, road dust.
25	Chail	AQS25	Residential area	Domestic cooking, vehicles, road dust.

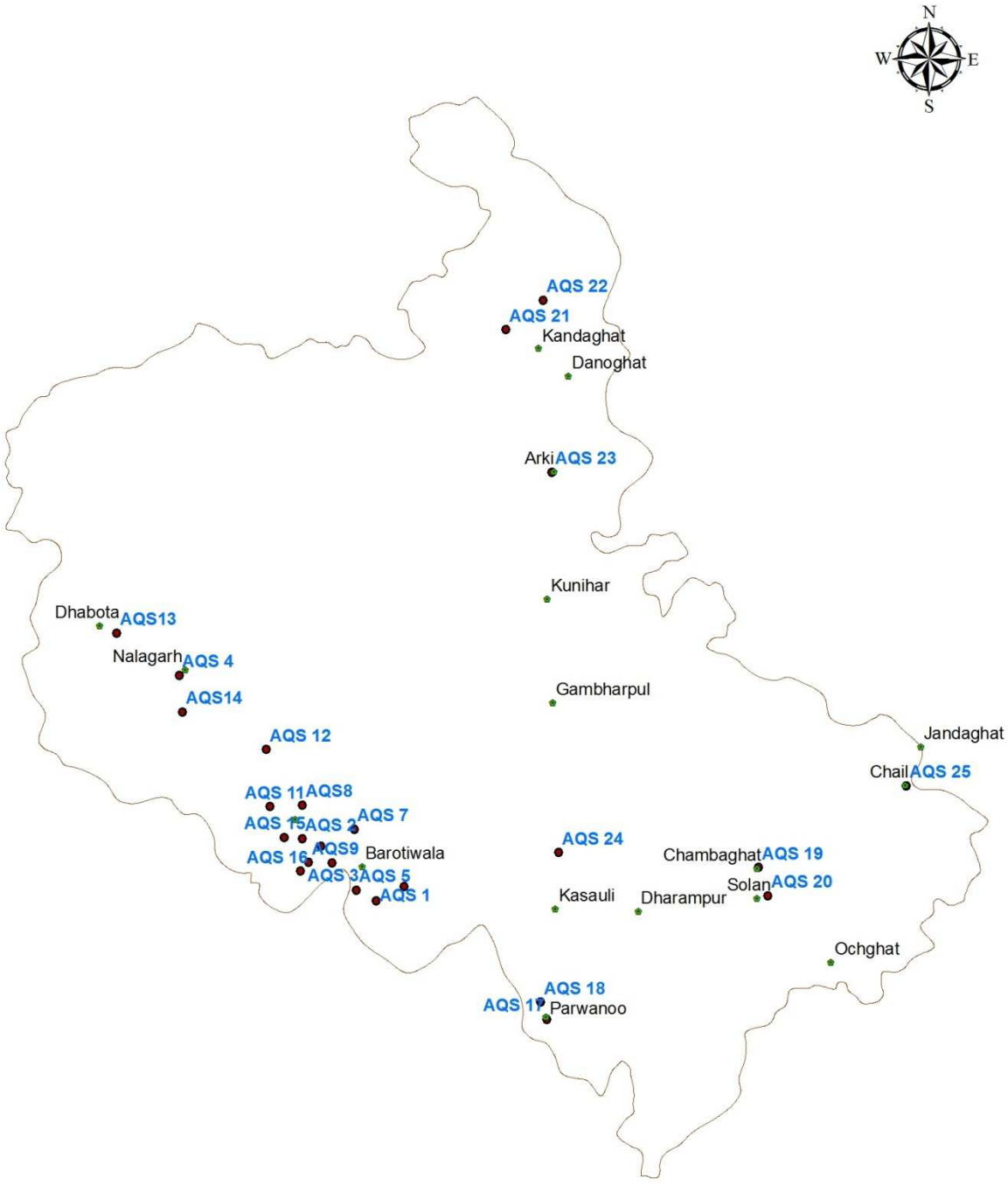

Fig. 2.1 Air Quality Sampling Locations

The parameters for sampling and their monitoring methodologies including type of filter papers/chemicals and calibration protocols were prescribed by CPCB, Delhi (www.cpcb.nic.in). The whole monitoring programme is divided into two groups, i.e. gaseous sampling and particulate matter sampling. NO_2, SO_2, VOCs, O_3, NH_3, and CO is among the gaseous species. The particulate matter (PM) sampling include particulate matter of aerodynamic diameter of 10 μm or less (PM_{10}) and particulate matter of aerodynamic diameter of 2.5 μm or less ($PM_{2.5}$). The monitoring parameters for this study along with sampling and analytical methods are presented in Table 2.2.

Table 2.2: Samplers/Analyzers and Methods

Parameter	Sampler/Analyzer Type	Model	Method
PM_{10}	WINS Impactor based combo PM10 and PM2.5 Sampler	ECOTECH MODEL AAS 271	Gravimetric
$PM_{2.5}$	WINS Impactor based combo PM10 and PM2.5 Sampler	ECOTECH MODEL AAS 271	Gravimetric
SO_2	Bubbler/Spectrophotometer	Model 166, Systronics	Improved West and Gaeke Method
NO_2	Bubbler/Spectrophotometer	Model 166, Systronics	Jacob & Hochheiser modified (NaOH-NaAsO2) Method
O3	Bubbler/Spectrophotometer	Model 166, Systronics	Chemical Method
Ammonia	Bubbler/Spectrophotometer	Model 166, Systronics	Indophenol Method
Elements	X-Ray Fluorescence	Rigaku, Japan	XRF Spectroscopy
OC-EC	OC/EC Analyzer	Model 2001A DRI	Thermal Optical Reflectance
Ions	Ion Chromatograph	Metrom, Switzerland	Ion Chromatography
Benzene	VOC Sampler; GC-ATD-FID / MS Or GC-FID / MS	ECOTECH MODEL AAS 172	IS 5182 Part11:2006
Benzo(a)Pyrene (BaP)	Solvent extraction followed by HPLC analysis	Leckel Sampler (Germany); TurboVap; HPLC, Agilent	Florescence /UV detector
Carbon Monoxide(CO)	Continuous online analyzer	Environment SA CO Analyzer	Non dispersive Infrared (NDIR) Spectroscopy

The complete analytical procedures were as per the method prescribed by CPCB, Delhi. As a part of quality control, calibration charts (for example Absorbance vs. SO_2-/NO_2/O_3/NH_3 content) were prepared just before the analysis. Absorbing solutions were stored in amber colour bottle and fresh solutions were prepared once in every three days.

PM_{10} and $PM_{2.5}$

All initial and final weighing of filter papers (Whatman PTFE (Teflon) Membrane, 46.2mm with support ring) were done on Mettler balance having sensitivity of 0.00001 g (for PM10) and 0.000001g (for PM2.5) in a humidity-controlled room. Filters were conditioned in desiccators for 24 hours before and after sampling.

The desiccated filter papers were weighed twice for accuracy. The conditioned and weighed filter papers were then placed in specially designed cassettes and taken to the field for sampling to avoid contamination of the filter papers on the way. Before starting the sampling, initial volume and timer readings were noted from the sampler. The pre-weighed and coded filter papers were placed in the filter holder of the sampler and screwed properly before starting the samplers. PM_{10} and $PM_{2.5}$ combo sampler was operated for 24 hours every day and filter papers were changed every twelfth-hour. The dry gas manometer reading (DGMR) for PM_{10} and $PM_{2.5}$ sampler was recorded every twelve hours. Before and after each set of sampling, data were entered in the field data sheet. Concentrations of PM_{10} and $PM_{2.5}$ were calculated after gravimetric analysis; all data and information were computerized for later interpretation.

SO_2

SO_2 was measured by absorbing it in tetrachloromercurate (TCM) solution and then analyzing it using modified West and Gaeke Method. For collection of sample, 35 ml of absorbing solution was taken in a midget impinger. The rate of air sampling was kept at 1LPM (liters per minute). SO_2 was analyzed colorimetrically using spectrophotometer at 548 nm wavelength.

NO_2

NO_2 was measured by absorbing it in the solution of sodium-hydro-oxide and sodium arsenate and then analyzing it using Jacob & Hochheiser Modified Method. For collection of sample, 35ml of absorbing solution was taken in a midget impinger. The rate of air sampling was kept at 1LPM. NO_2 was analyzed calorimetrically using spectrophotometer at 540 nm wavelength. The colour was developed using H_2O_2, sulfanilamide and NEDA solution.

O_3

O_3 was measured by absorbing it in the absorbing solution of 1% KI in 0.1 m Phosphate Buffer and then analyzing it using recommended chemical method. For collection of sample, 10ml of absorbing solution was taken in a midget impinger. The rate of air sampling was kept at 1LPM. O3 was analyzed calorimetrically using spectrophotometer at 352 nm wavelength.

NH_3

Ammonia in the atmosphere is collected by bubbling a measured volume of air through a dilute solution of sulphuric acid to form ammonium sulphate. The ammonium sulphate

formed in the sample is analyzed colorimetrically by reaction with phenol and alkaline sodium hypochlorite to produce indophenol. The reaction is accelerated by the addition of Sodium Nitroprusside as catalyst. For collection of sample, 10ml of absorbing solution was taken in a midget impinger. The rate of air sampling was kept at 1LPM. NH3 was analyzed calorimetrically using spectrophotometer at 630 nm wavelength.

CO

For CO monitoring, Continuous online analyzer (Environment SA, USEPA approved) is used at six selected site. This equipment works on Non Dispersive Infrared (NDIR) Spectroscopy. NDIR photometry provides a method of utilizing the integrated absorption of infra-red energy over most of the spectrum for a given compound to provide a quantitative determination of the concentration of CO in ambient air. The spectrometer measures the absorption by CO at 4.7 mm using two parallel infrared beams through a sample cell, a reference cell and a selective detector. The detector signal is led to an amplifier control section and the analyzer output measured on a meter and recording system.

Benzo(a)Pyrene & other PAHs

Benzo(a)Pyrene (BaP) is one of the most important constituents of PAH and also one of the most potent carcinogens. This can be measured in both particulate phase and vapour phase. In the vapour phase the concentration of B(a)P is significantly less than the particulate phase. Therefore, more care is to be taken for the measurement of Benzo(a)Pyrene in the particulate phase. For measuring the PAHs, Leckel sampler with PM_{10} impactors, Whatman Grade QM-A Circles filter Paper, TurvoVap (automatic nitrogen streaming to concentrate the PAHs in any solvent), and HPLC (high performance Liquid chromatography) were used.

OC-EC

For measuring the OC/EC, Leckel sampler with PM_{10} impactors, Whatman Grade QM-A Circles filter Paper, OC/EC analyzer is used. Organic and elemental carbon particle samples were collected on 47 mm diameter (Whatman Grade QM-A Circles) filter Paper.

Many optical, thermal and chemical methods exist for the measurement of EC but are either unable to differentiate or neglect the difference between the different forms of OC and EC. The analyzer operation is based on the preferential oxidation of OC compounds and EC at different temperatures. Its function relies on the fact that organic compounds can be volatilized from the sample in a non-oxidizing helium (He) atmosphere, while EC must be combusted by an oxidizer.

Elements

Elemental analyses were done using X- ray fluorescence (XRF) by (**RIGAKU ZSX Primus II series machine**, **Japan**) which is wave-length dispersive X- ray fluorescence spectrometer (WDXRF). The instrument generates X-rays from the cathode plate that made up of target element **Rh 4KW** power and having **End- typewindow.**

The fundamental principle of X-ray fluorescence is the emission of characteristic fluorescent X-rays from the material that has been excited by bombardment with high energy X- rays. When an atom is exposed to radiation with energy greater than its ionization potential, ejection of one or more electrons from the atom may take place. Removal of an inner orbital electron renders the electronic structure of an atom unstable, and electron falls from higher energy level to the lower one, for filling the gap that left behind.

Energy releases in the form of photons, that energy is equal to the difference in the energy of the two orbits. Thus, the material emits the radiations, which is a characteristic of the atoms present. It is used to analyze the major oxides (in wt. %) and selected trace elements present in the sample.

2.3 Quality Assurance and Quality Control (QA/QC)

At the time of sampling and analysis, the coding systems were adopted effectively to avoid the confusion. Separate codes for site locations, parameters, time slots were adopted. The persons working in the sampling sites and in the laboratory were aware of these coding system. Special training was given to the personnel working in the project prior to the commencement of the work. A suitable coding system was adopted to represent the results. The calibrations for all samplers and equipments were done before the sampling and analysis. Separate hard copies of standard operating procedures for different purposes were distributed among the personnel dealing with the specific work in this project for their reference.

Chapter 3

Monitoring Results

This chapter presents the results of air quality measurements. The comparison of monitoring result with National Ambient Air Quality Standards (NAAQS) is presented in Table 3.1. Wherever the concentration of pollutants exceeds the NAAQS, the field is marked in red colour. It may be noted that standards of BaP, Pb, and As are annual and cannot be compared with the short-term measurement of three days. The elements results of all twenty five sites are presented in Table 3.2. The PAHs and OC-EC results are presented Tables 3.4 and 3.5.

Table 3.1 Comparative Table of Monitoring Results and NAAQS at Different Sampling Sites.

Date of Sampling	Time of Sampling	PM_{10}	$PM_{2.5}$	SO_2	NO_2	O_3		NH_3	BaP (ng/m^3)	Pb	As (ng/m^3)
NATIONAL AMBIENT AIR QUALITY STANDARDS		**100.0 (24 hrs)**	**60.0 (24 hrs)**	**80.0 (24 hrs)**	**80.0 (24 hrs)**	**100.0 (8hrs)**	**6 hr peak**	**400.0 (24 hrs)**	**1.0 (Annual)**	**1.0 (24 hrs)**	**6.0 (Annual)**
Site : 1 Buranwala											
15/05/2012 to16/05/2012	6 PM - 6PM	255.94	76.60	100.06	31.62	19.51	34.20	20.83	2.98	6.95	BDL
16/05/2012 to17/05/2012	6 PM - 6PM	764.80	113.87	61.38	21.34	15.53		6.91			
17/05/2012 to18/05/2012	6 PM - 6PM	414.04	104.65	107.67	25.78						
	Average	478.26	98.38	89.70	26.24	17.52		13.87			

Site : 2 Industry Department Near Fire Brigade Office											
18/05/2012 to 19/05/2012	12:30 PM - 2:05 PM	364.38	92.18	27.86	34.56	13.48	115.95	4.27	1.44	0.81	21.25
19/05/2012 to 20/05/2012	2:05:00 PM-2:30 PM	162.20	24.95	10.06	19.42	65.08		6.13			
20/05/2012 to 21/05/2012	2:05:00 PM-2:30 PM	259.62	59.86	7.18	24.70						
	Average	262.07	59.00	15.03	26.23	39.28		5.20			
Site : 3 Ayurvedic Dispensary Barotiwala											
18/05/2012 to 19/05/2012	2:30 PM - 2:30 PM	331.64	99.47	19.11	56.81	6.70	71.20	3.44	BDL	1.51	18.50
19/05/2012 to 20/05/2012	2:35 PM-2:35 PM	69.50	30.49	17.86	23.94	41.90		5.86			
20/05/2012 to 21/05/2012	2:40 PM-2:40 PM	125.24	32.88	9.59	24.53						
	Average	175.46	54.28	15.52	35.10	24.30		4.65			
Site : 4 Housing Board Phase 2											
19/05/2012 to 20/05/2012	3:25 PM - 3:25 PM	117.96	37.75	BDL	10.40	41.26	54.11	4.13	0.44	BDL	BDL
20/05/2012 to 21/05/2012	3:30 PM - 3:30 PM	106.11	63.92	BDL	8.37	6.38		3.09			
21/05/2012 to 22/05/2012	3:35 PM - 3:35 PM	125.87	89.28	BDL	10.70						
	Average	116.65	63.65	BDL	9.82	23.82		3.61			
Site : 5 MC Nalagarh											
20/05/2012 to 21/05/2012	5:20 PM - 5:20 PM	154.26	23.04	BDL	15.75	8.67	11.73	2.48	0.24	BDL	BDL
21/05/2012 to 22/05/2012	5:30 PM - 5:30 PM	119.82	38.57	BDL	14.25	8.31		3.18			
22/05/2012 to 23/05/2012	5:40 PM - 5:40 PM	162.26	46.53	BDL	15.70						
	Average	145.44	36.05	BDL	15.23	8.49		2.83			
Site : 6 MC Building											
21/05/2012 to 22/05/2012	11:20 PM - 11:20 PM	292.26	115.55	9.48	38.14	15.61	18.32	23.23	1.74	0.82	BDL
22/05/2012 to 23/05/2012	11:25 PM - 11:25 PM	251.03	85.31	4.80	32.35	9.01		21.62			
23/05/2012 to 24/05/2012	11:30 PM - 11:30 PM	425.89	171.96	4.53	46.48						
	Average	323.06	124.27	6.27	38.99	12.31		22.43			
Site : 7 Housing Board Phase 3											
22/05/2012 to 23/05/2012	11:00 PM - 11:00 PM	107.71	81.82	BDL	7.76	43.46		2.93			

23/05/2012 to 24/05/2012	11:05 PM - 11:05 PM	77.98	57.45	BDL	11.82	15.36	43.59	4.73	0.94	BDL	BDL
24/05/2012 to 25/05/2012	11:10 PM - 11:10 PM	176.53	95.59	BDL	10.10						
	Average	120.74	78.29	BDL	9.89	29.41		3.83			
Site : 8 Thana											
23/05/2012 to 24/05/2012	5:55 PM - 5:55 PM	257.09	96.17	8.40	17.94	40.35	40.96	3.87	0.26	0.29	10.89
24/05/2012 to 25/05/2012	6:00 PM - 6:00PM	185.38	72.03	11.95	24.75	9.36		3.59			
25/05/2012 to 26/05/2012	6:05 PM - 6:05PM	221.02	53.76	6.01	18.53						
	Average	221.17	73.99	8.78	20.41	24.86		3.73			
Site : 9 Homeland City Mall											
24/05/2012 to 25/05/2012	4:00 PM - 4:15 PM	143.95	47.33	BDL	33.27	78.41	85.44	20.76	2.60	BDL	BDL
25/05/2012 to 26/05/2012	4:20 PM - 4:20 PM	230.55	48.07	BDL	32.36	17.34		10.89			
26/05/2012 to 27/05/2012	4:25 PM - 4:25 PM	205.82	61.02	BDL	31.36						
	Average	193.44	52.14	BDL	32.33	47.87		15.83			
Site : 10 BBNDA Rest House											
26/05/2012 to 27/05/2012	5:30 PM - 5:30 PM	111.61	50.36	BDL	9.14	19.94	33.37	9.31	BDL	BDL	BDL
27/05/2012 to 28/05/2012	5:35 PM - 5:35PM	140.11	53.92	BDL	10.46	12.22		4.97			
28/05/2012 to 29/05/2012	5:40 PM - 5:40 PM	122.90	39.40	BDL	5.06						
	Average	124.87	47.90	BDL	8.22	16.08		7.14			
Site : 11 Katha (Mahabir Mill)											
26/05/2012 to 27/05/2012	3:20 PM - 3:20 PM	104.00	38.98	BDL	15.75	4.26	146.36	4.18	0.39	0.39	BDL
27/05/2012 to 28/05/2012	3:25 PM - 3:25 PM	150.84	71.33	BDL	14.38	143.45		5.40			
28/05/2012 to 29/05/2012	3:30 PM - 3:30 PM	103.28	59.22	BDL	16.06						
	Average	119.37	56.51	BDL	15.40	73.85		4.79			
Site : 12 Morepan											
28/05/2012 to 29/05/2012	3:20 PM - 3:20 PM	237.82	51.38	11.87	25.05	11.47	39.10	4.37	0.81	1.02	BDL
29/05/2012 to 30/05/2012	3:25 PM - 3:25 PM	207.82	39.30	9.33	23.14	39.25		5.22			

30/05/2012 to 31/05/2012	3:30 PM - 3:30 PM	222.53	65.75	11.64	24.57						
	Average	222.72	52.14	10.95	24.26	25.36		4.79			
Site : 13 Malpura (Panacea Biotec)											
28/05/2012 to 29/05/2012	2:30 PM - 2:30 PM	229.59	39.28	12.46	17.24	20.29	76.77	3.97	1.89	0.83	13.11
29/05/2012 to 30/05/2012	2:35PM - 2:35 PM	209.78	62.93	15.52	14.03	22.35		5.06			
30/05/2012 to 31/05/2012	2:40 PM - 2:40 PM	208.48	52.21	18.98	11.67						
	Average	215.95	51.47	15.66	14.31	21.32		4.51			
Site : 14 Khera											
31/05/2012 to 1/01/2012	11:20 PM - 11:20 PM	176.95	53.59	48.51	16.22	90.96	99.02	4.53	0.72	0.25	8.18
1/06/2012 to 2/01/2012	11:25 PM - 11:25 PM	170.67	35.66	18.59	24.11	16.30		4.40			
2/06/2012 to 3/01/2012	11:30 PM - 11:30 PM	221.41	67.06	22.62	8.73						
	Average	189.68	52.10	29.91	16.35	53.63		4.46			
Site : 15 Bhatain (TVS Nalagarh)											
1/06/2012 to 2/01/2012	7:00 PM - 7:00 PM	158.14	39.95	BDL	17.98	10.51	28.43	4.27	0.48	0.30	BDL
2/06/2012 to 3/01/2012	7:05 PM - 7:05 PM	185.88	78.35	BDL	14.89	20.02		3.96			
3/06/2012 to 4/01/2012	7:10 PM - 7:10 PM	202.81	40.27	BDL	13.02						
	Average	182.28	52.86	BDL	15.30	15.27		4.12			
Site : 16 Lodhimajra (Marico)											
1/06/2012 to 2/01/2012	8:00 PM - 8:00 PM	215.75	68.91	13.28	13.77	14.05	32.88	5.59	0.66	BDL	BDL
2/06/2012 to 3/01/2012	8:05 PM - 8:05 PM	122.79	69.77	12.46	10.41	32.50		4.76			
3/06/2012 to 4/01/2012	8:10 PM - 8:10 PM	173.38	57.22	15.03	8.90						
	Average	170.64	65.30	13.59	11.03	23.28		5.18			
Site : 17 NRTC (Parwanoo)											
6/06/2012 to 7/01/2012	10:00 PM - 10:00 PM	88.21	41.22	11.16	13.22	16.09	73.59	2.84	0.28	BDL	BDL
7/06/2012 to 8/01/2012	10:05 PM - 10:05 PM	165.67	51.42	12.74	10.45	4.65		2.43			
8/06/2012 to 9/01/2012	10:10 PM - 10:10 PM	124.58	42.73	11.60	13.81						
	Average	126.15	45.12	11.83	12.49	10.37		2.64			

Site : 18 Parwanoo Office											
6/06/2012 to 7/01/2012	11:30 PM - 11:30 PM	124.42	44.45	BDL	10.72	45.69	22.58	3.60	0.28	BDL	BDL
7/06/2012 to 8/01/2012	11:35 PM - 11:35 PM	130.86	28.42	BDL	9.96	21.94		2.76			
8/06/2012 to 9/01/2012	11:40 PM - 11:40 PM	115.62	31.71	BDL	11.78						
	Average	123.64	34.86	BDL	10.82	33.82		3.18			
Site : 19 Chambaghat (Solan)											
8/06/2012 to 9/01/2012	11:00 AM - 11:00 AM	79.47	30.59	BDL	12.64	52.35	67.31	4.58	0.29	BDL	BDL
9/06/2012 to 10/01/2012	11:05 AM - 11:05 AM	77.37	17.80	BDL	11.89	51.09		5.13			
10/06/2012 to 11/01/2012	11:10 AM - 11:10 AM	69.61	16.60	BDL	12.64						
	Average	75.48	21.66	BDL	12.39	51.72		4.86			
Site : 20 Solan Town (SP Office)											
8/06/2012 to 9/01/2012	11:00 AM - 11:00 AM	87.00	29.94	BDL	11.36	21.29	29.32	4.40	0.30	BDL	BDL
9/06/2012 to 10/01/2012	11:05 AM - 11:05 AM	91.00	27.21	BDL	16.94	27.53		15.78			
10/06/2012 to 11/01/2012	11:10 AM - 11:10 AM	85.19	15.24	BDL	19.23						
	Average	87.73	24.13	BDL	15.84	24.41		10.09			
Site : 21 Darlaghat (Police Station)											
10/06/2012 to 11/01/2012	5:40PM-5:40PM	185.05	57.04	BDL	13.59	5.40	9.55	3.07	0.23	BDL	BDL
11/06/2012 to 12/01/2012	5:45PM-5:45PM	158.69	52.24	BDL	18.39	8.84		2.90			
12/06/2012 to 13/01/2012	5:50PM-5:50PM	160.20	60.96	BDL	15.38						
	Average	167.98	56.75	BDL	15.79	7.12		2.99			
Site : 22 Darlaghat (Rathoh)											
10/06/2012 to 11/01/2012	7:40PM-7:40PM	50.77	23.08	BDL	12.88	6.80	7.90	2.71	0.44	BDL	BDL
11/06/2012 to 12/01/2012	7:45PM-7:45PM	63.48	37.44	BDL	14.75	4.55		2.91			
12/06/2012 to 13/01/2012	7:50PM-7:50PM	75.67	62.07	BDL	16.13						
	Average	63.30	40.86	BDL	14.59	5.67		2.81			
Site : 23 Arki											
12/06/2012 to 13/01/2012	11:00 AM - 11:00 AM	93.00	35.34	BDL	12.96	12.67	13.12	6.05	0.39	BDL	BDL

13/06/2012 to 14/01/2012	11:05 AM - 11:05 AM	86.00	29.65	BDL	14.91	11.36		4.95			
14/06/2012 to 15/01/2012	11:10 AM - 11:10 AM	81.00	32.48	BDL	13.67						
	Average	86.67	32.49	BDL	13.85	12.02		5.50			
Site : 24 Kasauli											
12/06/2012 to 13/01/2012	11:00 AM - 11:00 AM	72.38	20.38	BDL	6.48	21.82	101.83	3.94	0.49	BDL	BDL
13/06/2012 to 14/01/2012	11:05 AM - 11:05 AM	80.67	31.76	BDL	6.89	70.20		4.86			
14/06/2012 to 15/01/2012	11:10 AM - 11:10 AM	83.04	16.65	BDL	5.01						
	Average	78.70	22.93	BDL	6.12	46.01		4.40			
Site : 25 Chail											
15/06/2012 to 16/01/2012	11:00 AM - 11:00 AM	78.01	29.37	BDL	5.96	13.97	15.39	3.20	BDL	BDL	BDL
16/06/2012 to 17/01/2012	11:05 AM - 11:05 AM	47.57	25.08	BDL	7.22	12.31		2.80			
17/06/2012 to 18/01/2012	11:10 AM - 11:10 AM	56.61	30.96	BDL	5.16						
	Average	60.73	28.47	BDL	6.11	13.14		3.00			

Table 3.3 Elements Concentration at Different Sampling Sites

Site Name	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Cu	Zn	Cd
ALL UNITS IN µg/m3 (Unless Specified Otherwise)																	
Buranwala	2.3	2.6	13.9	33.0	0.3	6.5	8.1	10.7	16.8	1.1	0.6	0.1	0.6	14.3	0.3	3.2	BDL
Industry Department Near Fire Brigade Office	2.5	4.6	19.5	49.9	0.4	4.2	2.1	13.8	17.4	1.6	0.1	0.1	0.5	15.0	0.3	1.1	BDL
Ayurvedic Dispensary Barotiwala	2.1	4.2	15.6	37.4	0.4	4.8	3.2	11.9	16.5	1.2	0.3	0.3	1.3	14.0	0.5	7.0	BDL

Housing Board Phase 2	0.4	1.3	8.4	19.5	0.2	1.6	0.6	4.6	8.6	0.6	BDL	BDL	BDL	7.1	0.2	0.0	BDL
MC Nalagarh	0.7	1.7	7.3	18.1	0.1	2.2	1.6	5.2	8.8	0.3	BDL	BDL	0.1	6.6	3.1	0.6	BDL
MC Building	2.0	3.9	22.6	61.2	0.4	3.1	4.3	12.5	17.4	1.5	0.1	0.1	0.8	20.2	0.4	6.1	BDL
Housing Board Phase 3	0.6	1.1	7.0	17.4	0.2	3.0	1.4	6.0	9.5	0.8	0.1	BDL	BDL	5.9	0.2	0.7	BDL
Thana	1.1	1.8	8.8	20.2	0.2	3.2	1.2	6.2	9.1	1.1	0.1	0.1	BDL	9.2	0.3	0.7	BDL
Homeland City Mall	1.0	2.5	10.2	25.7	0.3	3.0	1.5	6.4	12.4	0.7	0.1	BDL	BDL	8.6	0.3	0.8	BDL
BBNDA Rest House	0.9	2.5	8.5	21.2	0.1	1.9	0.9	4.5	11.2	0.6	BDL	BDL	BDL	6.7	0.2	0.3	BDL
Katha Mahabir Mill	0.7	1.8	7.8	20.3	0.2	2.1	0.9	4.9	11.0	0.6	BDL	BDL	BDL	6.9	0.3	BDL	BDL
Morepan	1.5	2.5	12.2	29.9	0.3	3.2	2.2	7.6	11.6	1.2	0.1	0.1	0.4	10.6	0.3	1.5	BDL
Malpura (Panacea Biotec)	1.4	2.7	12.9	31.8	0.3	3.1	2.2	8.0	12.1	1.4	0.1	BDL	0.4	11.0	0.3	1.4	BDL
Khera	0.9	2.5	11.8	28.4	0.3	2.7	1.5	6.6	11.3	0.9	BDL	BDL	BDL	11.0	0.2	5.5	BDL
TVS Nalagarh	1.0	2.2	11.8	27.7	0.2	3.0	1.9	6.7	12.0	1.0	0.1	0.1	BDL	9.9	0.3	3.4	BDL
Lodhimajra (Marico)	0.7	1.2	7.9	18.4	0.2	1.7	0.8	4.1	6.6	0.9	BDL	BDL	BDL	6.3	0.3	0.0	BDL
NRTC (Parwanoo)	1.2	2.6	8.6	21.6	0.2	2.0	1.2	4.0	10.8	0.7	BDL	BDL	BDL	7.7	0.2	0.4	BDL
Parwanoo Office	0.5	1.1	3.8	8.9	0.1	1.4	0.1	1.7	3.9	0.2	BDL	BDL	BDL	2.9	0.3	0.3	BDL
Chambaghat (Solan)	0.4	1.0	4.0	9.8	0.1	1.5	0.1	2.0	4.4	0.4	BDL	BDL	BDL	3.2	0.3	BDL	BDL
SP Office (Solan)	0.6	1.4	6.5	16.5	0.1	1.7	0.4	3.2	6.0	0.2	BDL	BDL	BDL	5.3	0.3	BDL	BDL
Darlaghat (Police Station)	0.4	3.6	3.6	9.0	0.2	1.4	0.3	2.1	13.1	0.0	BDL	BDL	BDL	3.3	0.3	BDL	BDL
Darlaghat (Rathoh)	0.2	0.5	2.7	6.8	0.1	1.1	0.1	1.8	5.9	0.0	BDL	BDL	BDL	2.2	0.3	BDL	BDL
Arki	0.5	1.5	5.0	12.7	0.1	1.6	0.3	2.7	7.0	0.3	BDL	BDL	BDL	3.9	0.2	BDL	BDL
Kasauli	0.6	1.7	6.5	15.8	0.1	1.6	0.3	3.2	7.5	0.5	BDL	BDL	BDL	5.7	0.1	0.2	BDL
Chail	0.5	1.3	4.6	11.2	0.1	1.6	0.2	2.3	5.3	0.3	BDL	BDL	BDL	3.7	0.3	BDL	BDL

Table 3.4 PAHs Concentration at Different Sampling Sites

Site Name	Fluorene	Acenaphthene	Phenantherene	Anthracene	Fluoranthene	Pyrene	Chrysene	Benzo(b)f	Benzo(k)f	Dibenz(a,h)a	Inp	Bghi
ALL UNITS IN ng/m3 (Unless Specified Otherwise)												
Buranwala	43.807	3.715	4.228	17.119	23.787	4.449	2.750	4.742	2.699	1.362	BDL	31.317
Industry Department Near Fire Brigade Office	0.930	0.559	1.777	2.711	3.647	0.872	1.007	2.092	1.291	0.674	BDL	14.890
Ayurvedic Dispensary Barotiwala	0.776	0.737	0.236	4.140	8.793	0.658	0.681	BDL	BDL	BDL	BDL	BDL
Housing Board Phase 2	51.488	2.832	4.392	11.611	1.563	0.784	1.152	BDL	0.289	BDL	BDL	5.395
MC Nalagarh	1.206	0.752	2.668	2.363	4.504	0.422	0.651	BDL	BDL	BDL	BDL	BDL
MC Building Baddi	1.012	0.538	1.973	2.830	3.633	1.089	1.264	2.167	1.309	0.646	BDL	14.739
Housing Board Phase 3	1.063	0.673	2.127	3.117	4.276	0.840	0.984	1.411	0.805	BDL	BDL	10.125
Thane	45.786	3.104	4.662	11.527	5.970	0.743	1.138	BDL	BDL	BDL	BDL	BDL
Homeland City Mall	0.800	6.648	0.858	4.063	6.016	1.761	1.968	3.383	1.947	0.438	BDL	29.671
BBNDA Rest House	1.566	0.826	3.091	1.245	1.834	0.529	0.829	BDL	0.191	BDL	BDL	2.733
Katha (Mahabir Mill)	1.152	0.757	2.567	3.142	4.192	0.729	0.807	BDL	0.277	BDL	BDL	4.012
Morepan	9.723	2.094	6.241	7.877	9.801	1.313	1.863	0.961	0.562	BDL	BDL	4.119
Malpura (Panacea Biotec)	1.424	1.053	2.049	4.561	7.736	0.736	1.052	2.323	1.359	0.673	BDL	18.015
Khera	1.354	0.871	2.661	2.482	2.328	0.668	1.301	0.876	0.490	BDL	BDL	7.132
Bhatain (TVS Nalagarh)	1.600	1.100	3.265	2.814	3.675	1.197	1.118	0.712	0.409	BDL	BDL	5.145
Lodhimajra (Marico)	1.256	0.870	2.494	2.087	3.405	0.710	0.966	0.853	0.630	BDL	BDL	6.432

NRTC (Parwanoo)	1.491	0.983	3.340	3.041	3.013	0.721	1.035	BDL	0.247	BDL	BDL	3.408
Parwanoo Office	1.815	0.821	2.664	2.083	2.836	0.652	0.796	BDL	0.266	BDL	BDL	3.188
Chambaghat (Solan)	1.995	1.092	3.333	3.514	2.417	0.614	0.885	BDL	0.198	BDL	BDL	BDL
Solan Town (SP Office)	0.863	0.598	1.923	2.262	3.736	0.481	0.601	0.519	0.289	BDL	BDL	3.685
Darlaghat (Police Station)	1.262	0.685	2.265	2.574	4.135	0.693	0.788	0.575	0.321	BDL	BDL	3.752
Darlaghat (Rathoh)	48.920	5.379	2.391	5.317	2.091	0.748	0.572	3.357	0.264	BDL	BDL	BDL
Arki	1.134	0.622	2.636	2.622	2.070	0.661	0.722	BDL	0.277	BDL	BDL	BDL
Kasauli	1.180	0.627	2.048	2.637	3.804	0.624	0.697	0.616	0.365	BDL	BDL	4.293
Chail	0.904	0.591	1.889	1.666	3.716	0.375	0.531	BDL	BDL	BDL	BDL	BDL

Table 3.5 OC-EC at Different Sampling Sites

Site Name	OC	EC	OC-PyR	OC-PyT
ALL UNITS IN mg/0.495cm2 (Unless Specified Otherwise)				
Buranwala	21.48	36.17	2.41	36.17
Industry Department Near Fire Brigade Office	16.90	19.52	6.14	19.52
Ayurvedic Dispensary Barotiwala	6.82	2.43	0.68	2.43
Housing Board Phase 2	8.66	6.10	0.44	6.11
MC Nalagarh	9.61	4.00	0.67	4.00
MC Building Baddi	12.63	15.46	3.21	15.46
Housing Board Phase 3	14.44	15.46	1.75	15.46
Thane	7.72	5.10	0.02	5.10
Homeland City Mall	18.88	22.33	4.37	22.33
BBNDA Rest House	9.08	5.74	0.76	5.74
Katha (Mahabir Mill)	11.80	7.73	0.87	7.73
Morepan	9.58	11.89	1.19	11.89
Malpura (Panacea Biotec)	13.77	13.97	2.07	13.97
Khera	11.42	9.38	1.18	9.38
Bhatain (TVS Nalagarh)	10.87	9.07	1.63	9.07
Lodhimajra (Marico)	15.08	11.50	4.42	11.50
NRTC (Parwanoo)	8.26	4.78	0.59	4.78
Parwanoo Office	7.97	4.91	0.80	4.91
Chambaghat (Solan)	4.84	4.15	0.54	4.14
Solan Town (SP Office)	4.72	3.83	0.00	3.83
Darlaghat (Police Station)	8.22	5.96	0.00	5.97
Darlaghat (Rathoh)	12.60	6.26	3.70	6.27
Arki	9.89	5.33	0.71	5.33
Kasauli	9.42	4.02	1.28	4.03
Chail	5.26	2.34	0.65	2.34

Table 3.2 CO Concentration at six sampling sites

S.No	Sampling Site	Sampling Time	CO (mg/m^3)	
			4 (1 hr peak)	2 (8hrs)
1	MC Building Baddi	17:00-01:00	1.412	0.826
		01:05-09:00	1.168	0.320
		09:05-17:00	2.065	0.794
2	MC Nalagarh	19:00-03:00	1.137	0.445
		03:05-11:00	0.893	0.307
		11:05-17:00	1.79	0.563
3	Parwanoo Office	13:00-21:00	0.885	0.339
		21:05-05:00	0.704	0.189
		05:05-13:00	1.052	0.408
4	Solan Town (SP	22:00-06:00	0.944	0.369

	Office)			
		06:05-14:00	1.676	0.848
		14:05-22:00	2.682	1.207
5	Darlaghat Town	20:00-04:00	1.023	0.415
		04:05-12:00	1.173	0.368
		12:05-20:00	1.676	0.499
6	Kasauli Town	12:00-20:00	0.325	0.859
		20:05-04:00	0.143	0.431
		04:05-12:00	0.395	1.026

3.0 Baddi and Nalagarh Region

In this region sixteen air quality monitoring sites were selected considering appropriate representation of air quality data.

PM_{10} and $PM_{2.5}$

Three day average concentrations observed for PM_{10} and $PM_{2.5}$ are shown graphically in this section for PM_{10} and $PM_{2.5}$ for sixteen sampling sites (Fig. 3.1 and 3.2). The PM_{10} concentration at fifteen sites in this region exceeds NAAQS, except Katha site (AQS11). The $PM_{2.5}$ concentration of six sites in this region exceeds NAAQS.

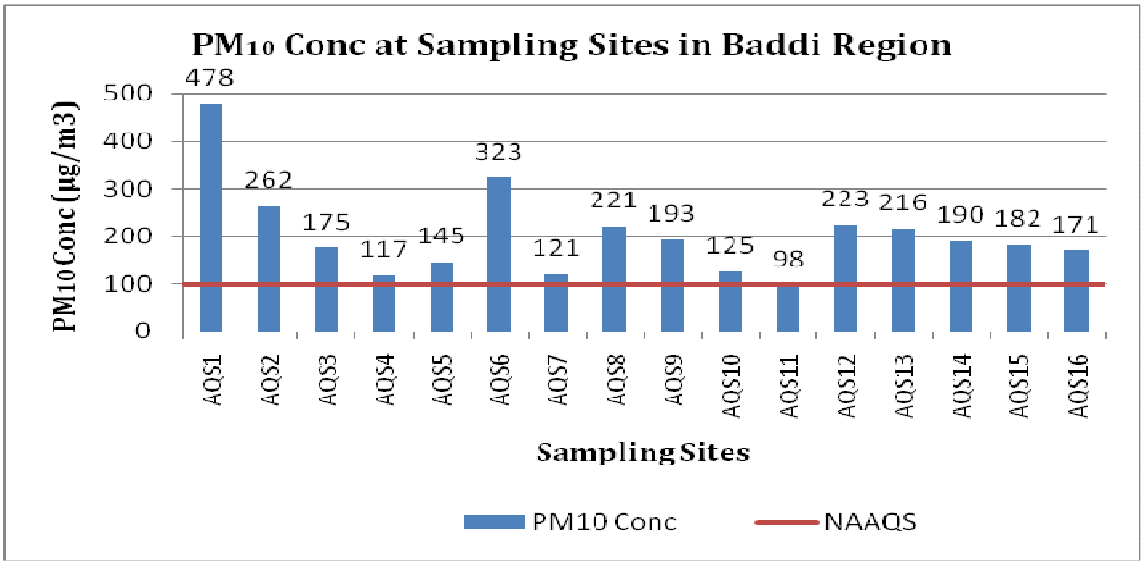

Fig. 3.1 PM_{10} concentration at Different Sampling Sites in Baddi and Nalagarh Region.

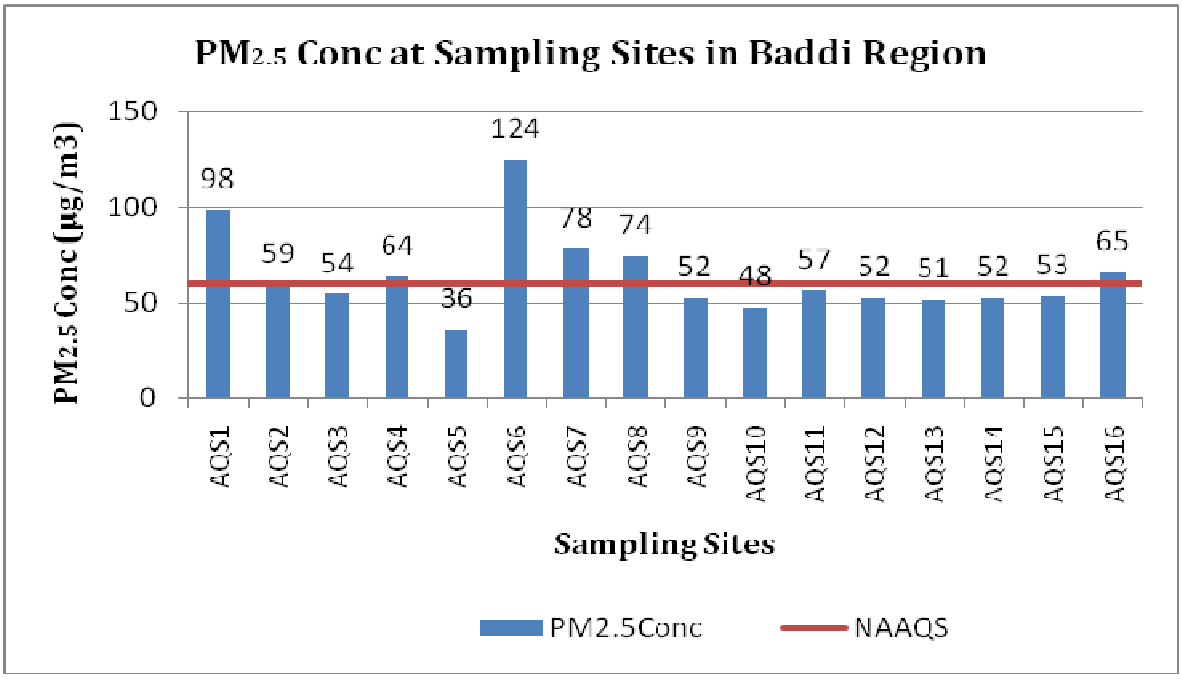

Fig. 3.2 $PM_{2.5}$ concentration at Different Sampling Sites in Baddi and Nalagarh Region.

SO_2 and NO_2

Three day average concentrations observed for SO_2 and NO_2 are shown graphically during the time of sampling (Fig. 3.3 and 3.4 respectively). SO_2 concentration at two sites exceeds NAAQS. At remaining six sites the concentration were below detection limit. NO_2 concentrations at all sixteen sampling sites are within the NAAQS.

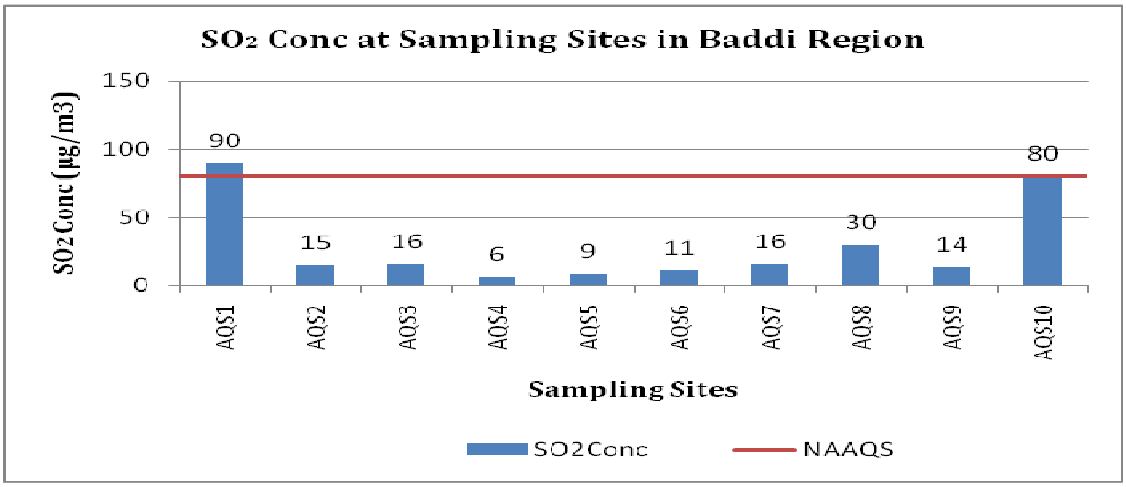

Fig. 3.3 SO_2 concentration at Different Sampling Sites in Baddi and Nalagarh Region.

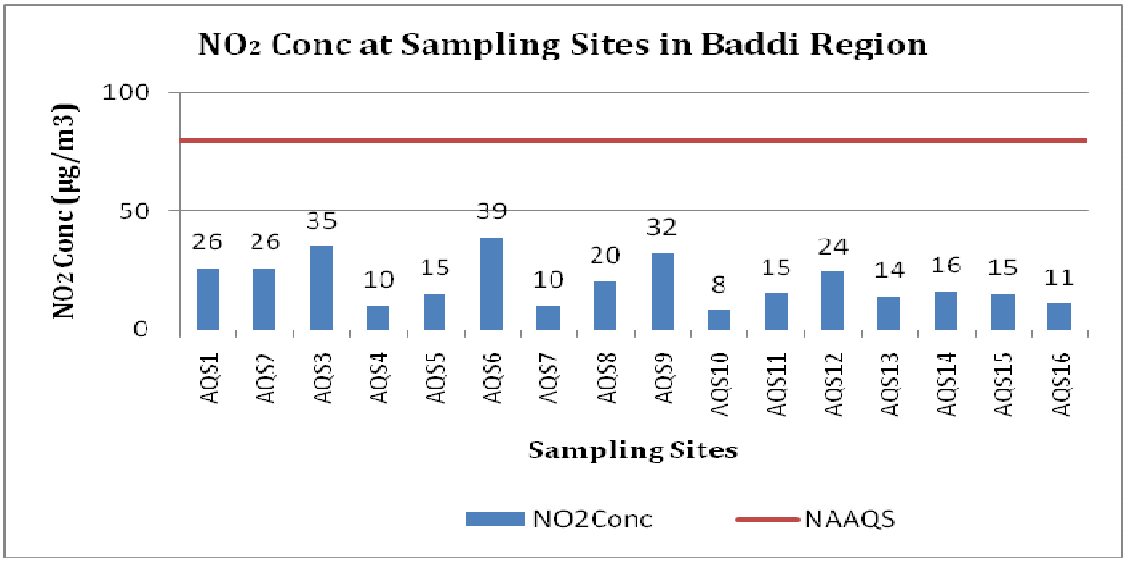

Fig. 3.4 NO_2 concentration at Different Sampling Sites in Baddi and Nalagarh Region.

O_3

Two day average concentrations observed for O_3 is shown graphically during the time of sampling (Fig. 3.5). O_3 concentrations at all sixteen sampling sites are within the NAAQS (Note: 80µg/m^3 is the 8 hour concentration).

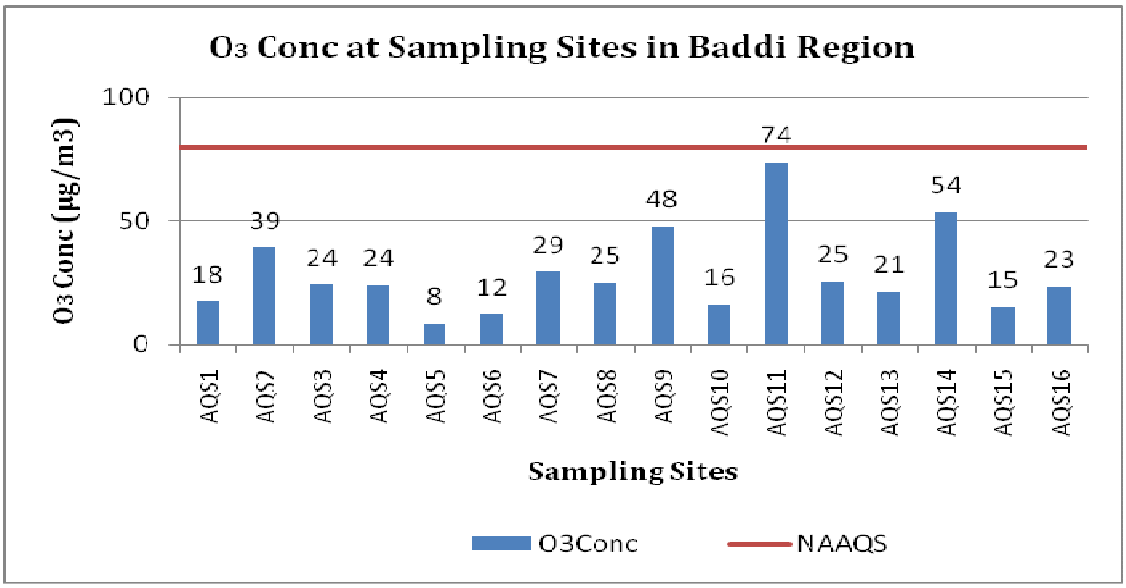

Fig. 3.5 O_3 concentration at Different Sampling Sites in Baddi and Nalagarh Region.

NH_3

Two day average concentrations observed for NH_3 is shown graphically during the time of sampling (Fig. 3.6). NH_3 concentrations at all sixteen sampling sites are within the NAAQS.

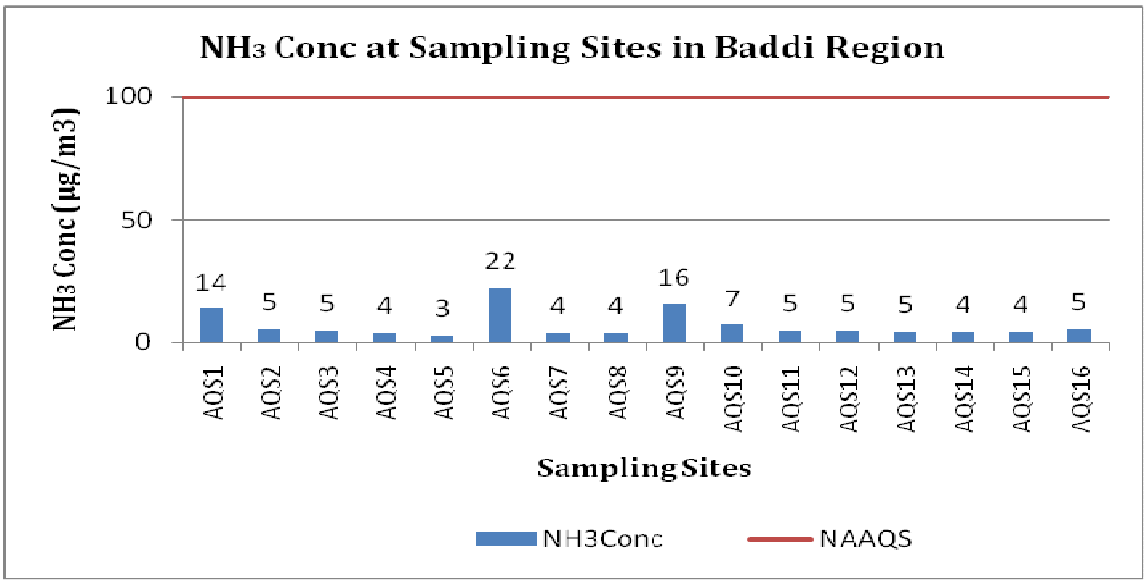

Fig. 3.6 NH_3 concentration at Different Sampling Sites in Baddi and Nalagarh Region.

BaP

The average concentrations observed for BaP is shown graphically during the time of sampling (Fig. 3.7). BaP concentration at five sites exceeds NAAQS. At remaining eleven sites the concentrations were below NAAQS (Note: $1ng/m^3$ is the annual concentration).

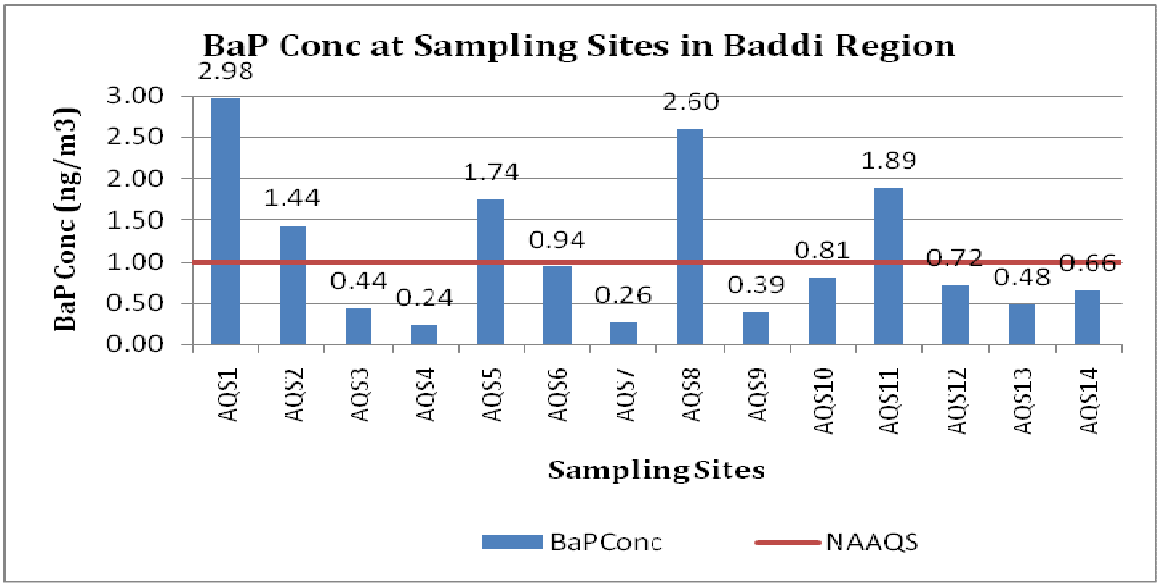

Fig. 3.7 BaP concentration at Different Sampling Sites in Baddi and Nalagarh Region: Note the standard is for annual average but reported values of three days; exceedence of the standard is not necessary if sampled over the year.

Pb

The average concentrations observed for Pb is shown graphically during the time of sampling (Fig. 3.8). Pb concentration at three sites exceeds NAAQS. At remaining thirteen sites the concentration were below NAAQS.

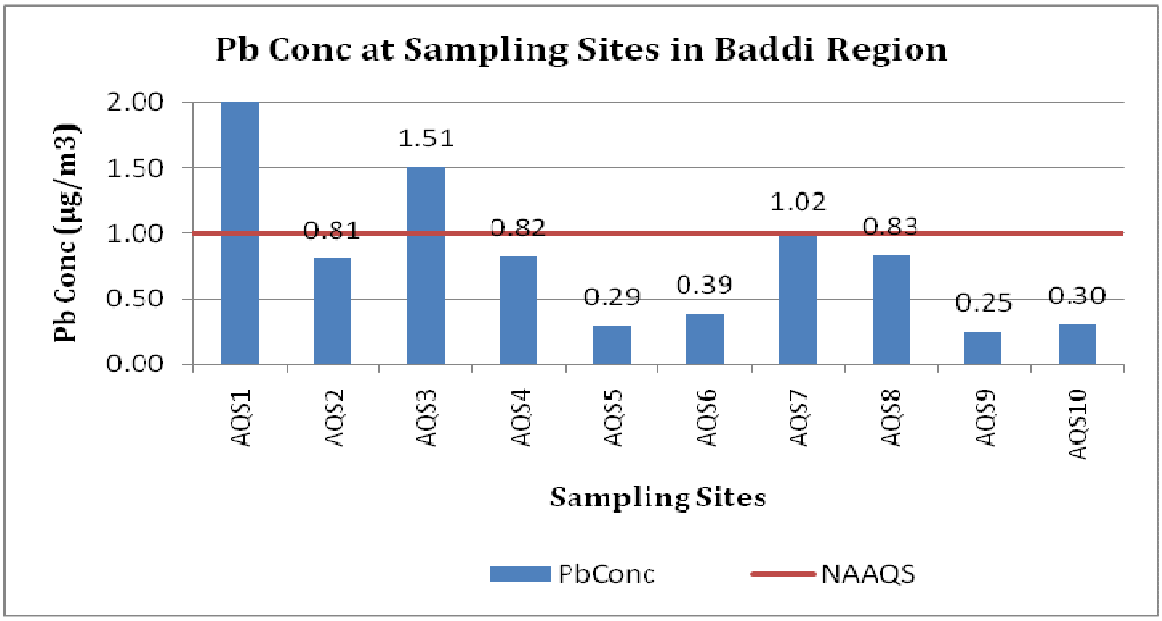

Fig. 3.8 Pb concentration at Different Sampling Sites in Baddi and Nalagarh Region.

As

The average concentrations observed for As is shown graphically during the time of sampling (Fig. 3.9). As concentration at five sites exceeds NAAQS (Note: 6ng/m^3 is the annual concentration). At remaining eleven sites the concentration were below detection limit.

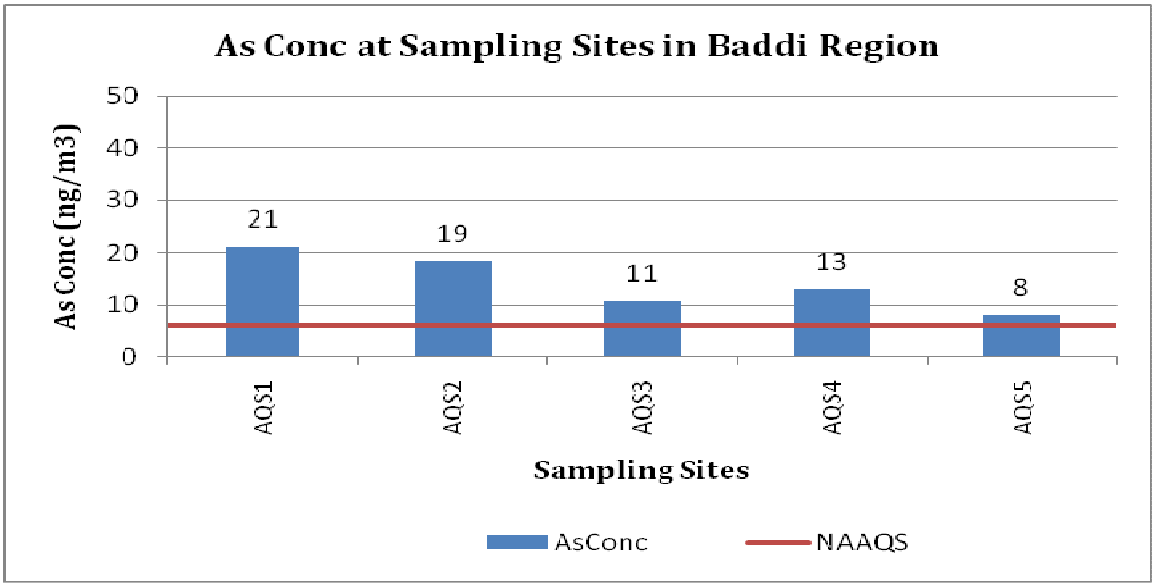

Fig. 3.9 As concentration at Different Sampling Sites in Baddi and Nalagarh Region.

3.1 Solan, Parwanoo, and Darlaghat Region

In this region nine air quality monitoring sites were selected considering appropriate representation of air quality data.

PM_{10} and $PM_{2.5}$

Three day average concentrations observed for PM_{10} and $PM_{2.5}$ are shown graphically in this section during the time of sampling. PM_{10} and $PM_{2.5}$ concentrations of nine sampling

sites is shown in Fig. 3.10 and 3.11 respectively. The PM_{10} concentration at three sites in this region exceeds NAAQS. The $PM_{2.5}$ concentration of all nine sites in this region is within NAAQS.

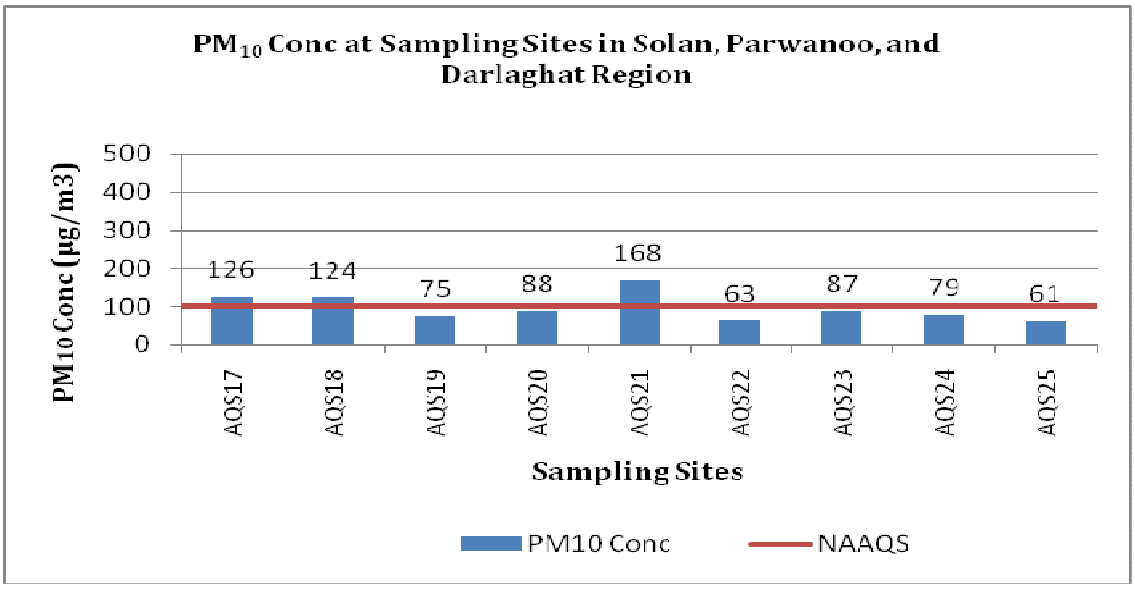

Fig. 3.10 PM_{10} concentration at Different Sampling Sites in Solan, Parwanoo, and Darlaghat Region.

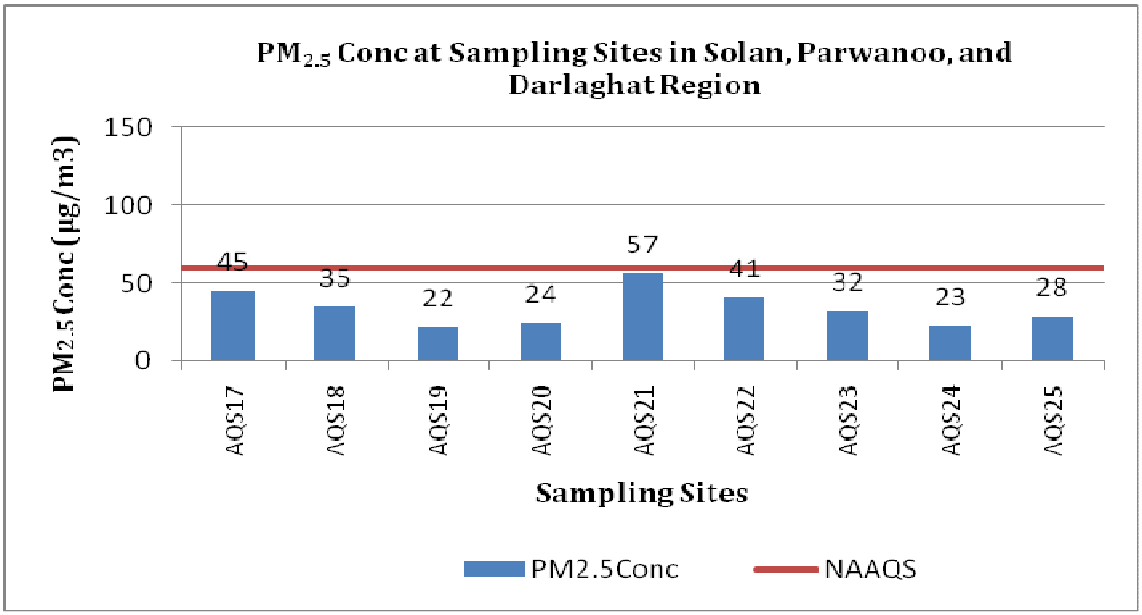

Fig. 3.11 $PM_{2.5}$ concentration at Different Sampling Sites in Solan, Parwanoo, and Darlaghat Region.

SO_2 and NO_2

Three day average concentrations observed for SO_2 is below detection limit of five sites. The NRTC Parwanoo site is having SO_2 concentration of 12µg/m^3. The three day average concentrations of NO_2 are shown graphically during the time of sampling (Fig. 3.12). NO_2 concentrations at all nine are within NAAQS.

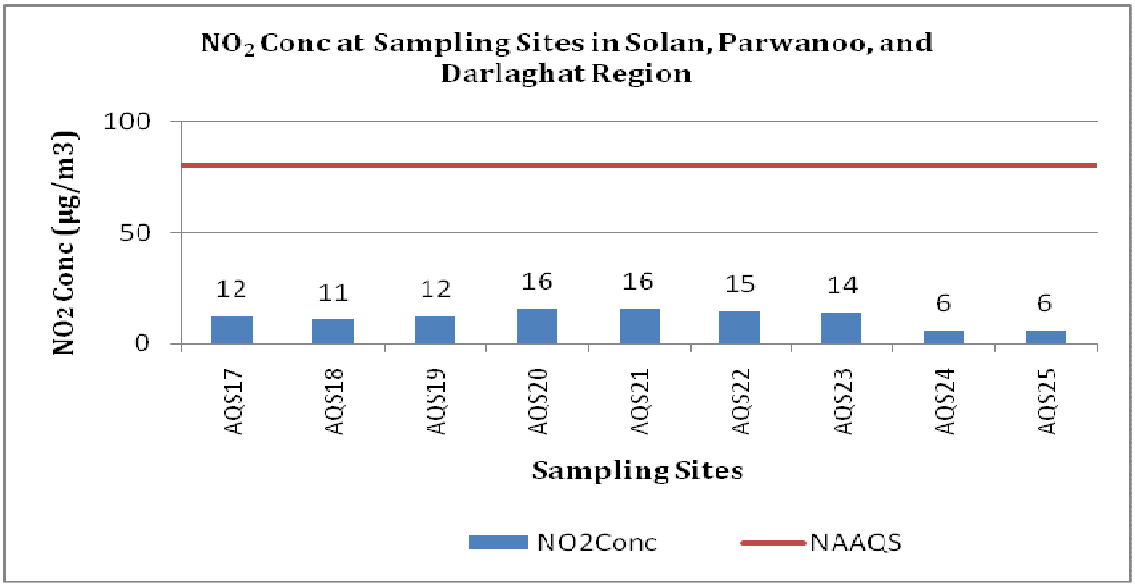

Fig. 3.12 NO_2 concentration at Different Sampling Sites in Solan, Parwanoo, and Darlaghat Region in Solan, Parwanoo, and Darlaghat Region.

O_3

Two day average concentrations observed for O_3 is shown graphically during the time of sampling (Fig. 3.13). O_3 concentrations at all sixteen sampling sites are within the NAAQS O_3 concentrations at all sixteen sampling sites are within the NAAQS (Note: 80µg/m^3 is the 8 hour concentration).

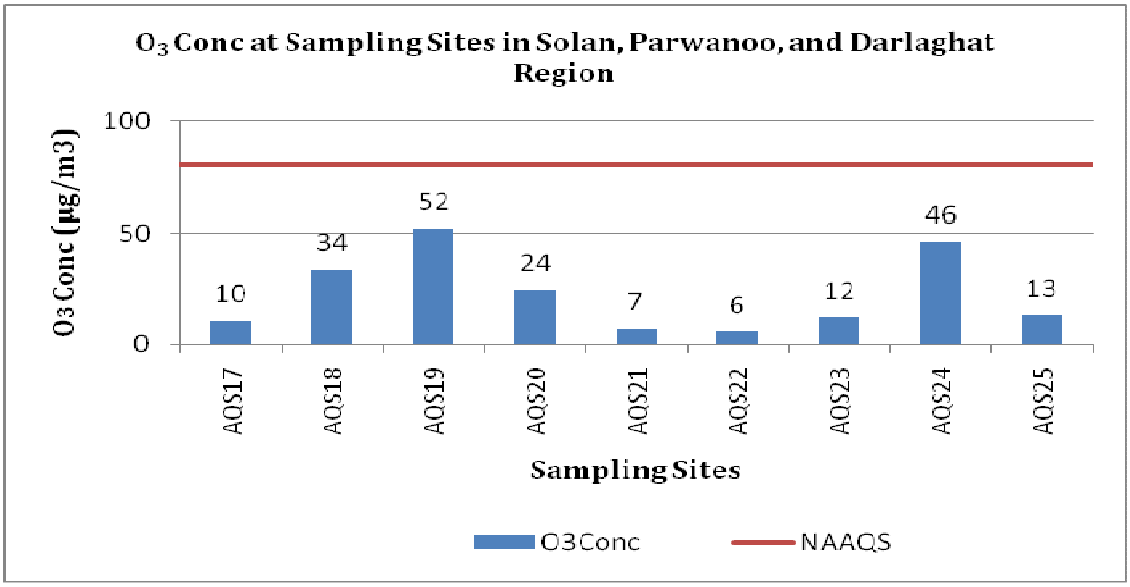

Fig. 3.13 O_3 concentration at Different Sampling Sites in Solan, Parwanoo, and Darlaghat Region.

NH_3

Two day average concentrations observed for NH_3 is shown graphically during the time of sampling (Fig. 3.14). NH_3 concentrations at all sixteen sampling sites are within the NAAQS.

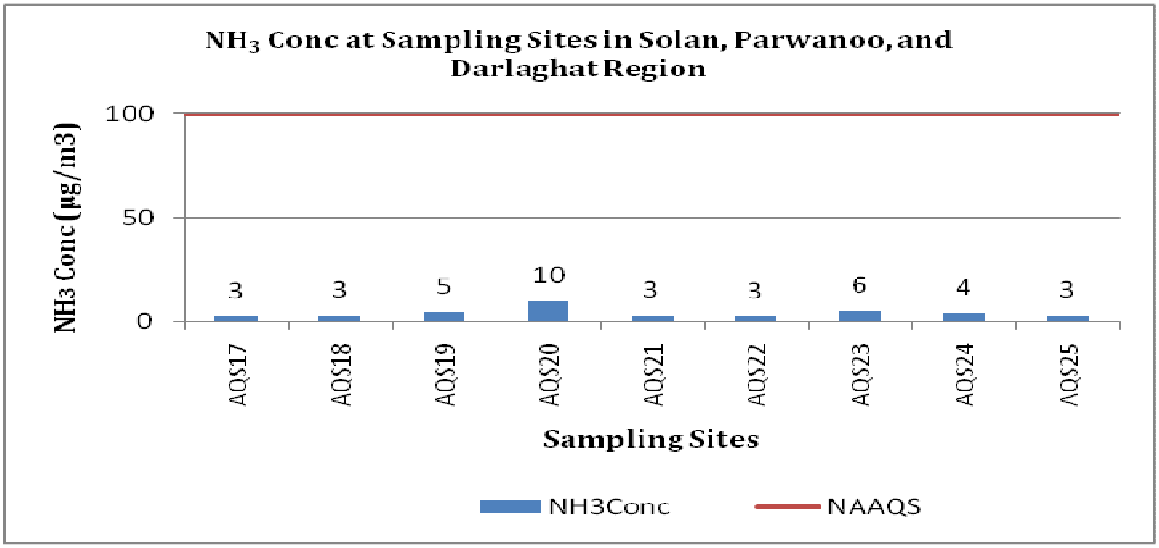

Fig. 3.14 NH_3 concentration at Different Sampling Sites in Solan, Parwanoo, and Darlaghat Region.

BaP

The average concentrations observed for BaP is shown graphically during the time of sampling (Fig. 3.15). BaP concentration at all nine sites are within NAAQS(Note: 1ng/m^3 is the annual concentration).

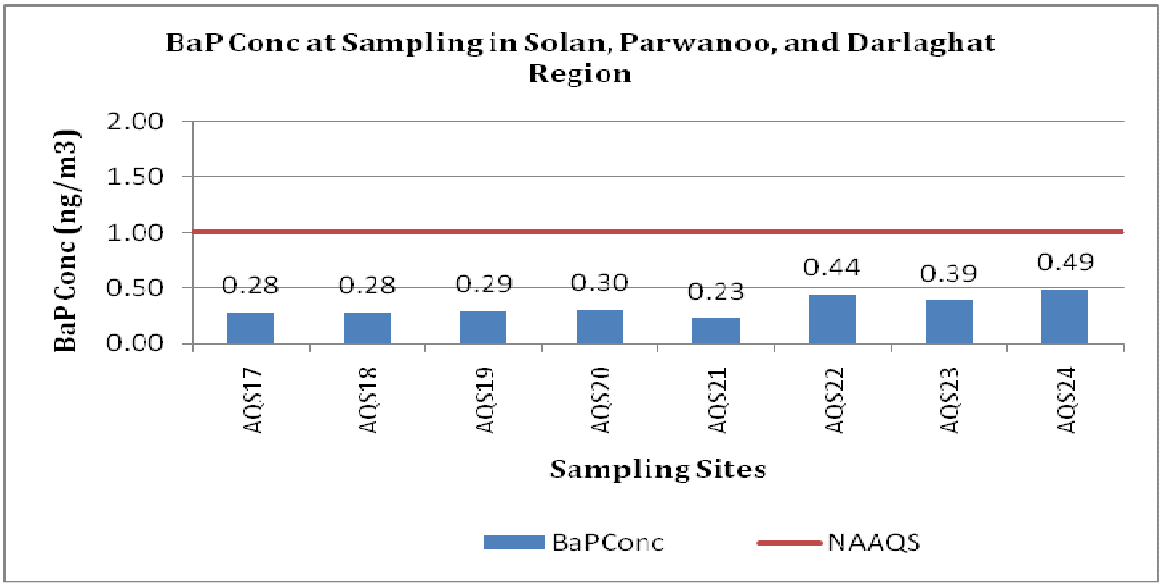

Fig. 3.15 BaP concentration at Different Sampling Sites in Solan, Parwanoo, and Darlaghat Region.

Pb and As

The average concentrations observed for Pb and As is below detection limit in all nine sites.

Chapter 4

Work in Progress

The following work is in progress:

- Analysis of Benzene.
- Analysis of Nickel.
- Water sample element analysis
- Ion analysis of air filters
- Emission inventory
- Modeling
- Pesticides analysis
- Development of control options.

It is expected that the analysis work of all the parameters of water and air will be completed in next three weeks with all quality control analysis and interpretations. However, the work related to preparation to emission inventory, air quality modeling hazardous waste inventory and disposal will take some time as important data are to be received from the HPSPCB. Specifically it is required that details on industry locations, product capacity, raw material and fuel usage, chimney details are required for modeling work and apportioning of the sources. Once sources are apportioned, then the possible control options can be worked out and possibly implemented for improving air and water quality.

It is to be noted that emission inventory related to vehicular emissions and road dust is already in the process and will be completed shortly. To cover the emissions from the domestic sectors, it is important to get the population data at the ward and pachayat level. Information on type and quantities of fuel being used at the domestic level will also help in preparing the emission inventory.

It may be noted that meteorological data is very important to interpret the air quality data and to undertake air quality modeling. We are in process of obtaining the meteorological data from India Meteorology Department (IMD) and CDAC, Pune which have the data at spatially resolved level and the same will be used in the modeling because the meteorology can change quickly in Solan district due to presence of hills and complex terrain.

It may be noted that the maps have been digitized and most of the information has been stored in the soft form which will be utilized for spatial planning. It is desired that other information which has been requested is made available so that other activities of the projects are undertaken and a well-interpreted and conclusive report can be submitted to HPSPCB.