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Project:	**Bangladesh Air Pollution Management (BAPMAN)**

Ambient Air Pollution Screening Study in Dhaka

31 January - 15 February 2011

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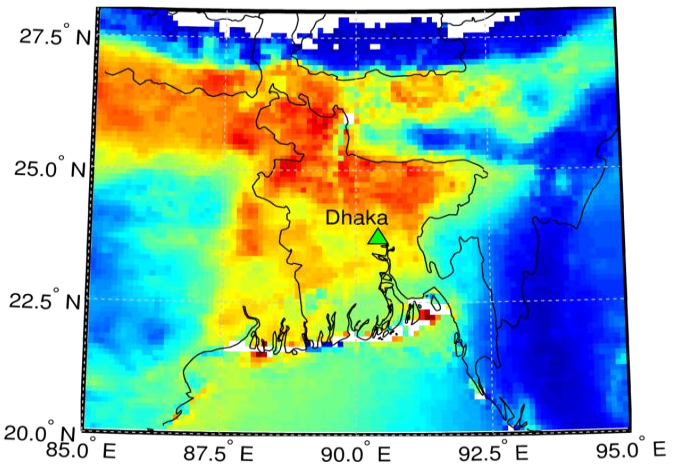

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Executive Summary

As a part of the Bangladesh Air Pollution Management (BAPMAN) project, a screening study of air pollution was performed by the project partners Norwegian Institute for Air Research (NILU) and the Clean Air and Sustainability Project (CASE) at the Department of Environment (DoE) in Bangladesh. The screening study work fell under Task 1 (Emissions Inventory) of the BAPMAN project.

The screening study was performed in Dhaka from 31 January – 15 February 2011. The main objective of the study was to gain an overview of the background concentrations and the spatial distribution of the air pollution in the Dhaka city area. Thorough ambient air quality data has not been collected in the city for some years.

The screening study contained the following three parts:

1. **Passive Sampling**. Passive samplers for NO_2 and SO_2 were located at 48 sites throughout the Dhaka City Corporation city limits, where 20 of these sites had in addition passive samplers for O_3. Exposure period for the samplers was 10-14 days.
2. **Active Sampling**. Short-term active PM grab samples (PM_1, $PM_{2.5}$, and PM_{10}) were collected at 23 sites in selected areas of the city and various microenvironments. PM samples were taken for 30-minutes.
3. **Traffic Counting**. Traffic counting was performed at 13 sites to get a general picture of average traffic flows and vehicle distributions on different road types. Traffic counting was calculated as 1-hour averages.

In addition, the study examined satellite mapping data to get a general regional picture of NO_2 and PM concentrations.

The screening study was performed during the winter season because this is the dry period where air pollutant concentrations will be at their peak. The winter season is also the time of the year in which the brick kilns are being operated, of which are suspected to be the single greatest local contribution to AQ problems in Dhaka. Other possible sources of air pollution include re-suspension of road dust from traffic, open burning, residential cooking, and industrial sources such as cement manufacturing and metal smelting. Regional haze from India and their burning of dirty coal is also a significant contribution to local PM values on the regional scale.

Results from the study show that SO_2 concentrations are relatively high on average (86.9 $\mu g/m^3$) ranging from 38.0 µg/m3 to 199.3 $\mu g/m^3$, and NO_2 concentrations are also relatively high on average (83.6 $\mu g/m^3$) ranging from 35.6 µg/m3 to 161.3 $\mu g/m^3$. Some sites most likely exceed local Bangladesh standards for SO_2 and NO_2, and most sites sampled exceed WHO guidelines. O_3 concentrations were moderate on average (47 $\mu g/m^3$), ranging from 18 $\mu g/m^3$ to 62 $\mu g/m^3$. Distribution of the concentrations of these pollutants is relatively varied throughout the city area, and levels occur highest in micro-environments (site classifications) with sources for the particular gas.

PM_{10} concentrations ranged from 258 $\mu g/m^3$ to 2039 $\mu g/m^3$, with an average concentration of 613 $\mu g/m^3$ for all sites, and $PM_{2.5}$ concentrations ranged from 216 $\mu g/m^3$ to 1131 $\mu g/m^3$, with an average concentration of 439 $\mu g/m^3$. These results show that a large majority of PM was of the fine fraction. The concentration distribution was also to a certain degree dependent on the type of micro-environment in the city, but PM appears

also to a large extent impacted by special regional factors and regional meteorology during the winter period. Satellite mapping can preliminarily confirm this situation, showing differing levels of aerosol optical depth (AOD) at the regional level which roughly correspond to ground level PM measurements for Dhaka. Traffic counting results from the study will be important for future work in that the data can be used to establish basic traffic flows and vehicle distributions for varying road classes.

It can be certainly concluded from these screening results that Dhaka experiences severe AQ problems in the winter season, and the sheer volume of human exposure to these ambient pollutants is staggering. It is encouraging that the CASE project is currently improving AQ management for the country, and that the BAPMAN project is increasing capacity building where necessary.

Contents

Bangladesh Air Pollution Management (BAPMAN) Ambient Air Pollution Screening Study in Dhaka

1 Introduction

As a part of the Bangladesh Air Pollution Management (BAPMAN) project, a screening study was performed by the project partners Norwegian Institute for Air Research (NILU) and the Clean Air and Sustainability Project (CASE) at the Department of Environment (DoE) in Bangladesh. The screening study work fell under Task 1 (Emissions Inventory) of the BAPMAN project.

A screening study of air pollution in Dhaka was performed from 31 January – 15 February 2011. The main objective of the study was to gain an overview over the background concentrations and the spatial distribution of the air pollution in the Dhaka area. So far, such a thorough ambient air quality screening study has not been conducted in the city.

Passive samplers for NO_2 and SO_2 were located at 48 sites throughout the Dhaka City Corporation city limits, where 20 of these sites also had passive samplers for O_3. Samplers were placed in an equal spatial distribution throughout the city within various microenvironments taking in consideration the prevailing winds and brick kiln cluster fields, believed to be a major pollutant contributor to ambient air. The passive sampling campaign was performed in February during the winter season (no precipitation), and the samplers were exposed to ambient air for approximately 10-14 days.

Parallel and in addition to the passive sampling campaign, short-term active PM grab samples were collected at 23 sites in selected areas of the city and various microenvironments. Also parallel and in addition to the passive sampling campaign, traffic counting was performed at 13 sites to get a general picture of average traffic flows and vehicle distributions on different road types. An analysis of satellite mapping data was also performed to a get a spatial and temporal picture of the general regional NO_2 and PM concentrations.

1.1 Background

Dhaka can be considered the mega-city with the world's worst urban air quality (Gurjar et al., 2008). A combination of numerous local emissions sources in the winter season in addition to special local and regional winter meteorological conditions gives the city exceedingly high air pollution concentrations during this time of the year. The exposure of the cities estimated 12-15 million residents to this alarmingly poor air quality demands attention including immediate research and corresponding mitigation. It is estimated that if the annual guidelines for PM concentration were met in 2004 that 1,213 premature deaths could have been avoided in Dhaka alone for that year (Aktar, et al., 2005); and the World Health Organization estimates that up to 10,000 premature deaths per year in Bangladesh are attributed to air pollution (WHO, 2009).

Currently there is a lack of comprehensive AQ data for Dhaka (as well as for the rest of Bangladesh). The two Continuous Air Monitoring Stations (CAMS) in Dhaka have been partially down since 2006, but as of date of publication are currently being repaired. Mini-vol and GENT sampling for PM in two size fractions ($PM_{2.5}$ and PM_{10}) has been performed in recent years, with some reporting of this data occurring in published journal articles (Begum et al., 2006, 2010a, 2010b). The DoE is in the process of upgrading and expanding the AQM program through the current CASE program, in which NILU is assisting in training and knowledge transfer during this expansion period through the BAPMAN project.

The lack of available data and comprehensive understanding of the greater air quality problems and hot spots in Dhaka gave need for the screening study and corresponding results.

1.2 Emission Sources

During the winter season the brick kilns are the primary local source of AQ problems, specifically PM. Figure 1 displays a map of 983 identified brick kilns in the greater Dhaka area. A majority of these brick kilns are structurally identical (mainly Fixed Chimney Kilns), where most use "low-grade" coal from India as their primary fuel source.

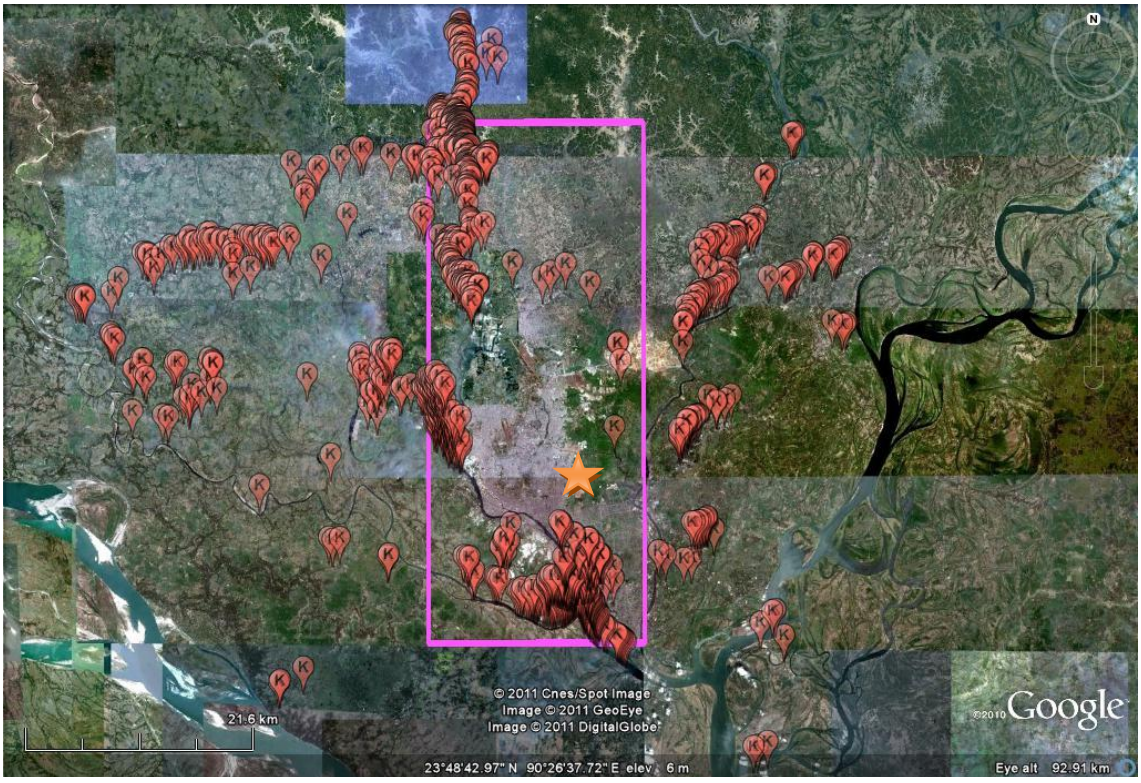

Figure 1: Map of 983 Brick Kilns in greater Dhaka area. Pink rectangle signifies the modelling grid area for the BAPMAN project; Dhaka city center is marked by the orange star. (Background Imagery Source: Google Earth).

In addition to brick kilns, vehicle emissions are a large source. However, a large percentage (up to approximately 73%) of traffic sources (excluding motorcycles)

run on CNG (Wadud, 2011) so the direct contribution of vehicle traffic to PM is low, but during the dry winter season, re-suspension of road dust from traffic is also a considerable local-scale source of PM. While the large volume of vehicles running on CNG reduces the PM values, CNG combustion could also be a considerable local source of NO_X.

Other smaller local emission sources include open-air waste burning and industrial sources such as cement manufacturing and metal smelting. Most industries, including domestic power plants, use CNG as their fuel source. Residential cooking can also be considered one of the more important smaller local area sources (Randall, 2011).

Regional haze from the greater Bangladeshi area as well as India and the abundant use of "dirty" coal as a primary industrial fuel source may be a considerable regional source to Dhaka. Figure 2 shows a satellite image from 11 February 2011 displaying a large haze over India and Bangladesh which is backed-up against the Himalayas. The regional haze contribution to local PM levels in Dhaka is further discussed in Section 5.5 with a presentation of varying satellite data.

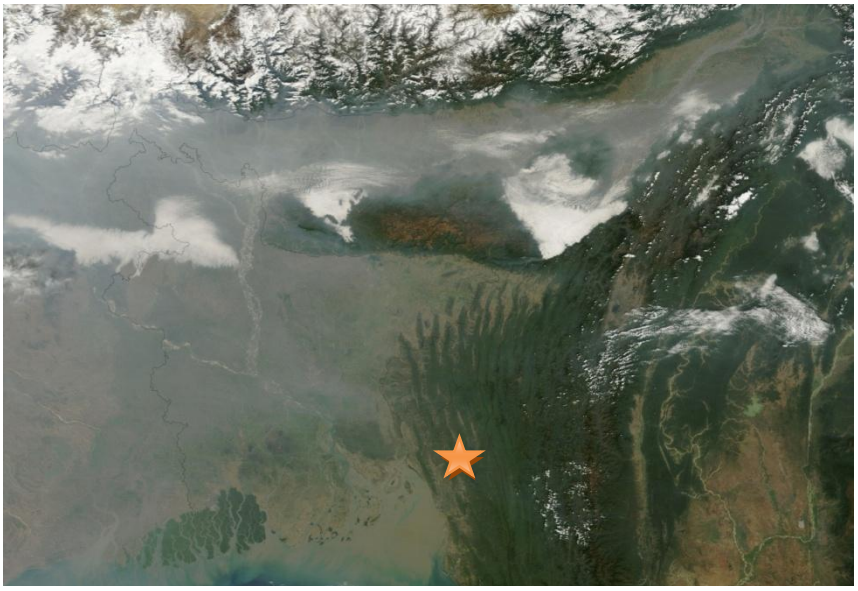

Figure 2: Satellite imagery showing regional haze over India and Bangladesh getting blocked-up against the Himalayas. Location of Dhaka is distinguished by the orange star. (Source: MODIS).

1.3 Meteorology

Dhaka can be divided into four distinct meteorological seasons: pre-monsoon (March–May), monsoon (June–September), post-monsoon (October–November) and winter (December–February) (Salam et al., 2003). The winter season is characterized by low north and north-westerly prevailing winds including minimal rainfall and low humidity resulting in dry soil conditions. A wind rose for Dhaka based on the 2002-2008 winter season data is presented in Figure 3 below.

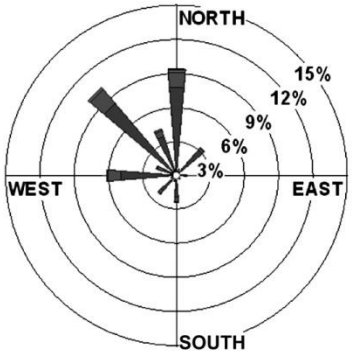

Figure 3: Wind rose for Dhaka during winter season (Source: Begum et al., 2010c).

Temperature during the screening study was warm at a consistent 30°C high during the day and low of 15°C during the night. There was no precipitation during the entire screening study. Figure 4 displays a forecasted meteogram for a typical 2 day period during the screening study, which includes temperature, cloud cover, precipitation, wind speed, and wind direction. Appendix A contains meteograms for all days of the screening study.

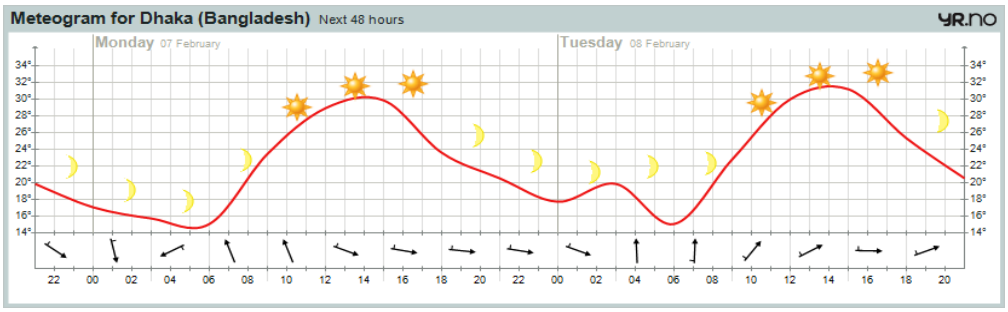

Figure 4: Forecasted meteogram for Dhaka during 07-08 February 2011. (Source: yr.no)

2 Methods

The Dhaka screening study campaign design was based on previous screening studies performed by NILU such as in Burgas, Bulgaria (Hak, 2010; Hak and Sivertsen, 2010); Dakar, Senegal (Guerreiro et al., 2005); Cairo, Egypt (Sivertsen, 2001a); and Ho Chi Min City, Vietnam (Sivertsen, 2003). Monitoring design features were borrowed from these studies as well as adding new features in order to create a tailor-made study for Dhaka. The complete design including site selection, instrumentation, and sampling procedures will be presented for each of the three parts of the Dhaka field study:

- Passive Sampling (NO_2, SO_2, O_3)
- PM sampling ($PM_{2.5}$, PM_{10})
- Traffic Counting (vehicle distributions and flows)

In addition, the methods for how we examined satellite mapping of NO_2 and PM (optical depth) in Dhaka will be presented.

2.1 Passive Sampling Design

A passive sampling design memorandum was prepared in advance of the screening study to establish the sampling methods (Appendix B). The memo laid out the components to measure, site selection, including the instrumentation and basic sampling procedures. It was decided that 50 NO_2, 50 SO_2, and 20 O_3 samplers would be placed throughout the city.

2.1.1 Passive Sampling Site Selection

It was attempted to select the passive sampling sites based on the following three main criteria:

- Measuring in different microenvironments (e.g. street canyon, road side, urban background, industrial area, regional background, etc.).
- Selection of compounds to be measured in different microenvironments depending on emission sources.
- Typically prevailing wind direction for the time of the year when sampling campaign is carried out. Figure 5 shows the desired transects to locate sampling sites upon.

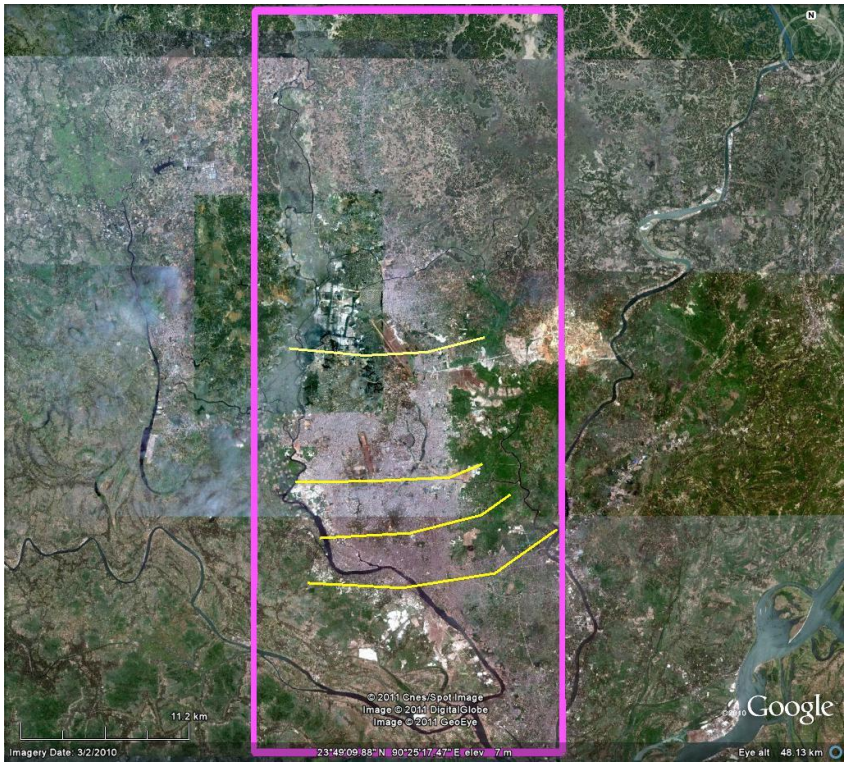

Figure 5: Targeted transect lines (yellow lines) to locate passive sampling sites along. Pink rectangle signifies the modelling grid area for the BAPMAN project. (Background Imagery Source: Google Earth).

Most of the selected sites followed the desired criteria, but many of the sites were first selected for security reasons. Because it was warned that there was a high probability for samplers to be stolen or damaged in public areas, a majority of samplers were located at DoE/CASE staff residencies, ensuring a good distribution throughout the city area. Samplers not located at secure residences were located at businesses with outdoor secure areas, also ensuring an even distribution throughout the city area.

2.1.2 Passive Sampling Instrumentation

For sampling of NO_2, SO_2, and O_3 gases the passive sampling devices include an impregnated filter inside a small plastic tube (Figure 6). To avoid turbulent diffusion inside the sampler, the inlet is covered by a thin porous membrane filter. Gases are transported and collected by molecular diffusion. The samplers were bought from the Swedish Environmental Research Institute (IVL) (IVL, 2011), and the NO2 and SO2 filters are analyzed at the laboratories at NILU, while the O3 samplers were analyzed by IVL.

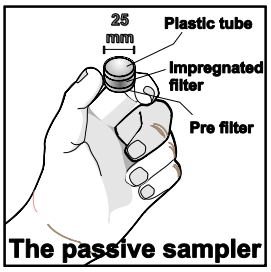

Figure 6: Illustration of passive sampler.

2.1.3 Passive Sampling Procedures

All available samplers were divided into three teams of two people per team. Each team was responsible for between 13-19 sampling sites, for a total of 48 sites each containing NO2 and SO2, where 20 of these sites also contained O3. The passive samplers were place according to detailed instructions (Appendix C), where it was very important to document placement time/date and other important site information for later reference. It was also important to take careful notice not to place the samplers in near contact of any identifiable direct local sources (such as generators, parking lots, bus stops, etc.).

2.2 PM Sampling Design

The design for PM sampling was to collect samples in different micro-environments distributed throughout the city, as well as to collect daily measurements in the same fixed location at the same time each day to roughly identify temporal variations. A total of 23 unique sites were sampled for a one time measurement for a 30 minute average, while one site was sampled repeatedly, and one site was additionally sampled for a 24-hour period.

2.2.1 PM Sampling Site Selection

PM site selection followed the stated sampling design, with close attention to place a sampler a good distance (at least a few meters) for direct local sources such as immediate roadside or other areas with direct dust disturbance. Where possible, PM sampling sites were attempted to be placed at existing passive sampling sites.

While an equal spatial disbursement of sites was attempted according to the stated design of different micro-environments, a few sites were targeted for particular reasons:

- Down-wind of brick kiln fields
- Market areas with high density of people
- Hotel site (15m and 150m) for temporal variations
- Secure embassy site for 24-hour sampling

2.2.2 PM Sampling Instrumentation

PM sampling was collected using the TSI DustTrak DRX (model 8534), which collects PM1, PM2.5, PM4, and PM10 simultaneously (Figure 7). For most sites data was collected over 30 minutes at one second increments (data was prepared with 10 second averages). The sampler was calibrated before each sample was taken according to the manufacturers specifications.

Figure 7: TSI DustTrak DRX (model 8534)

2.2.3 PM Sampling Procedures

The sampler was placed at 1m-2m height above ground and run for 30 minutes in a pre-programmed mode according to the manufacturer's instructions (TSI, 2011). The sampler was left alone for the sampling period, with careful attention not to have others walk in the vicinity of the sampler. The file number of the dataset was noted along with important site details and information. Data was downloaded from the sampler each evening into a developed MS Excel macro to easily display and analyze the raw data.

2.3 Traffic Sampling

Traffic sampling employed a simple design of counting vehicles on various roads during various times and days of week to roughly estimate vehicle volumes and

vehicle class distributions for different road types. Counting was based on vehicle classes and road classes pre-defined by the BAPMAN project (Table 1).

Table 1: Vehicle Classes and Road Classes used in Traffic Sampling

Vehicle Classes
Car
Truck
Bus
Auto-rickshaw
Taxi
Motorcycle

Road Classes
Primary
Secondary
Diffuse
Diffuse (Industrial)

2.3.1 Traffic Sampling Site Selection

Traffic sampling sites were located at a PM site for convenience of conducting traffic counting while the PM sampler was collecting data. However, the varying criteria for site selection for PM sampling ensured a fairly good selection of roads for traffic sampling, which were also well distributed throughout the city.

2.3.2 Traffic Sampling Instrumentation

No technical instrumentation used for traffic sampling. Data collection was reliant upon a manual hand counter, including a compass to determine traffic flow direction.

2.3.3 Traffic Sampling Procedures

Traffic was counted for each vehicle class for 10 minutes for each direction of a sampled road and estimated an hourly average by multiplying values by 6; for some smaller roads all vehicles classes could be counted for both direction for 10 minutes, larger volume roads had to be divided between directions for each 10 minute counting period. Site information was noted along with the raw data collected in the field.

2.4 Satellite Mapping

Satellite data for both NO_2 and Aerosol Optical Depth (AOD) were analyzed for the purpose of mapping regional air pollution over Bangladesh. NO_2 was analyzed in particular with respect to trends in emission since 2002. The main goal in analyzing the AOD data was to obtain a regional-scale spatial overview of PM levels in the Bangladesh area and to investigate to what extent the AOD data can duplicate time series measured on the ground as part of the screening study.

2.4.1 Aerosol Optical Depth

Data from the MODIS (Moderate Resolution Imaging Spectroradiometer) instrument onboard the Terra and Aqua satellite platforms was used for mapping AOD and particulate matter concentrations. More specifically all data of the operational MODIS aerosol product (MOD04_L2) (Kaufman and Tanré, 1998; Remer et al., 2005) available during the study period was acquired from the Level

1 and Atmosphere Archive Distribution System (ladsweb.nascom.nasa.gov). Time series of AOD were obtained by extracting and averaging a 3 × 3 array of pixels over the desired location. Imagery from the MODIS sensor on Terra was obtained at around 04:30 UTC (10:30 local time) and data from Aqua was acquired at 07:30 UTC (13:30 local time). When comparing against in situ data measured during the screen study, AOD values were linearly interpolated to match the observation time of the in situ data.

2.4.2 NO_2

Tropospheric NO_2 columns between 2002 and 2011 were obtained from the SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CartograpHY) sensor onboard of Envisat (Bovensmann et al., 1999). More specifically, the data product used was acquired from www.temis.nl and consisted of monthly gridded tropospheric NO_2 columns at 0.25 degree spatial resolution. The product has been derived from SCIAMACHY spectra using the Differential Optical Absorption Spectroscopy (DOAS) (Platt and Stutz, 2008) technique in conjunction with a combined modelling and assimilation approach developed at the Royal Netherlands Meteorological Institute (KNMI). Details on the methodology and retrieval algorithm can be found in Boersma et al. (2004). Time series of NO_2 were obtained by extracting and averaging a 3 × 3 array of pixels over the desired location.

3 Sampling Sites

As previously mentioned, there were 48 unique sites for NO_2/SO_2 passive sampling (of which 20 also sampled O_3), 23 unique sites for PM active sampling, and 13 unique sites for traffic counting/sampling.

3.1 Passive Sampling

A map of the 48 passive sampling sites for NO_2 and SO_2 is in Figure 8. A map of the 20 passive sampling sites for O_3 is in Figure 9, note these are at existing sampling sites for NO_2/SO_2. Most passive samplers were set on 01 February or 02 February, and collected on 13 February or 14 February, for an average exposure of 12 days.

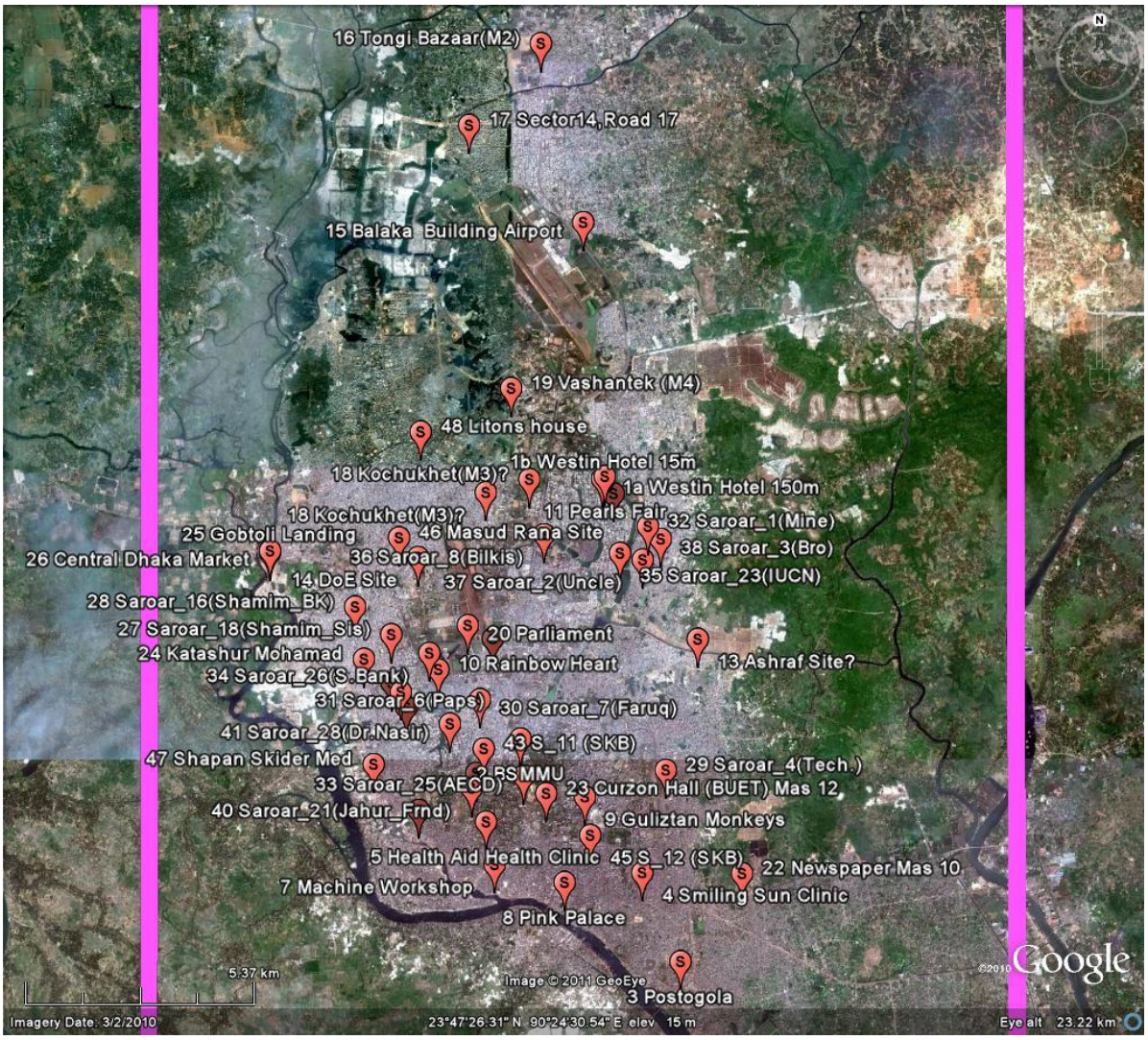

Figure 8: Location of 48 Passive Sampling Sites for SO_2 and NO_2 (Background Imagery Source: Google Earth).

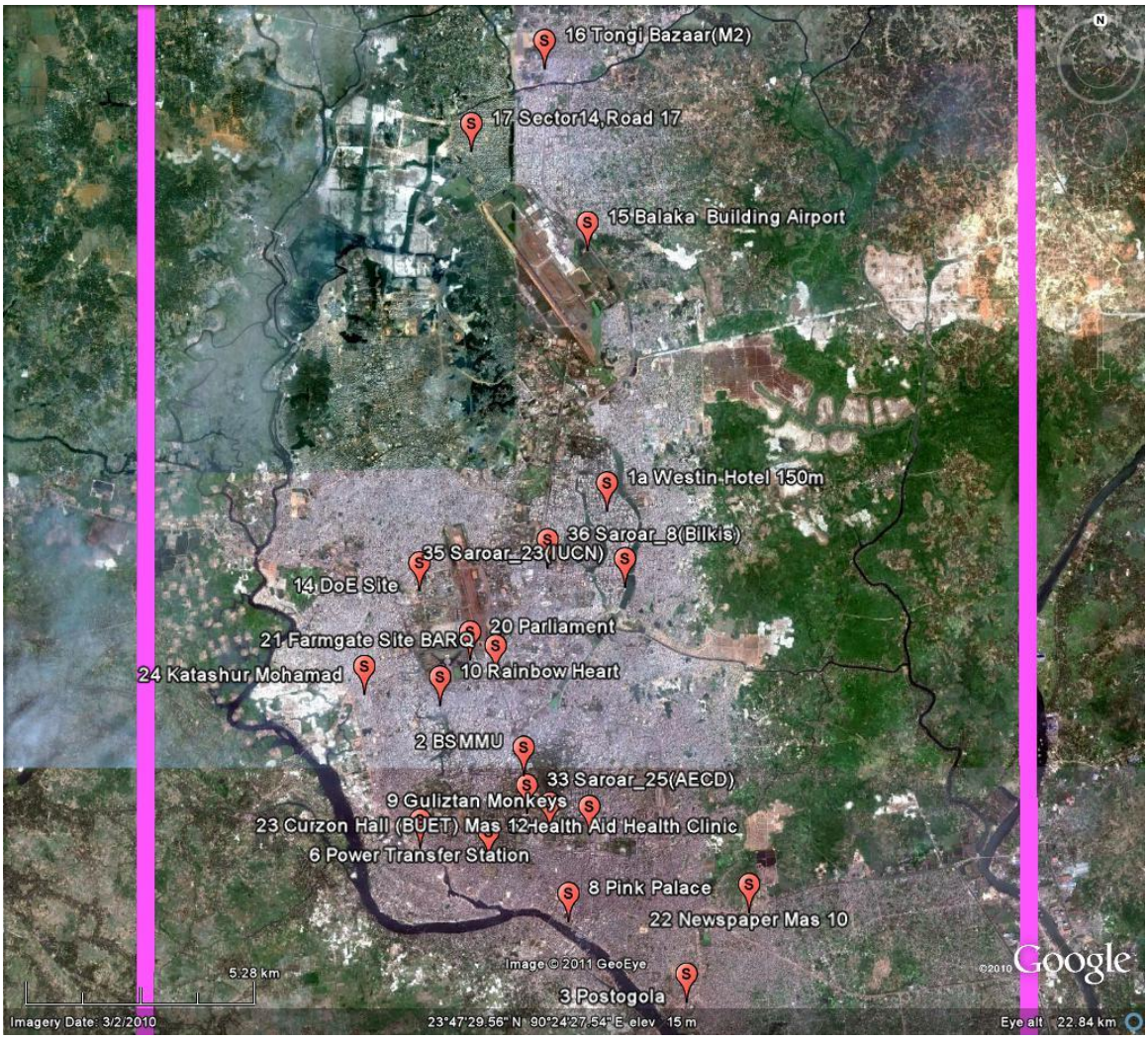

Figure 9: Location of 20 Passive Sampling Sites for O_3 (Background Imagery Source: Google Earth).

Site classification parameters used can be seen in Table 2; these classifications were developed in a previous passive sampling study for Burgas, Bulgaria (Hak, 2010). Basic information for all passive sampling sites, including classifications of each site can be seen in Table 3; this table also lists corresponding PM sampling sites and/or traffic counting sites found at each passive sampling site. Complete individual profiles for each passive sampling site can be found in Appendix D, which includes pictures and detailed maps for each site.

Table 2: Site classification parameters used for passive sampling sites.

Type of zone	Type of station	Characterisation of zone
Urban (U)	Traffic (T)	Residential (R)
Suburban (S)	Industrial (I)	Commercial (C)
Rural (R)	Background (B)	Industrial (I)
		Agricultural (A)
		Natural (N)
		Res. / Comm. (RC)
		Comm. / Ind. (CI)
		Ind. / Res. (IR)
		Res. / Comm. / Ind. (RCI)
		Agri. / Nat. (AN)

Table 3: Passive Sampling site placement information and classifications.

Site#	Description	Placement	Height	Classification	PM Site	Traffic Site
1a	Westin hotel 23rd	Balcony N.	100m	U/T/C	11A	No
1b	Westin hotel 2nd	Balcony S.	15m	U/T/C	11B	No
2	BSMMU	Guard house	3m	U/T/C	No	No
3	Postogola	Front door	3m	U/T/C	No	No
4	Smiling Sun Clinic	Up stairs	6m	U/T/C	No	No
5	Health Aid Clinic	Front door	3m	U/T/C	No	No
6	Power St. Haziabag	Inside gate	4m	S/I/I	No	No
7	Machine Workshop	Above gate	6m	U/I/I	No	No
8	Pink Palace	Left front	5m	U/B/NRC	No	No
9	Guliztan Monkies	Left up	4m	U/T/C	No	No
10	Rainbow Heart	Back camera	3m	U/T/C	No	No
11	Pearls Fair	Above door	3m	U/T/C	13	No
12	Norwegian Embassy	Lund balcony	7m	U/B/R	1C	1A
13	Ashraf - S. Banasree	Balcony	10m	R/B/R	No	No
14	DoE	At fence	4m	U/B/C	12	No
15	Balaka build Airport	Behind recept	2m	S/B	No	No
16	Tongi Bazaar	Balcony 2 fl	5m	U/T/C	No	No
17	Sector14,Road 17	Balcony 3 fl	14m	S/B/R	No	No
18	Kochukhet(M3)	Balcony gf	3m	U/T	No	No
19	Vashantek (M4)	Balcony 2 fl	12m	S/B/R	No	No
20	Parliament site	roof	6m	U/B/C	16	6
21	BARC, Farmgate	Roof 2fl	10m	U/T/C	3	3
22	Newspaper, Mas 10	Roof 2fl	3m	U/B	No	No
23	Karzon Hall, Mas12	University	8m	U/B	No	No
24	Katashur Mohamad	Private house	12m	S/B/R	No	No

Site#	Description	Placement	Height	Classification	PM Site	Traffic Site
25	Gobtoli Landing	On post	2m	S/I/I	No	No
26	Central Dh marked	On roof	8m	S/I/I	14	No
27	S-18(Shamim_Sis)	2nd floor	8m	U/R	No	No
28	S-16(Shamim)	2nd floor	6m	U/R	No	No
29	S-04(Tech)	2nd floor	8m	U/R	No	No
30	S-07(Faruq)	2nd floor	8m	U/R	No	No
31	S-06(paps)	1st floor	9m	U/R	No	No
32	S-01(Mine)	1st floor	6m	U/R	No	No
33	S-25(AECD)	1st floor	5m	U/R	No	No
34	S-26(S.Bank)	1st floor	5m	U/T	No	No
35	S-23(IUCN)	2nd floor	8m	U/R	No	No
36	S-08(Bilkis)	1st floor	6m	U/R	No	No
37	S-02(Uncle)	1st floor	5m	U/R	No	No
38	S-03(Bro)	2nd floor	8m	U/R	No	No
39	S-27(Sumon)	1st floor	6m	U/R	No	No
40	S-20 (Jahur_Frn)	2nd floor	8m	U/T	No	No
41	S-28 (Dr.Nasir)	2nd floor	8m	U/R	No	No
42	S_10(SKB)	1st floor	5m	U	No	No
43	S_11(SKB)	3rd floor	11m	U	No	No
44	S_13(SKB)	2nd floor	9m	U	No	No
45	S_12(SKB)	1st floor	5m	U	No	No
46	Masuds house			S/B/R	No	No
47	Shapan Shirdo med				No	No
48	Liton's house				No	No

3.2 PM Sampling

A map of the 23 active sampling sites for PM is in Figure 10. Passive sampling was conducted from 03 February to 15 February for 30 minutes at each site. Site 11A and 11B were collected many days during the same time period, and site 1C was a 24 hour sample.

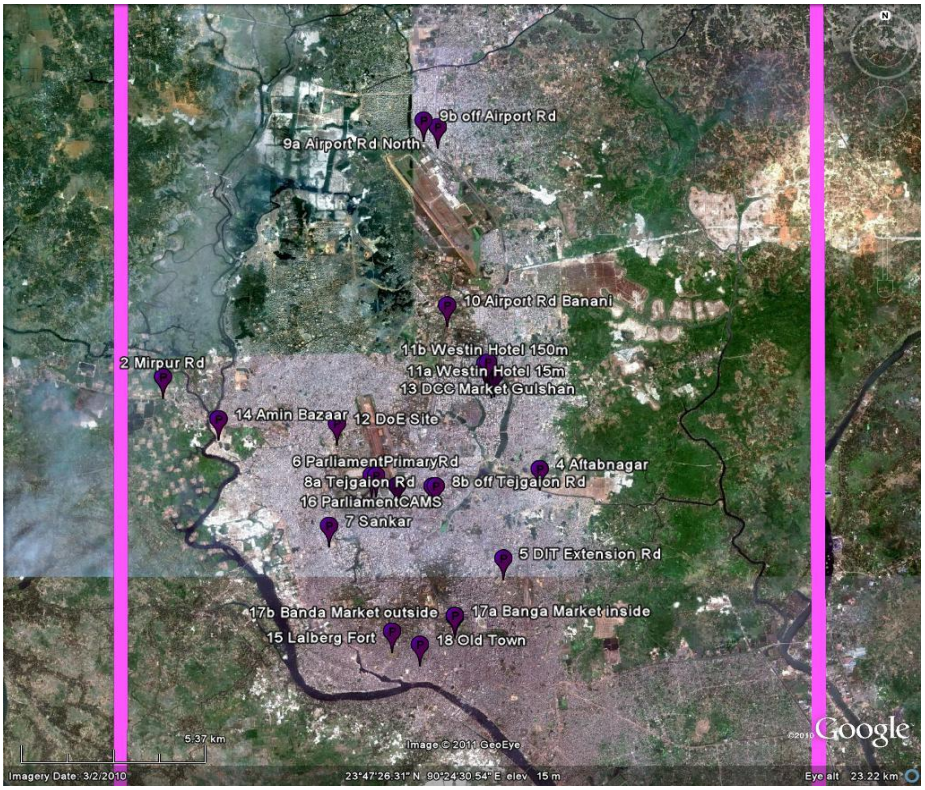

Figure 10: Location of 23 active sampling sites for PM (Background Imagery Source: Google Earth).

Site classifications for PM sampling used the same classification scheme as use for the passive sampling sites, see Table 2. Basic information for all PM sampling sites, including classifications of each site can be seen in Table 4; this table also lists corresponding passive sampling and/or traffic counting sites found at each PM sampling site. Complete individual profiles for each PM sampling site can be found in Appendix F which also includes a summary of the results (to be discussed in Section 5), where site pictures and maps can be seen in Appendix F for each associated site.

Table 4: PM sampling site placement information and classifications.

Site#	Description	Road	Classification	Traffic Site	Passive Site
1a	At Norwegian Embassy	Road 111	U/B/R	1A	No
1b	West from Norwegian Embassy	Gulshan Ave	U/T/R	1B	No
1c	At Norwegian Embassy Balcony	Road 111	U/B/R	No	12
2	Ishkabad	Mirpur road	R/T/A-I	2	No
3	Farmgate CAMS station	Airport Road	U/T/C	3	21
4	Aftabnagar	TV tower road	S/B/R	4	No
5	Paltan	DIT Extension Rd	U/T/R	5	No
6	Parliament Primary Rd	Rokeya Sarani Rd	U/T/R	6	No
7	Sankar	Satmasjid Rd	U/T/R	7	No
8a	Tejgaion	Tejgaion Rd	U/T/I	8A	No
8b	off Tejgaion	Tejgaion Rd	U/T/I	8B	No
9a	Airport Rd North	Airport Rd	U/T/R	9A	No
9b	off of Airport Rd North	Jashimuddin	U/T/R	9B	No
10	Airport Rd Banani	Airport Rd	S/T/R	10	No
11a	Westin Hotel 2nd floor	Gulshan Ave	U/T/C	No	1A
11b	Westin Hotel 23rd floor	Gulshan Ave	U/T/C	No	1B
12	DoE Office	N/A	U/B/C	No	14
13	DCC Market Gulshan-2	Gulshan Ave	U/T/C	No	11
14	Amin Bazaar	N/A	S/I/I	No	26
15	Lalberg Fort	N/A	S/B/R	No	No
16	Parliament CAMS station	N/A	U/B/C	No	20
17a	Bangla Market - inside	N/A	U/C	No	No
17b	Bangla Market - ouside	N/A	U/C	No	No
18	Old Town	N/A	U/C	No	No

3.3 Traffic Counting

A map of the 13 sampling sites for traffic counting is in Figure 11. Traffic counts were performed from 03 February through 10 February, where traffic was counted for an average of 10 minutes per direction.

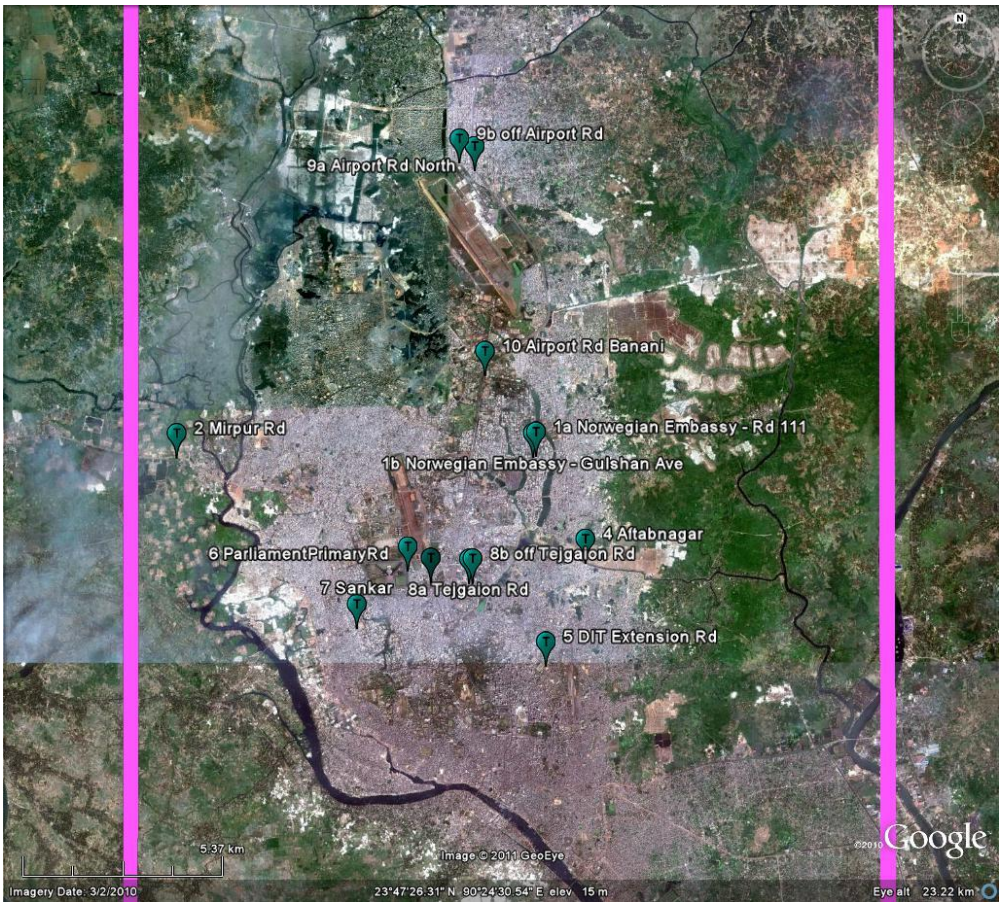

Figure 11: Location of 13 sampling sites for traffic counting (Background Imagery Source: Google Earth).

Site classifications for traffic sampling used the road type classes shown in Table 1. Basic information for all traffic sampling sites, including classifications of each site can be seen in Table 5; this table also lists corresponding PM sampling sites found at each traffic counting site. Complete individual profiles for each traffic sampling site can be found in Appendix G, which includes pictures and detailed maps for each site, as well as a summary of the results (to be discussed in Section 5).

Table 5: Traffic sampling site placement information and classifications.

Site#	Description	Road	Road type	Traffic flow	PM Site
1a	At Norwegian Embassy	Road 111 (both directions)	diffuse	very light	**1a**
1b	West from Norwegian Embassy	Gulshan Road (Northbound)	primary	very heavy	**1b**
1b	West from Norwegian Embassy	Gulshan Road (Southbound)	primary	light	**1b**
2	Ishkabad	Mirpur road (both directions)	primary	medium	**2**
3	Farmgate CAMS station	Airport Road (Northbound)	primary	light	**3**
3	Farmgate CAMS station	Airport Road (Southbound)	primary	medium	**3**
3	Farmgate CAMS station	Airport Road (Southbound)	primary	medium	**3**
4	Aftabnagar	TV tower road (both directions)	diffuse	light	**4**
4	Aftabnagar	TV tower road (both directions)	diffuse	light	**4**
5	Paltan	DIT Extension Rd (Southbound)	primary	medium	**5**
5	Paltan	DIT Extension Rd (Southbound)	primary	medium	**5**
5	Paltan	DIT Extension Rd (Northbound)	primary	medium	**5**
6	Parliament Primary Rd	Rokeya Sarani Rd (Northbound)	primary	medium	**6**
6	Parliament Primary Rd	Rokeya Sarani Rd (southbound)	primary	medium	**6**
7	Sankar	Satmasjid Rd (Southbound)	primary	medium	**7**
7	Sankar	Satmasjid Rd (Northbound)	primary	medium	**7**
8a	Tejgaion	Tejgaion Rd (Southbound)	primary	medium	**8a**
8a	Tejgaion	Tejgaion Rd (Northbound)	primary	medium	**8a**
8b	off Tejgaion	Tejgaion Rd (both directions)	diffuse (industrial)	light	**8b**
9a	Airport Rd North	Airport Rd (Northbound)	primary	light	**9a**
9a	Airport Rd North	Airport Rd (Southbound)	primary	light	**9a**
9b	off of Airport Rd North	Jashimuddin (Westbound)	secondary	very light	**9b**
9b	off of Airport Rd North	Jashimuddin (Eastbound)	secondary	very light	**9b**
10	Airport Rd Banani	Airport Rd (Southbound)	primary	medium	**10**
10	Airport Rd Banani	Airport Rd (Northbound)	primary	medium	**10**

4 Limit Values

National Ambient Air Quality Standards (NAAQS) were updated for Bangladesh in 2005 through the national *S.R.O. No 220-Law*. The standards set for PM (PM_{10} and $PM_{2.5}$), NO_2, SO_2, and O_3 are mostly based on the US-EPA's ambient AQ standards, where Bangladesh is the only country in South Asia which set a standard for $PM_{2.5}$ (CAI-ASIA, 2006). These standards are not as stringent as the European Union (EU) limit values or the World Health Organization (WHO) air quality guidelines (AQG), although impacts to human health are a major driving force in developing NAAQS. Adverse effects on human health (and ecosystems) occur for both short-term and long-term exposure, so different standard values are valid for different averaging periods (1 hour, 8 hours, 24 hours, 1 year, etc.).

4.1 SO_2

Sulphur dioxide (SO_2) is an air pollutant which at certain levels and durations poses a human health risk. Elevated SO_2 concentrations can affect the respiratory system, and can also be harmful to ecosystems at very high concentrations. The primary contributor of anthropogenic SO_2 is the combustion of sulphur-containing fossil-fuels (mainly coal and heavy oils used in industrial and vehicular sources).

A summary of the SO_2 standards for Bangladesh, limit values from the EU, guideline values from the WHO, and standards for the US-EPA are shown in Table 6. Annual limit values for the protection of ecosystems are also given, where these values are most relevant for more remote areas.

Table 6: Various air quality standards, limit and guideline values for SO_2.

Effect	Averaging period	Bangladesh (standards)[a]	EU (limit values)[b]	WHO (guidelines)[c]	US-EPA (standards)[d]
Health	10 min	-	-	500 µg/m^3	-
Health	1 hour	-	350 µg/m^3 (1)	-	212 µg/m^3
Health	24 hours	365 µg/m^3	125 µg/m^3 (2)	20 µg/m^3	365 µg/m^3
Health/Ecosystem	Annual	80 µg/m^3	20 µg/m^3	-	78 µg/m^3

[a]NAAQS (CAI-Asia, 2006)
[b](EU, 2008)
[c]AQG (WHO, 2005)
[d]NAAQS (US-EPA, 2010)
(1) not to be exceeded more than 24 times a calendar year
(2) not to be exceeded more than 3 times a calendar year

4.2 NO_2

Nitrogen Dioxide (NO_2) is a highly reactive gas within the nitrogen oxide (NO_X) group that has human health effects to the respiratory system, as well as ecosystem effects caused by deposition of nitrogen compounds. NO_X emissions are generated mainly from anthropogenic combustion sources such as vehicles and power plants. NO_x emissions interact with O_3 to form NO_2, and also contribute to fine particle pollution.

A summary of the NO_2 standards for Bangladesh, limit values from the EU, guideline values from the WHO, and standards for the US-EPA are shown in Table 7.

Table 7: Various air quality standards, limit and guideline values for NO_2.

Effect	Averaging period	Bangladesh (standards)[a]	EU (limit values)[b]	WHO (guidelines)[c]	US-EPA (standards)[d]
Health	1 hour	-	200 µg/m^3 (1)	200 µg/m^3	200 µg/m^3
Health	Annual	100 µg/m^3 (2)	40 µg/m^3	40 µg/m^3	100 µg/m^3

[a]NAAQS (CAI-Asia, 2006)
[b](EU, 2008)
[c]AQG (WHO, 2005)
[d]NAAQS (US-EPA, 2010)
(1) not to be exceeded more than 18 times a calendar year
(2) Limit value only available for NO_x, no specific limit value for NO_2.

4.3 O_3

Ozone (O_3) is a toxic gas and photochemical oxidant which has effects upon the ecosystem and is linked to health problems associated with the respiratory system, including rise in human inflammatory responses and decreases in lung function. O_3 is formed through the action of short wavelength solar radiation on NO_x, and in the presence of VOCs it produces even higher levels of ozone. In this regard, the primary sources of O_3 are the same as the NO_2 sources, with the addition of sunlight to produce the gas.

A summary of the O_3 standards for Bangladesh, limit values from the EU, guideline values from the WHO, and standards for the US-EPA are shown in Table 8.

Table 8: Various air quality standards, limit and guideline values for O_3.

Effect	Averaging period	Bangladesh (standards)[a]	EU (limit values)[b]	WHO (guidelines)[c]	US-EPA (standards)[d]
Health	1 hour	235 µg/m^3	180 µg/m^3	-	235 µg/m^3
Health	8 hours	157 µg/m^3	120 µg/m^3	100 µg/m^3	157 µg/m^3

[a]NAAQS (CAI-Asia, 2006)
[b](EU, 2008), (EU, 2002)
[c]AQG (WHO, 2005)
[d]NAAQS (US-EPA, 2010)

4.4 PM

Particulate Matter (PM) with diameters less than 10 µm (PM_{10}) and 2.5 µm ($PM_{2.5}$) can penetrate deep into the lungs and have adverse effects on the respiratory and cardiovascular systems, where the particular size of the PM can be related to specific health effects. The most significant sources of PM are combustion sources (residential and industrial) such as vehicles, brick kilns, power plants, outdoor burning, etc.; while natural sources such as soil/dust re-suspension and sea spray also play a part. Secondary PM formation of anthropogenic origin are formed in the atmosphere from the oxidation and subsequent reactions of SO_2, NO_2, and VOCs.

A summary of the PM standards for Bangladesh, limit values from the EU, guideline values from the WHO, and standards for the US-EPA are shown in Table 9 for PM_{10} and Table 10 for $PM_{2.5}$.

Table 9: Various air quality standards, limit and guideline values for PM_{10}.

Effect	Averaging period	Bangladesh (standards)[a]	EU (limit values)[b]	WHO (guidelines)[c]	US-EPA (standards)[d]
Health	24 hours[)]	150 µg/m^3	50 µg/m^3 [(2)]	50 µg/m^3	150 µg/m^3
Health	1 year	50 µg/m^3	40 µg/m^3	20 µg/m^3	-

[a]NAAQS (CAI-Asia, 2006)
[b](EU, 2008)
[c]AQG (WHO, 2005)
[d]NAAQS (US-EPA, 2010)
(2) not to be exceeded more than 35 times a calendar year

Table 10: Various air quality standards, limit and guideline values for $PM_{2.5}$.

Effect	Averaging period	Bangladesh (standards)[a]	EU (limit values)[b]	WHO (guidelines)[c]	US-EPA (standards)[d]
Health	24 hours	65 µg/m^3	-	25 µg/m^3	35 µg/m^3
Health	1 year	15 µg/m^3	25 µg/m^3 [(1)]	10 µg/m^3	15 µg/m^3

[a]NAAQS (CAI-Asia, 2006)
[b](EU, 2008)
[c]AQG (WHO, 2005)
[d]NAAQS (US-EPA, 2010)
(1) Currently a target value, the limit value will initiate in 2015 (EU, 2008)

5 Results

The detailed data analysis for the entire screening study examining the Passive Sampling (SO_2, NO_2, and O_3), PM sampling (PM_{10} and $PM_{2.5}$), and Traffic Counting (vehicle flows and distributions) results are examined in this section. In addition these results are compared to existing limit values, as well as results found in other screening studies of mega-cities. It should again be noted that because this data was collected during the dry winter season, the results are most likely representing the highest/maximum pollution concentrations found throughout the year due to the special meteorological conditions during this period. The database of raw data for the entire screening study can be found in Appendix G.

5.1 SO_2 Concentrations

Of the 49 SO_2 samplers placed at 48 unique sites, the average concentration values ranged from 38.0 µg/m^3 (Site 13) to 199.3 µg/m^3 (Site 1B)[1], with an average concentration of 86.9 µg/m^3 for all sites. All SO_2 results can be seen in Figure 12, and information can be found for each site in Appendix D.

[1] Note that Site 1b was set later than all other sites (07 February), thus contains a shorter exposure period than most sites, only 7 days.

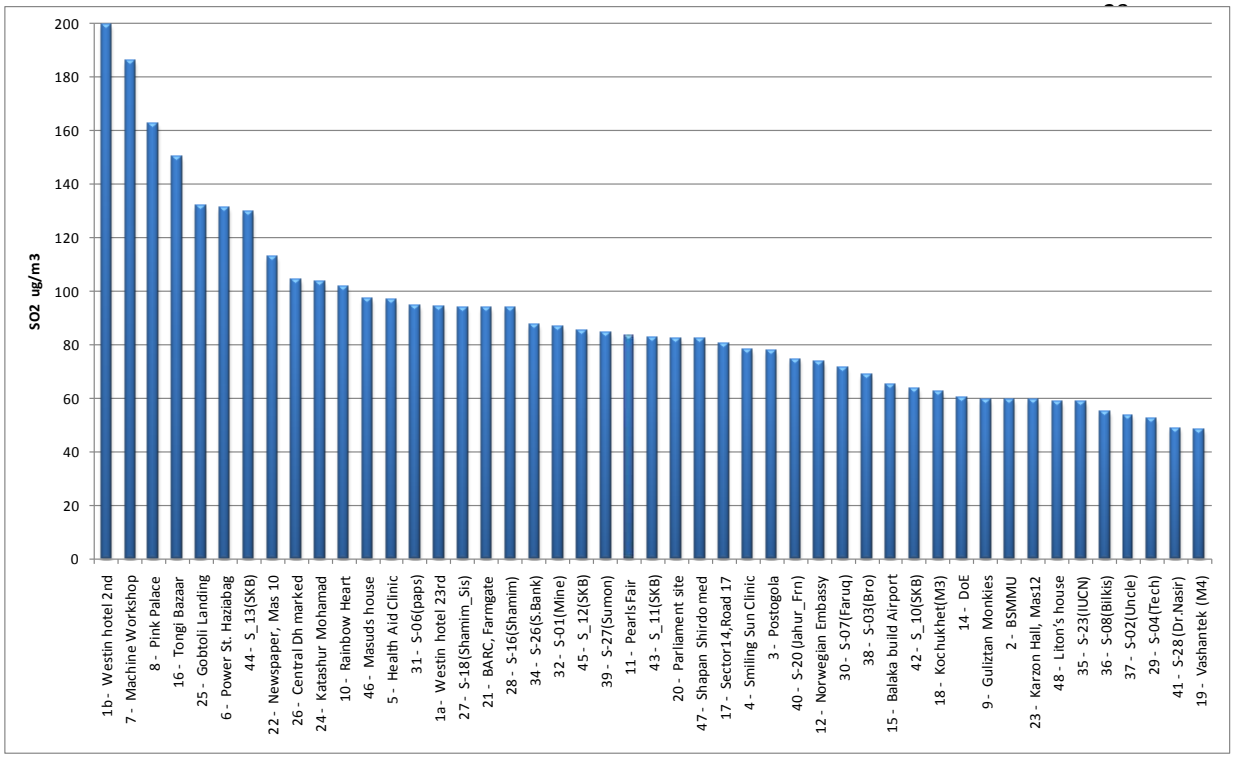

Figure 12: SO_2 concentration results, all sites (average concentrations over approximately 12 day period).

In relation to the Bangladeshi NAAQS for SO_2 concentrations, it is likely that none of the sites exceeded the standard of 365 µg/m^3 SO_2 over a 24-hour period[2]. However, all of the sites exceed the WHO AQG of 20 µg/m^3 SO_2 over a 24-hour period, and at least 7 sites exceeded the EU limit value of 120 µg/m^3 SO_2 over a 24-hour period. See Table 11 for a summary of the number of sites with average concentration above a set limit values.

Table 11: Number of sites where 12 day average SO_2 concentrations exceeded the SO_2 daily standards, limit values, and guidelines.[3].

Effect	Averaging period	Bangladesh (standards)[a]	EU (limit values)[b(1)]	WHO (guidelines)[c]	US-EPA (standards)[d]
Health	24 hours	0	7	48	0

[a]NAAQS (CAI-Asia, 2006), 365 µg/m^3
[b](EU, 2008), 125 µg/m^3
[c]AQG (WHO, 2005), 20 µg/m^3
[d]NAAQS (US-EPA, 2010), 365 µg/m^3
(1) not to be exceeded more than 3 times a calendar year

Geographical distribution of SO_2 results (Figure 13) shows that concentrations are highest in the Western and Southern zones along the Buriganga River and surrounding area, which is where much of the smaller industrial type operations are located, as well as the some of the larger brick kiln fields. Concentrations in

[2] Since the results are averaged over a 12 day period.
[3] Note that the color scheme used to display results in the limit value tables for this report is arbitrary and does not reflect the AQI color scheme for Bangladesh.

the Northern and Central zones are on average 15-20% less than the Western and Southern Zones, and concentrations in the Eastern Zone are approximately 30% less.

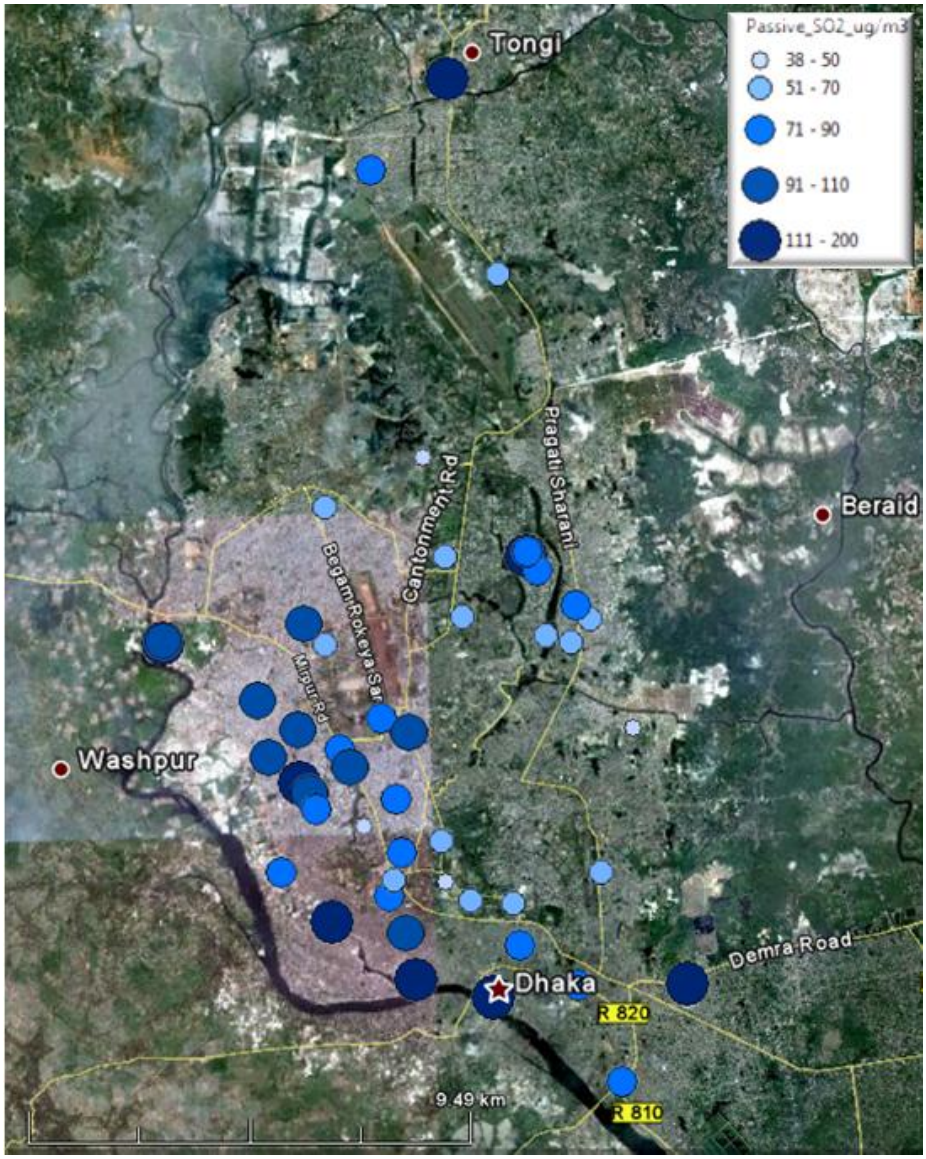

Figure 13: Geographical distribution of SO_2 results.

The SO_2 results are broken down into average concentrations for each general site classification sector (Figure 14). These general station classification sectors are derived from specific site classifications found in Table 3 and explained in Table 2. As expected for SO_2, industrial sites have higher average concentrations than the other sectors, while residential sites have the lowest average concentrations (even lower that background sites[4]).

[4] Background Site 8 had a very high concentration most likely due to small industrial activity in the immediate area, disregarding Site 8 the average background site concentration would be 75 µg/m^3.

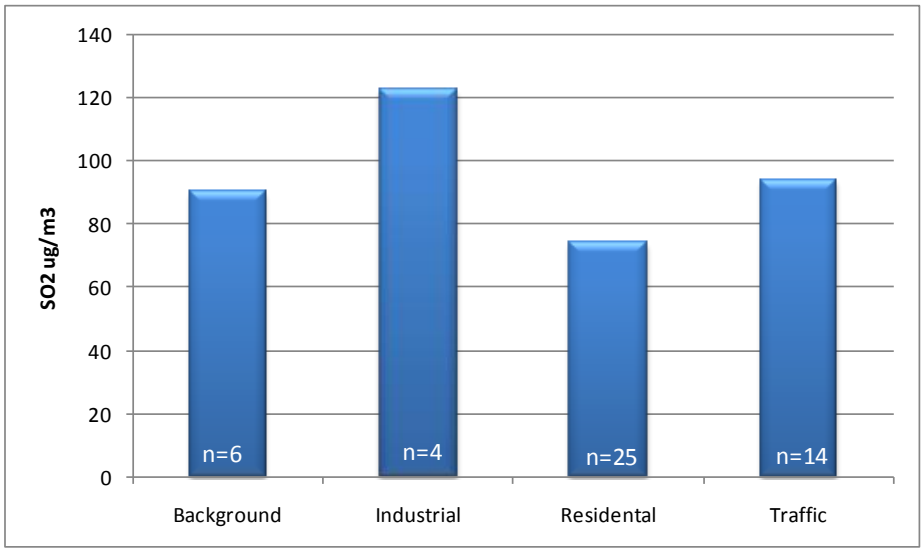

Figure 14: SO_2 concentration averages for general site classification sectors.

The typical average SO_2 concentrations measured in cities such as Cairo and Ho Chi Minh City (HCMC) are on average noticeably less than those values found in Dhaka. Annual average concentrations in the Cairo and HCMC ranged typically between 20 and 100 µg/m^3 (Sivertsen et al., 2001b, 2004, 2008).

5.2 NO_2 Concentrations

Of the 47 NO_2 samplers placed at 47 unique sites, the NO_2 average concentration values ranged from 35.6 µg/m^3 (Site 47) to 161.3 µg/m^3 (Site 18), with an average concentration of 83.6 µg/m^3 for all sites. All NO_2 results can be seen in Figure 15, and detailed information can be found for each site in Appendix D.

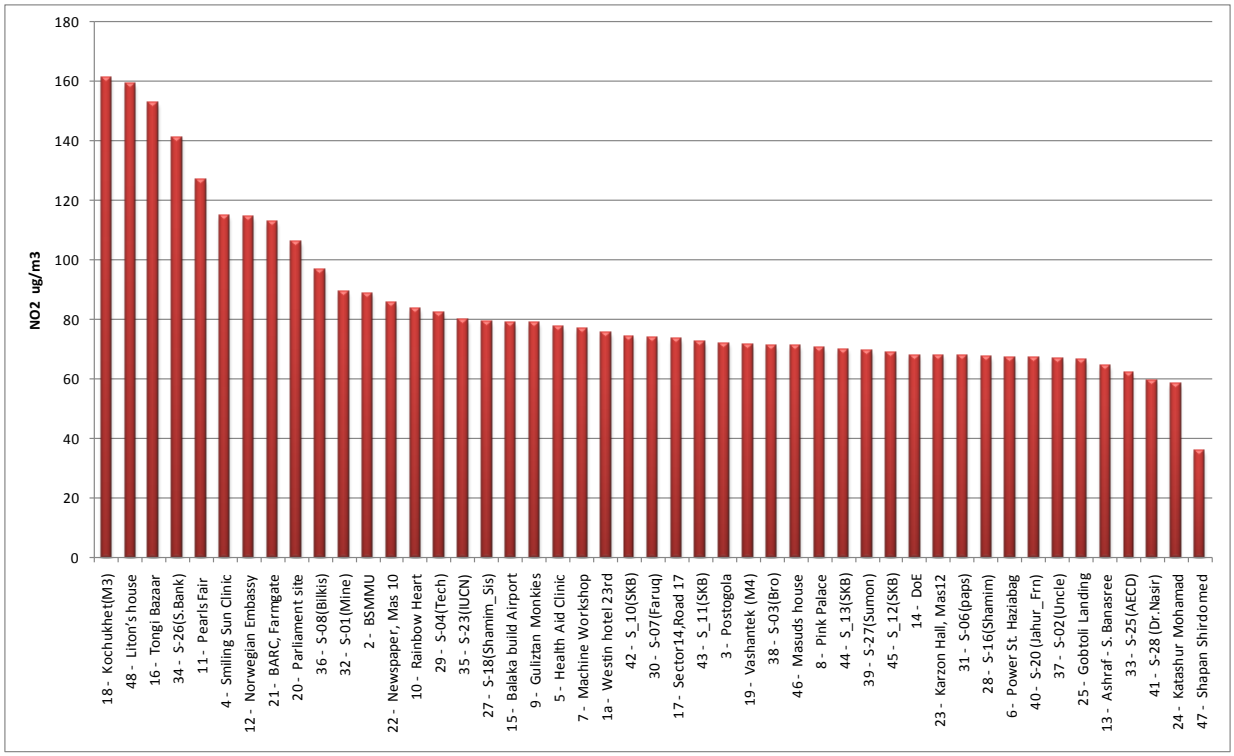

Figure 15: NO_2 concentration results, all sites (average concentrations over approximately 12 day period).

In relation to the Bangladeshi NAAQS for annual NO_2 concentrations, 9 of the 47 sites are likely to exceed the standard of 100 µg/m^3 NO_2 average over an annual period[5]; and all of the sites (except Site 47) are likely to exceed the EU limit value and WHO guidelines of 40 µg/m^3 NO_2 over an annual period. Table 12 shows the number of sites where the 12 day average concentrations indicated that exceeding of limit values may have occurred. However, it has to be stated that there is probably a strong seasonal variation in average concentrations, so the comparisons to annual average standard or limit values are not straight forward.

Table 12: Number of sites where the 12 day average NO_2 concentrations are likely to have exceeded annual average NO_2 standards, limit values, and guidelines.

Effect	Averaging period	Bangladesh (standards)[a]	EU (limit values)[b]	WHO (guidelines)[c]	US-EPA (standards)[d]
Health	Annual	9	46	46	9

[a]NAAQS (CAI-Asia, 2006), 100 µg/m^3
[b](EU, 2008), 40 µg/m^3
[c]AQG (WHO, 2005), 40 µg/m^3
[d]NAAQS (US-EPA, 2010), 100 µg/m^3

The geographical distribution of NO_2 results (Figure 16) shows that concentrations are in general highest in the Northern Zone, with high concentrations also in the Central and Southern Zone, while concentrations in the Western Zone are

[5] The annual standards and guidelines were the closest limits to be used for this comparison.

approximately 30% less. Concentrations in the Eastern Zone are slightly less than the Central/Southern zones.

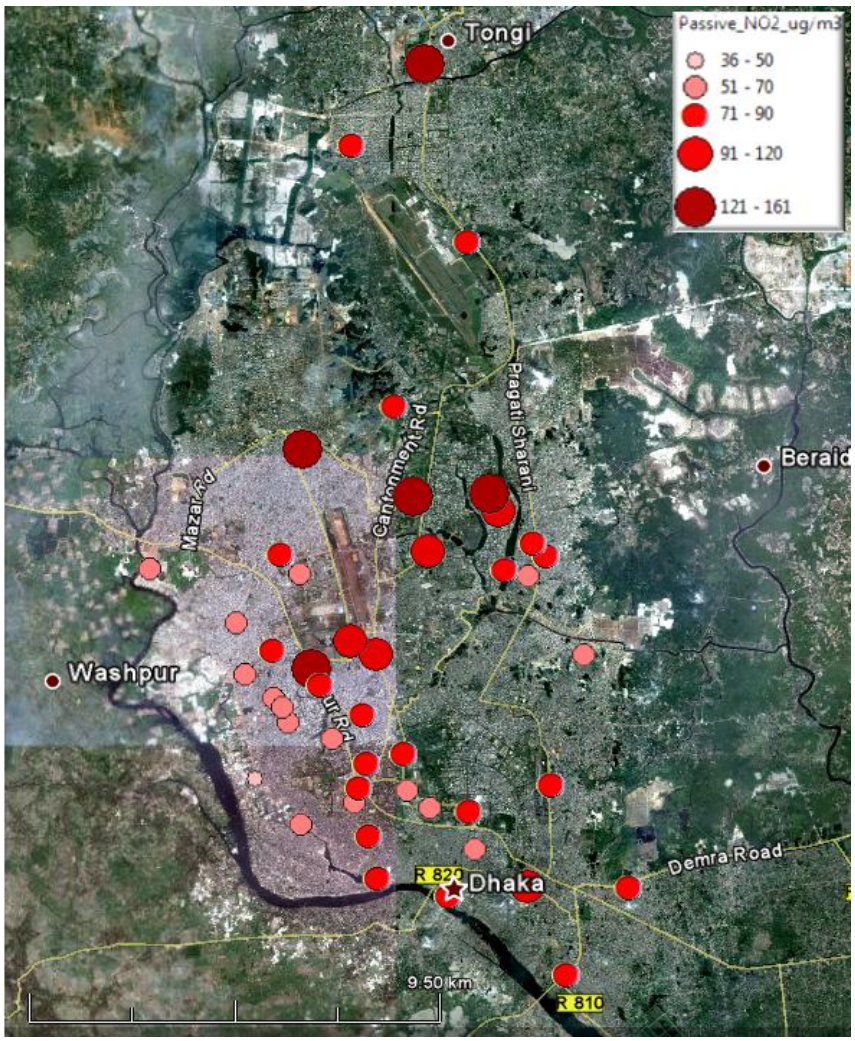

Figure 16: Geographical distribution of NO_2 measured concentrations (µg/m^3) over approximately 12 day periods.

The NO_2 results are broken down into average concentrations for each general site classifications (Figure 17). These general classifications of sites are derived from specific site classifications found in Table 3 and explained in Table 2. As expected for NO_2 traffic sites have higher average concentrations than other site types, while industrial sites have the lowest average concentrations.

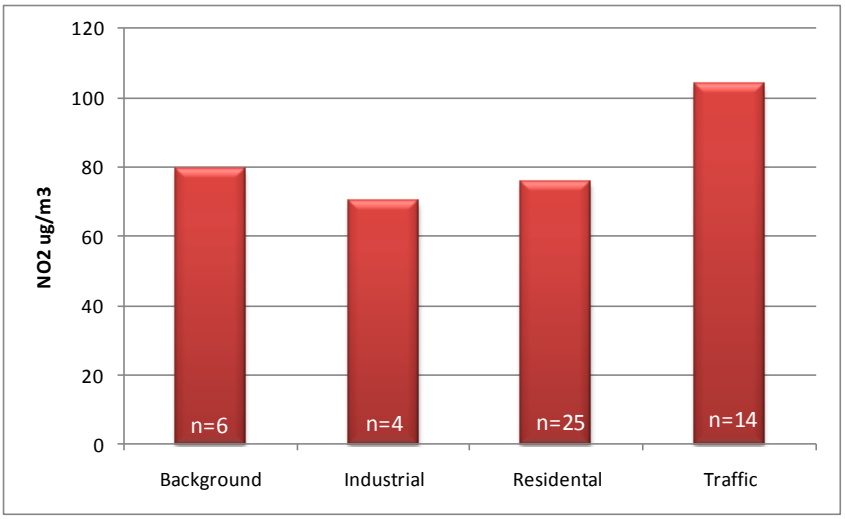

Figure 17: NO_2 concentration averages for general site classification areas.

The NO_2 concentrations measured in Dhaka were generally higher than those measured in cities like Cairo and HCMC. NO_2 concentrations in the narrow urban areas of Cairo varied between 40 µg/m3 (at night) to 100 µg/m3 (during daytime). In HCMC the annual average NO_2 concentrations were between 20 and 40 µg/m3 (Sivertsen et al., 2001b, 2004, 2008).

5.3 O_3 Concentrations

Of the 19 O_3 samplers placed, the O_3 average concentration values ranged from 18 µg/m^3 (Site 3) to 62 µg/m^3 (Site 1A), with an average concentration of 47 µg/m^3 for all sites. All O_3 results can be seen in Figure 18, and detailed information can be found for each site in Appendix D.

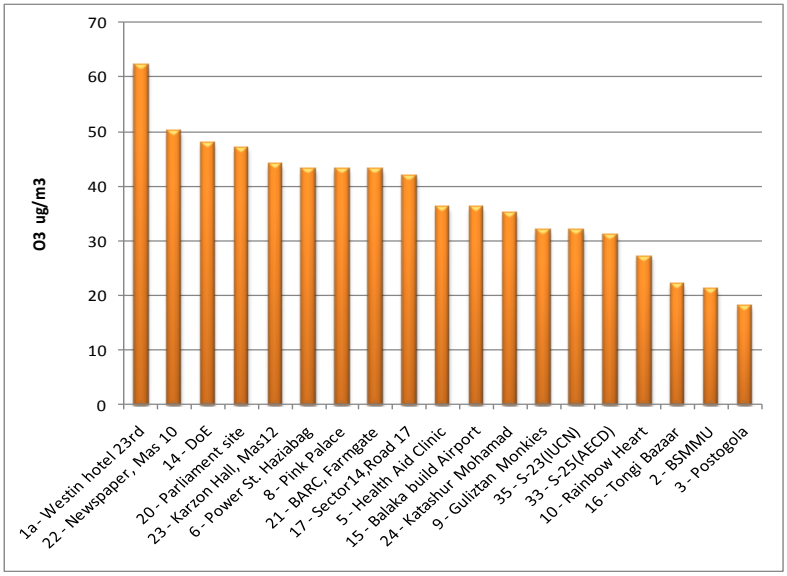

Figure 18: O_3 concentration results, all sites (average concentrations over approximately 12 day period).

In relation to the Bangladeshi NAAQS for O_3 concentrations, it cannot be definitively ascertained if the sites exceeded the standards and guidelines due to the strong diurnal nature of O_3 formation. The 12 day integrated average ozone concentrations cannot be used to conclude relative to limit values.

The geographical distribution of O_3 results (Figure 19) shows that concentrations are sporadically distributed with no clear spatial variations, however there are slightly higher concentrations in the more densely populated Central and Southern zones as expected.

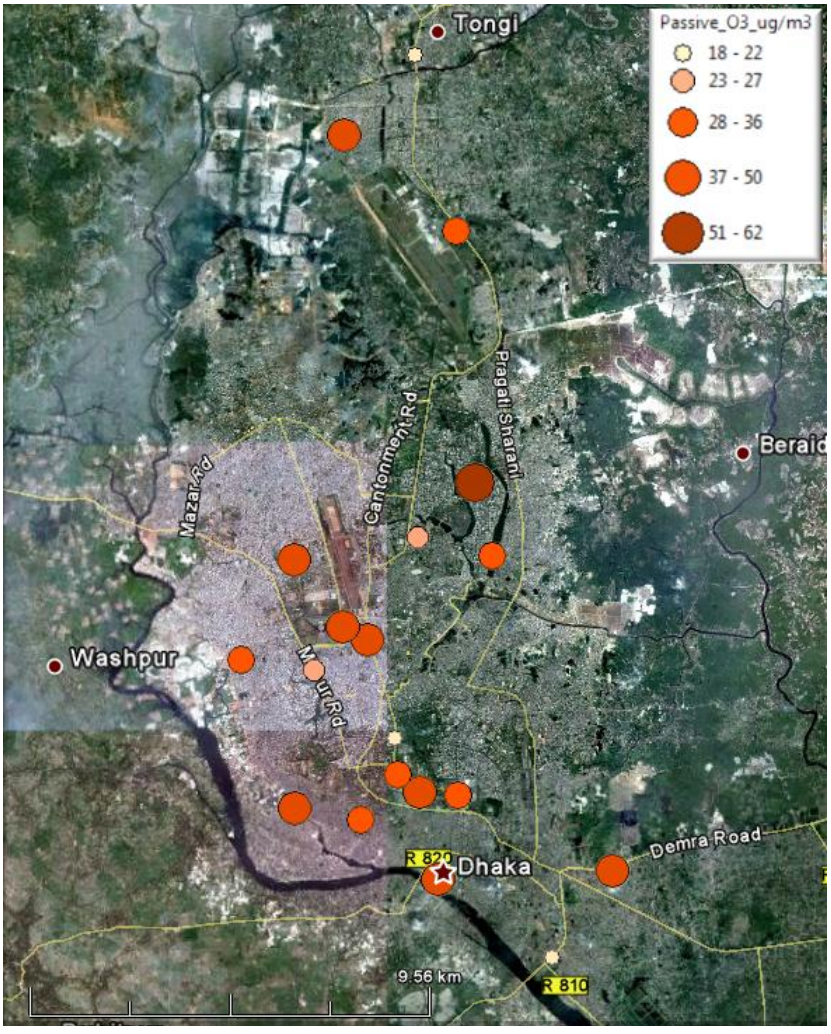

Figure 19: Geographical distribution of the measured 12 day average O_3 concentrtaions.

The O_3 results are broken down into average concentrations for each general site classification (Figure 20). These general station classification are derived from specific site classifications found in Table 3 and explained in Table 2. As expected for O_3, the background sites have higher average concentrations than other sites, while the traffic sites have the lowest average concentrations.

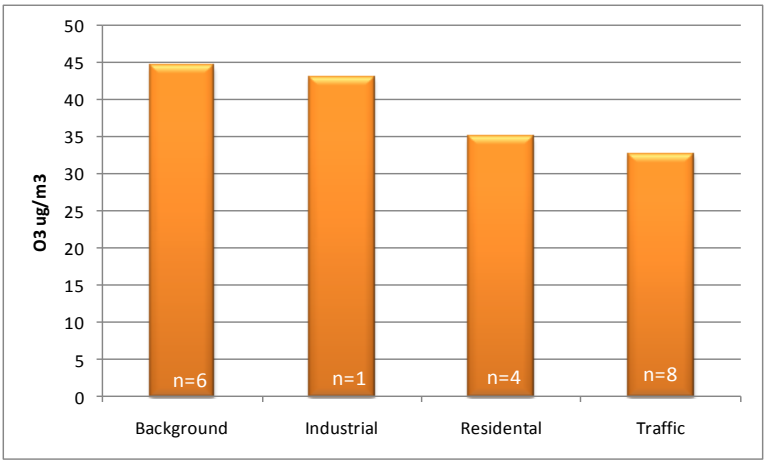

Figure 20: O_3 concentration averages for general classification of sites.

The average O_3 concentrations measured in Dhaka during the sampling period is similar or less than what was measured in HCMC during the dry season there (January). The average ozone concentrations in HCMC was typically around 60 µg/m^3 in the dry season, the average daytime ozone concentration was 150 µg/m^3. We had 3% exceeding of air quality limit values for ozone in HCMC (Sivertsen et al., 2001b, 2004, 2008).

Comparing O_3 results to NO_2 results (Figure 21), it is faintly visible that some sites with lower NO_2 values had higher O_3 values, while sites with higher O_3 values had lower NO_2 values.

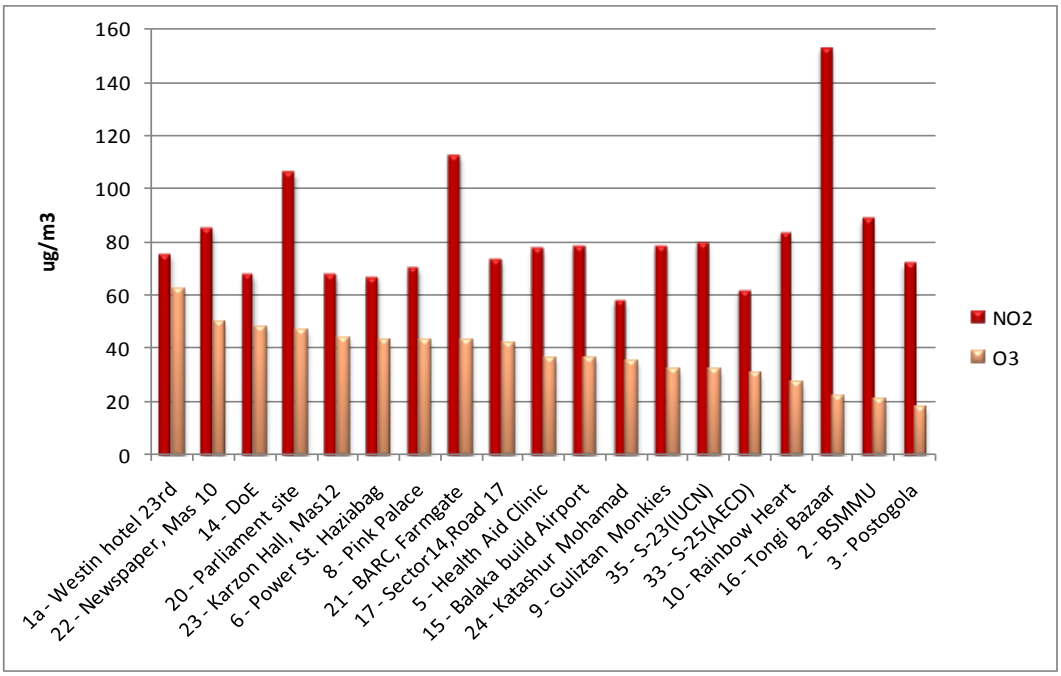

Figure 21: Comparison of sites for O_3 and NO_2 concentrations.

The overall geographical distribution of all passive sampling results can be seen in Figure 22. The map on the left shows sites where O_3 concentrations were collected, the map to the right shows all sites where NO_2 and SO_2 were collected. (Concentrations of SO_2 and NO_2 are also shown on the O_3 map for comparison).

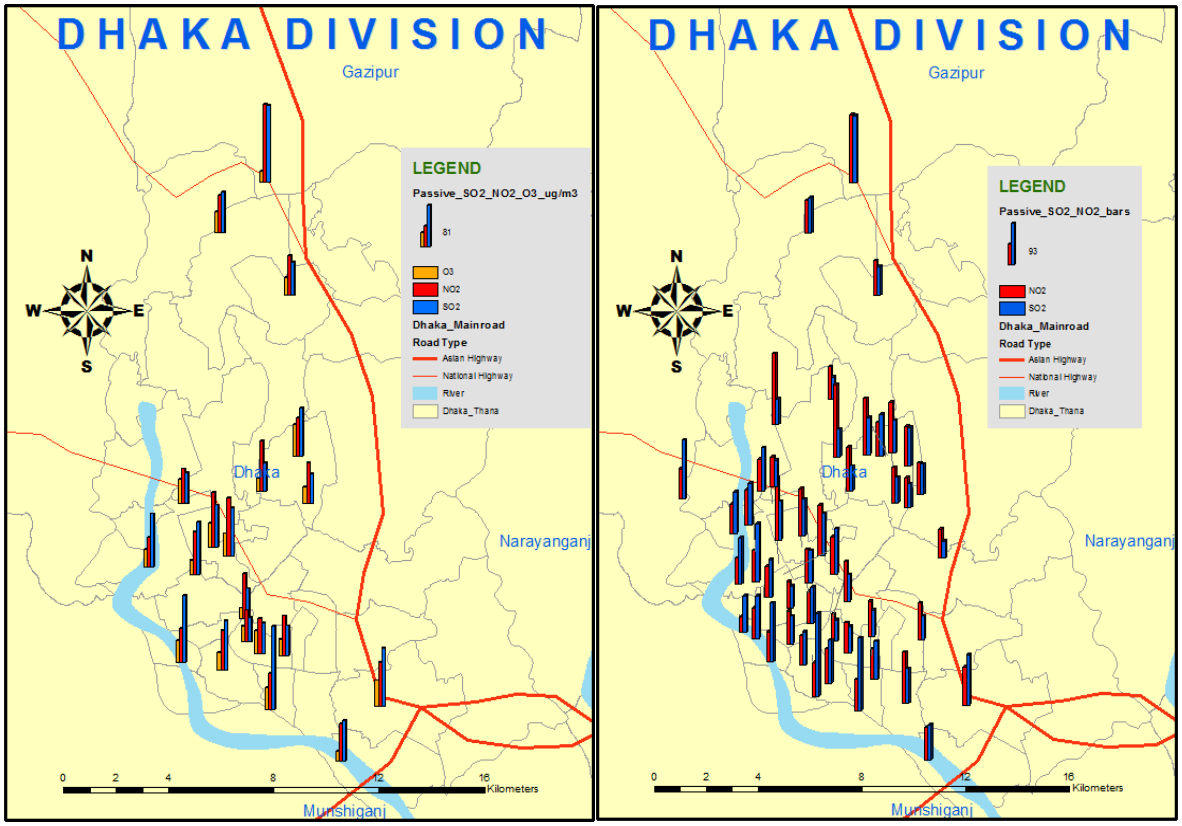

Figure 22: Geographical distribution of all passive sampling sites; to the left the ozone sampling sites, to the right all sampling sites. The length of bars indicate concentration levels.

5.4 PM concentrations

Of the 23 PM_{10} grab samples taken the average 30-minute concentration values ranged from 258 µg/m^3 (Site 9a) to 2039 µg/m^3 (Site 18), with an average concentration of 613 µg/m^3 for all sites[6]. Of the 23 $PM_{2.5}$ grab samples taken the average 30-minute concentration values ranged from 216 µg/m^3 (Site 9a) to 1131 µg/m^3 (Site 18), with an average concentration of 439 µg/m^3 for all sites. All PM results can be seen in Figure 23, and detailed information can be found for each site in Appendix E.

[6] All samples for the Westin Hotel sites are averaged to one value for this comparison.

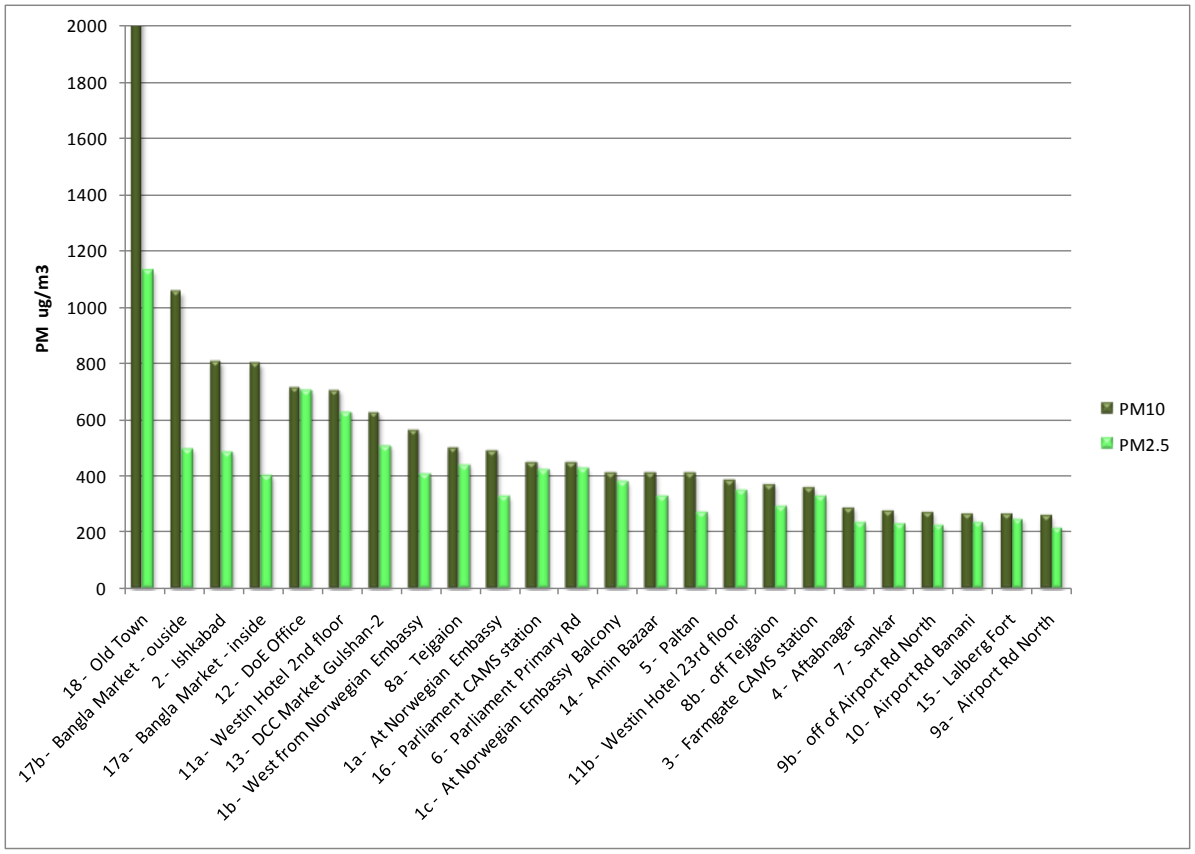

Figure 23: PM concentration results (30 minute averages) collected at 23 sites in Dhaka.

In relation to the Bangladeshi NAAQS for PM_{10} concentrations, all of the 23 sites exceeded the standard of 150 µg/m^3 PM_{10} over a 24-hour period[7]; and all of the sites also are very likely to have exceeded the EU limit value and WHO guidelines of 50 µg/m^3 PM_{10} over a 24-hour period. In relation to the Bangladeshi NAAQS for annual $PM_{2.5}$ concentrations, all of the 23 sites very likely exceeded the standard of 65 µg/m^3 $PM_{2.5}$ over a 24-hour period[8]; and all of the sites also exceeded the WHO guidelines of 25 µg/m^3 $PM_{2.5}$ over a 24-hour period. Table 13 and Table 14 presents in summary of the number of sites where the short term (30 min. average) PM concentrations measured most likely would have exceeded the concentrations given by the 24 h average limit values for PM_{10} and $PM_{2.5}$ respectively.

Table 13: Number of sites (out of 23) where the short term (30 min. average) PM concentrations measured exceeded the 24 h average PM_{10} standards, limit values, and guidelines.

Effect	Averaging period	Bangladesh (standards)[a]	EU (limit values)[b]	WHO (guidelines)[c]	US-EPA (standards)[d]
Health	24 hours	23	23	23	23

[a]NAAQS (CAI-Asia, 2006), 150 µg/m^3
[b](EU, 2008), 50 µg/m^3
[c]AQG (WHO, 2005), 50 µg/m^3
[d]NAAQS (US-EPA, 2010), 150 µg/m^3

[7] The 24-hour standards and guidelines were the closest limits to be used for this comparison.
[8] The 24 hour standards and guidelines were the closest limits to be used for this comparison.

Table 14: Number of sites where the 30 min. average PM concentrations measured exceeded the values given in the 24 h average $PM_{2.5}$ standards, limit values, and guidelines.

Effect	Averaging period	Bangladesh (standards)[a]	EU (limit values)[b]	WHO (guidelines)[c]	US-EPA (standards)[d]
Health	24 hours	23	-	23	23

[a]NAAQS (CAI-Asia, 2006), 65 µg/m^3
[b](EU, 2008), no 24-hour limit value set.
[c]AQG (WHO, 2005), 25 µg/m^3
[d]NAAQS (US-EPA, 2010), 35 µg/m^3

There are no characteristic spatial distribution associated with the geographical distribution of PM results (Figure 24), since much of these results are strongly dependant on the day (or time of day) the sample was taken. However, the PM value levels were slightly dependent upon the type of micro environment (site classification type as presented in Figure 32).

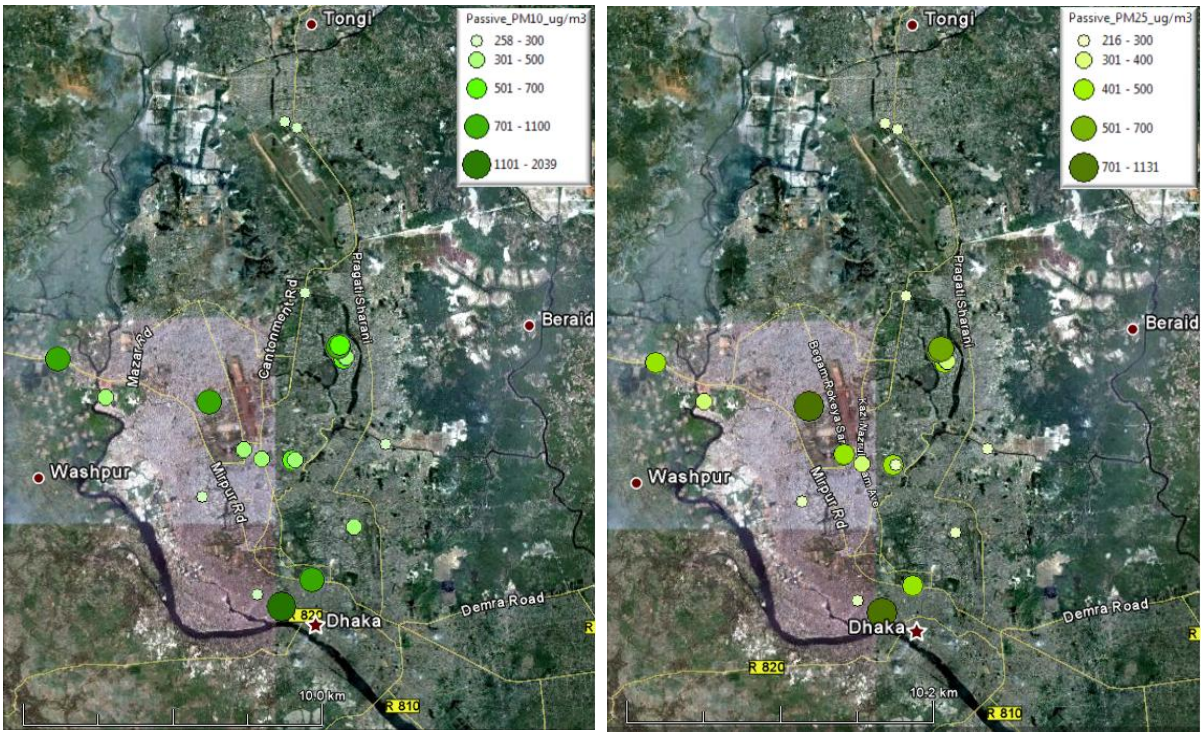

Figure 24: Geographical distribution of PM_{10} and $PM_{2.5}$ results.

The $PM_{2.5}/PM_{10}$ ratio of the concentrations for the samples ranges from 0.47 (Site 17B) to 0.99 (Site 12) respectively, and the average for all sites[9] is 0.8. Figure 25 displays the PM ratios for all sites showing that for most sites the majority of the PM is $PM_{2.5}$ fraction and smaller. This indicates that during winter season PM levels in the atmospheric air are dominated by $PM_{2.5}$ fraction and smaller, and combustion sources are major contributor to the particulate air pollution in Dhaka city.

[9] All samples for the Site 1A are averaged to one value for this comparison.

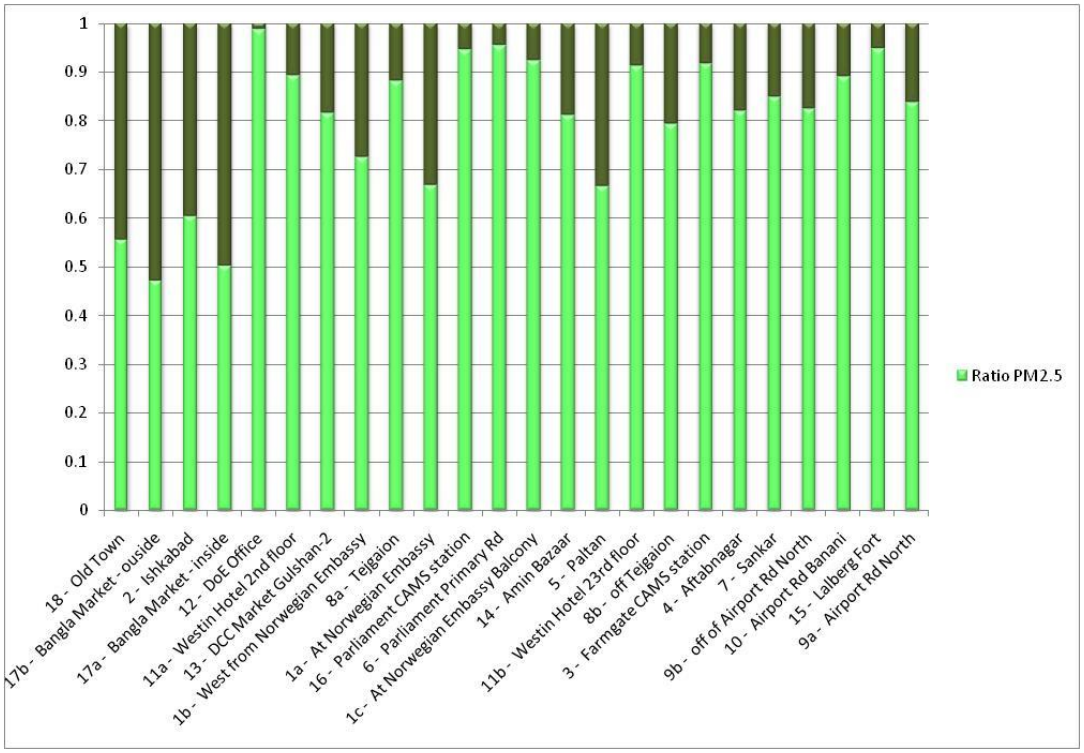

Figure 25: The $PM_{2.5}/PM_{10}$ ratios (green bars) estimated for all sites.

PM measurements were also collected from a single site (Site 11A) on a near daily basis, at a similar point in time for each sample, totaling 15 samples during the period of the Screening Study. The average PM_{10} concentration at Site 11A for the entire period was 705 µg/m^3, and 629 µg/m^3 for $PM_{2.5}$. The results from this daily 30-minute PM sampling at Site 11A can be seen in Figure 26. It should be noted that during sampling on 04 February there was a small fire approximately 100m upwind of the sampling location, and on 07 February there was general workers strike (*hartal*) for the whole city of Dhaka.

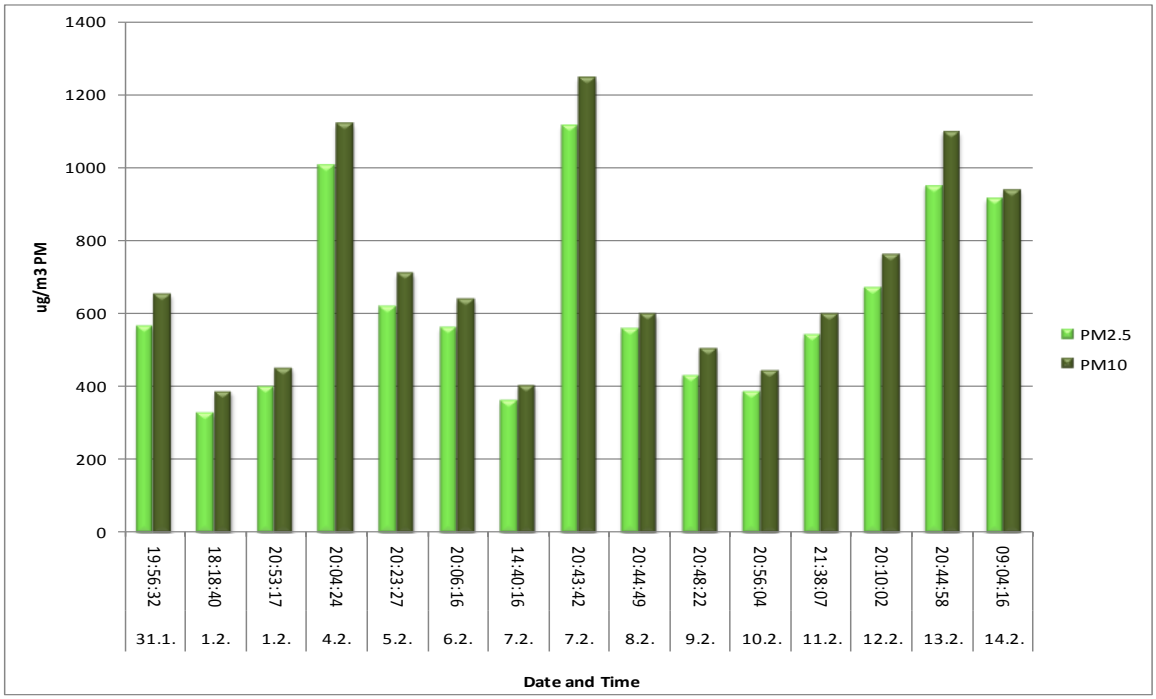

Figure 26: Daily 30-minute PM samples at Site 11A from 31 January – 14 February.

The $PM_{2.5}/PM_{10}$ average ratio of concentrations for Site 11A is 0.89 Figure 27 displays the PM ratios for all sites showing that for most sites the majority of the PM is $PM_{2.5}$ fraction and smaller, at a greater ratio of $PM_{2.5}$ than most other sites samples.

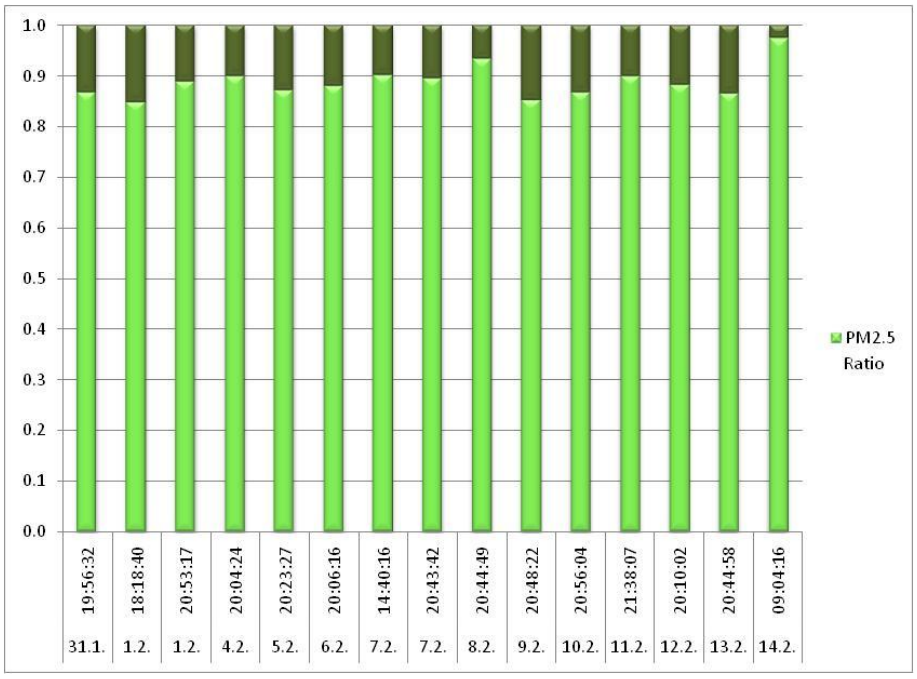

Figure 27: $PM_{2.5}/PM_{10}$ ratios (green bars) for Site 11A.

In addition to near daily 30 min average measurements collected at Site 11A, periodic measurements were also collected at Site 11B (100m directly vertical over Site 11A), totaling 4 measurements during the Screening Study. Site 11B measurements were taken within the same hour that some Site 11A measurements were taken. The average PM_{10} concentration at Site 11B was 384 µg/m^3, and 350 µg/m^3 for $PM_{2.5}$. The results from these periodic 30-minute PM samples at Site 11B can be seen in Figure 28. The $PM_{2.5}/PM_{10}$ average ratio of concentrations for Site 11B is 0.93, which was even larger $PM_{2.5}$ ratio than Site 11A.

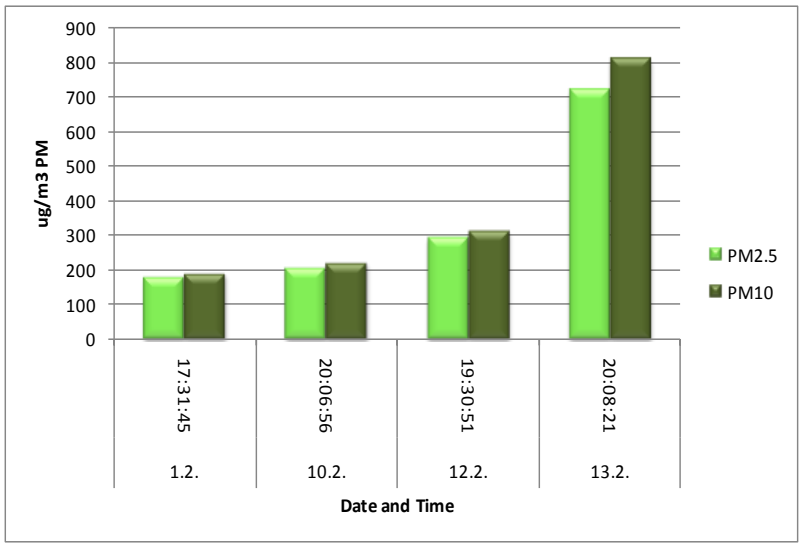

Figure 28: Periodic 30-minute PM samples at Site 11B from 01 February – 13 February.

Comparing $PM_{2.5}$ and PM_{10} taken within the same hour at Site 11A and Site 11B shows that there is approximately 50% greater PM concentration at the ground level (Site 11A) in comparison to 100 m up (Site 11B), see Figure 29 and Figure 30.

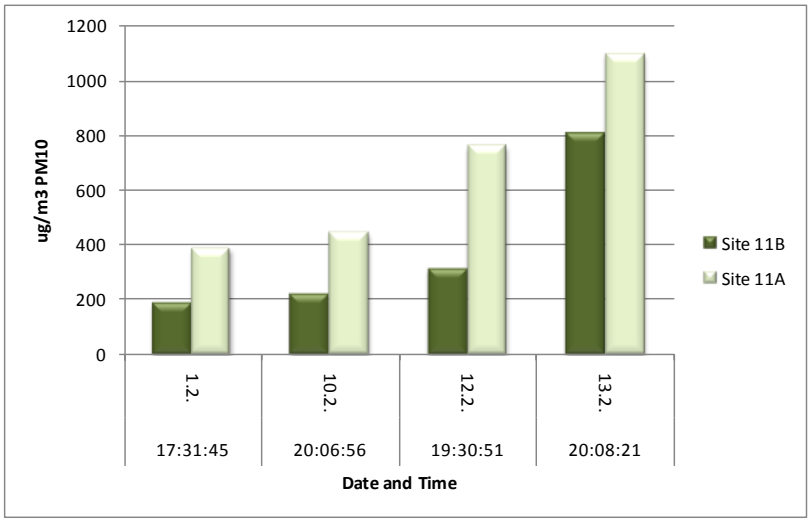

Figure 29: PM_{10} Site 11A and Site 11B Comparison.

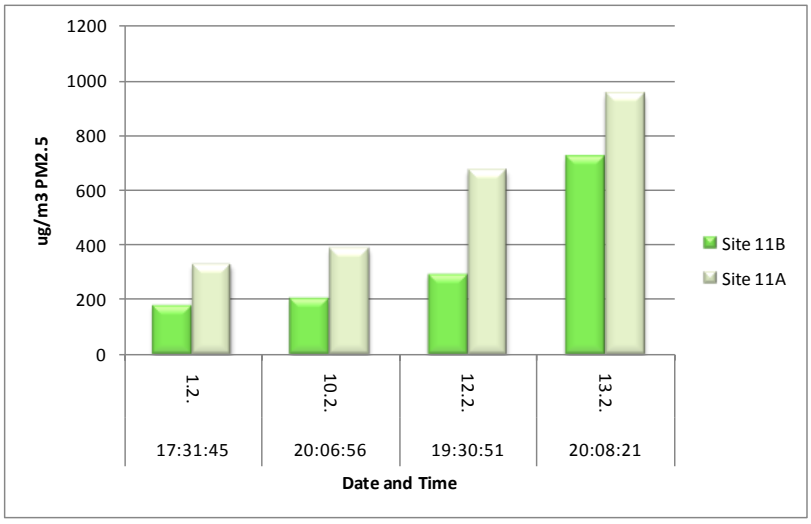

Figure 30: $PM_{2.5}$ Site 11A and Site 11B Comparison.

Continuopus sampling of $PM_{2.5}$ and PM_{10} was undertaken during 24-hours [10] at Site 1C from the afternoon of 14 February to the afternoon of 15 February. The average PM_{10} concentration for the entire period was 413 µg/m^3, and 381 µg/m^3 for $PM_{2.5}$. The results from this 24-hour PM sample at Site 1C can be seen in Figure 31. The $PM_{2.5}/PM_{10}$ average ratio of concentrations for Site 11B is 0,92. It should be noted that during the morning of 14 February there was a visible amount of smog in the area of the site, while later on 15 February it was visibly much clearer. Recent gravimetric PM monitoring data collected using Dichotomous sampler at BARC, Farmgate (Site 3) in December 2010 shows 24 hour average PM_{10} and $PM_{2.5}$ concentrations could reach as high as 289 µg/m^3 and 173 µg/m^3 respectively.

[10] Sampling interval of 10 seconds (not averaged).

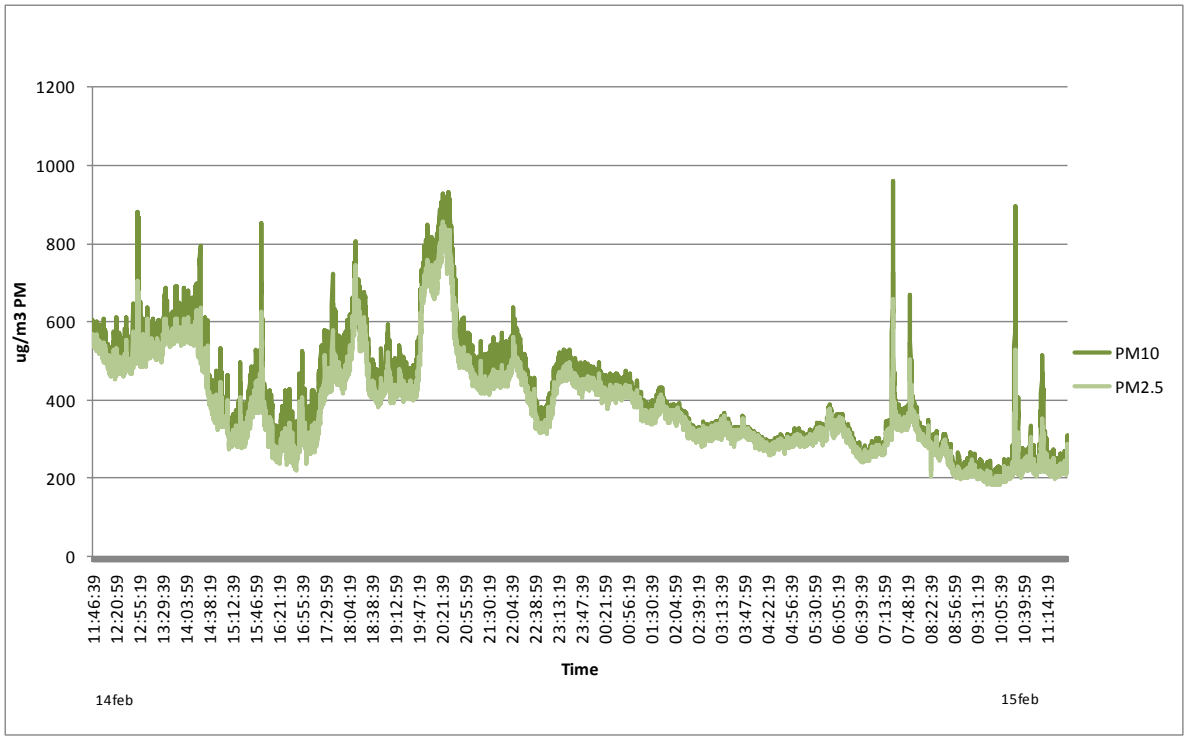

Figure 31: Continuous measurements of PM_{10} and $PM_{2.5}$ sampled at Site 1C during a 24 hour period from 14 February to 15 February 2011.

The PM results are broken down into average concentrations for each general site classifications (Figure 32). These general site station classifications are derived from Table 3 and explained in Table 2, with the addition of the "Market" This specific site name was used to describe the four sites collected in highly populated commercial market areas which were semi-enclosed or in street canyons. Except for the "Traffic" sites, there were not enough samples collected for the other type of sites to make any concrete analysis. However, at the limited market sites extremely high concentrations of PM were measured; with almost 50 % of these particles being in the larger size range (PM_{10}.- $PM_{2.5}$).

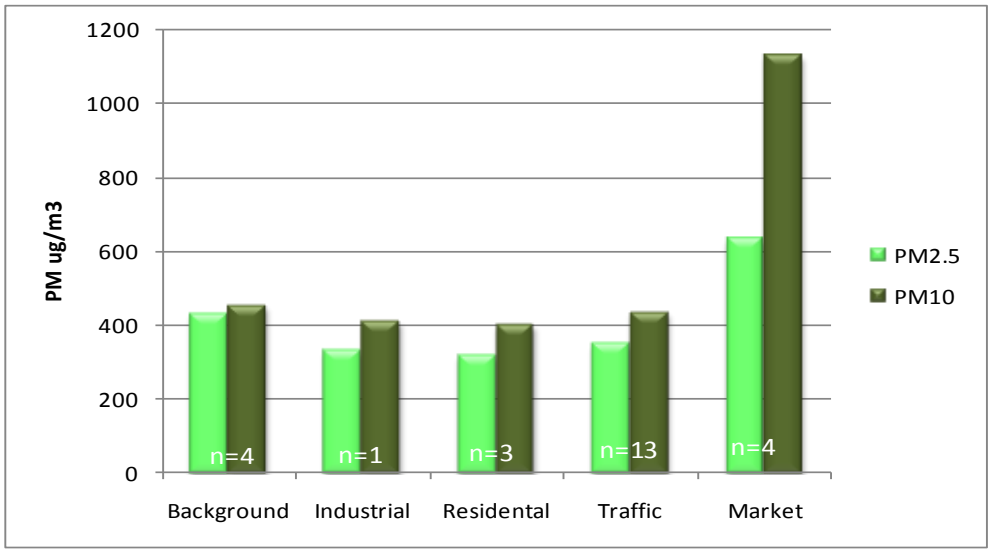

Figure 32: PM10 and PM2.5 concentration averages for general site classification sectors.

PM_{10} concentrations measured in HCMC was typically between 50 and 120 µg/m^3. In the city of Cairo PM_{10} concentrations ranged from 50 to 400 µg/m^3 as monthly and annual average concentrations. The average PM_{10} concentrations that we measured in Dhaka during the dry winter season conditions were thus higher than this. Also in the dry dusty areas of Abu Dhabi the monthly average PM_{10} concentrations ranged between 50 and 400 µg/m^3 (Sivertsen 2009). There are reasons to believe that the PM_{10} concentration in the city of Dhaka as measured in February 2011 was higher than what we have found in the three cities mentioned (Sivertsen et al., 2001b, 2004, 2008).

5.5 Satellite Mapping

Satellite data for both Aerosol Optical Depth (AOD) and NO_2 were analyzed for the purpose of mapping regional air pollution over Bangladesh, where AOD data is analyzed to obtain a regional-scale spatial overview of PM levels and to investigate to what extent the AOD data can duplicate time series measured on the ground as part of the screening study.

5.5.1 Aerosol Optical Depth and PM

It has been shown that in addition to local sources of air pollution, Particulate Matter (PM) levels in Dhaka are to some degree also influenced by contribution from more distant pollution sources through long-range transport (Begum et al., 2010a). It is therefore valuable to utilize satellite data for obtaining a synoptic view of regional spatial patterns of PM beyond the boundaries of Bangladesh.

While PM concentrations cannot yet be retrieved directly from satellite data, AOD is an operational product derived for a wide variety of satellite sensors and is closely linked to PM concentrations. This empirical relationship between AOD and PM has been applied in the past in order to map PM from satellite images (van

Donkelaar et al., 2010; Glantz et al., 2009; Wang and Christopher, 2003; Koelemeijer et al., 2006; Emili et al., 2010). The operational MODIS AOD product (MOD04_L2) (Kaufman and Tanré, 1998; Remer et al., 2005) obtained from both the Terra and Aqua satellites was used to investigate spatial and temporal patterns of AOD over Dhaka during the time frame of the screening study between January 31st 2011 and February 15th 2011.

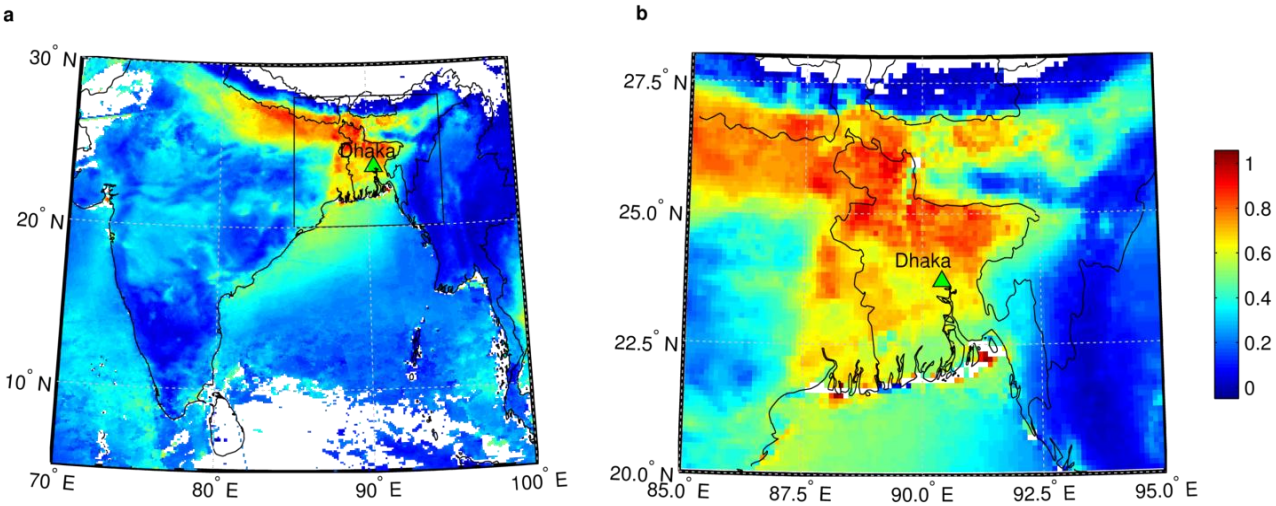

Figure 33: Mean MODIS-derived AOD over (a) South Asia and (b) Bangladesh for the study period between 31st January 2011 and 15th February 2011. The black rectangle in subfigure (a) indicates the spatial extent of the regional map in subfigure (b).

Figure 33 shows the overall mean AOD over both South Asia and Bangladesh for the study period. The highest AOD and thus PM load is found in a zonal band along the south side of the Himalaya with a southward extension over Bangladesh. Over Bangladesh a north-south gradient is visible, with Dhaka showing mean AOD values of around 0.6.

In order to provide a more detailed view of both spatial and temporal patterns of AOD over Bangladesh, Figure 34 and Figure 35 show the available AOD data individually for each day of the study period. They indicate not only a spatial but also a significant temporal variability of AOD.

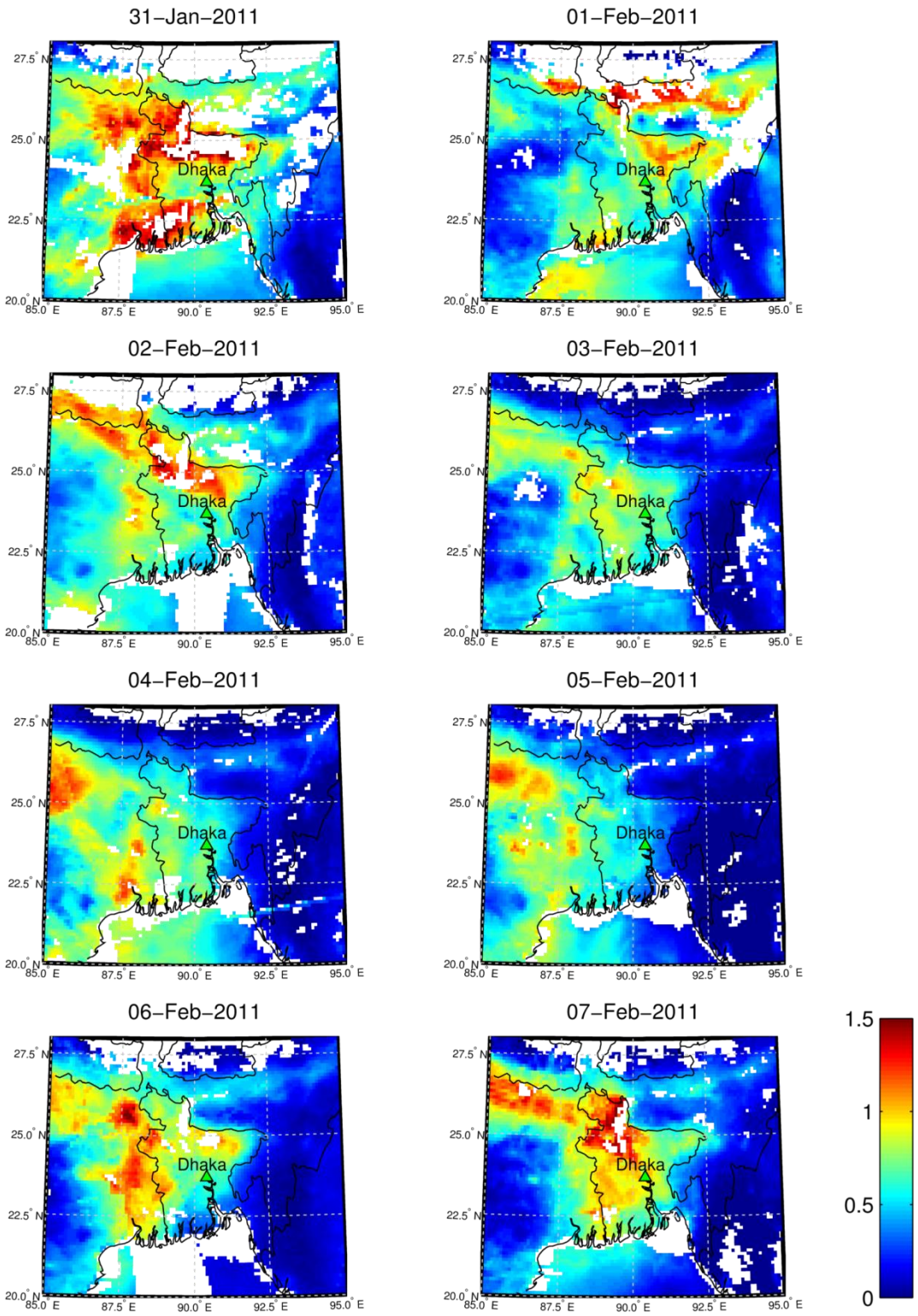

Figure 34: Daily AOD maps of Bangladesh for the first half of the screening study period. Data derived from the MODIS instruments on both the Terra and Aqua platforms.

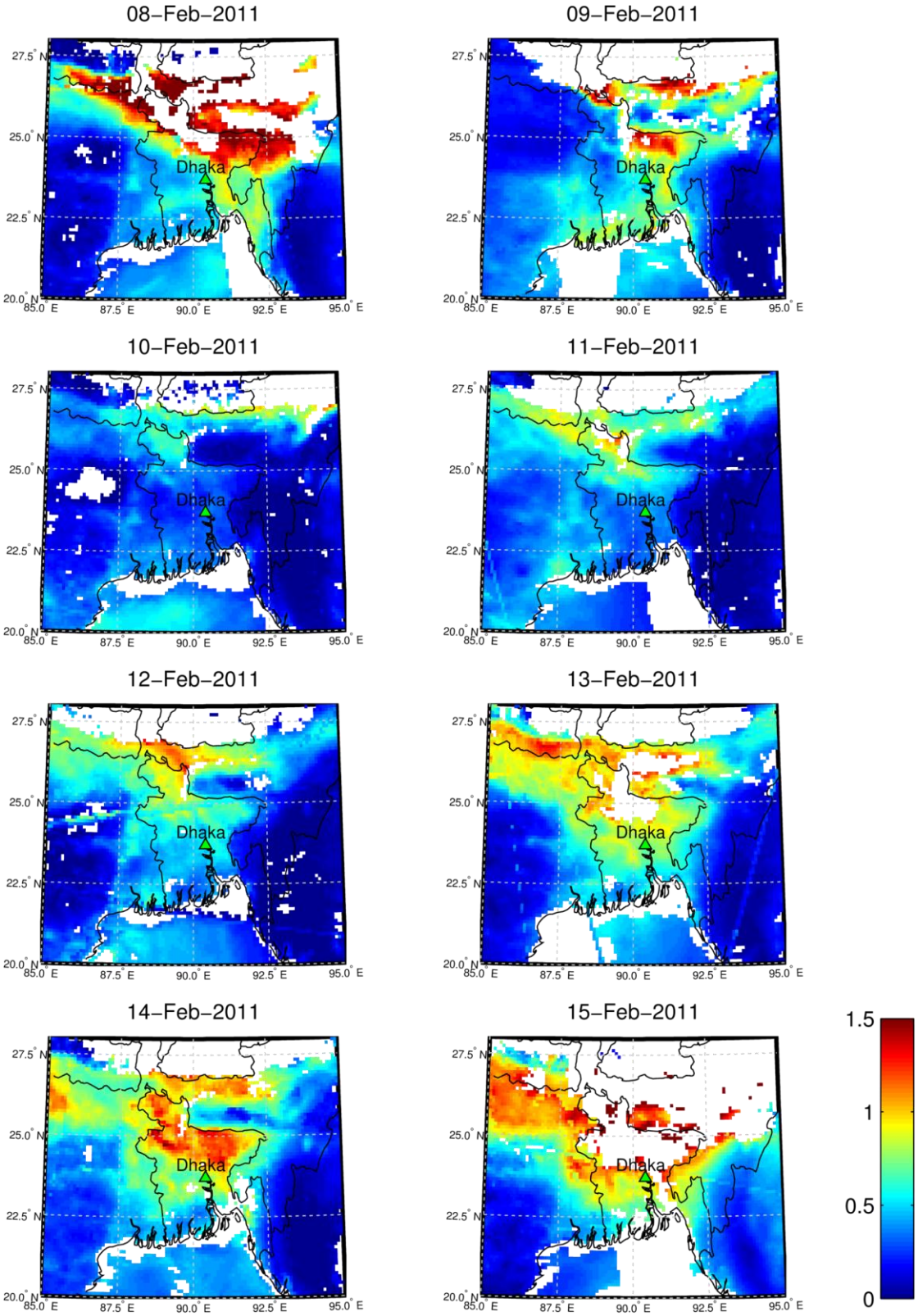

Figure 35: Daily AOD maps of Bangladesh for the second half of the screening study period. Data derived from the MODIS instruments on both the Terra and Aqua platforms.

Figure 36 shows a comparison of MODIS AOD with daily 30 min average PM measurements performed at Site 11A during the study period. Note that the units of both parameters are not directly comparable and that AOD has been scaled by a factor of 1000 for display purposes. Nonetheless, the Figure allows for a qualitative comparison of the temporal patterns. AOD shows a remarkably good temporal agreement with the PM measurements, given the uncertainty involved. Both the distinct peak on the 7th of February as well the local minimum on the 10th of February with a subsequent increase until the 13th of February are clearly shown by both datasets.

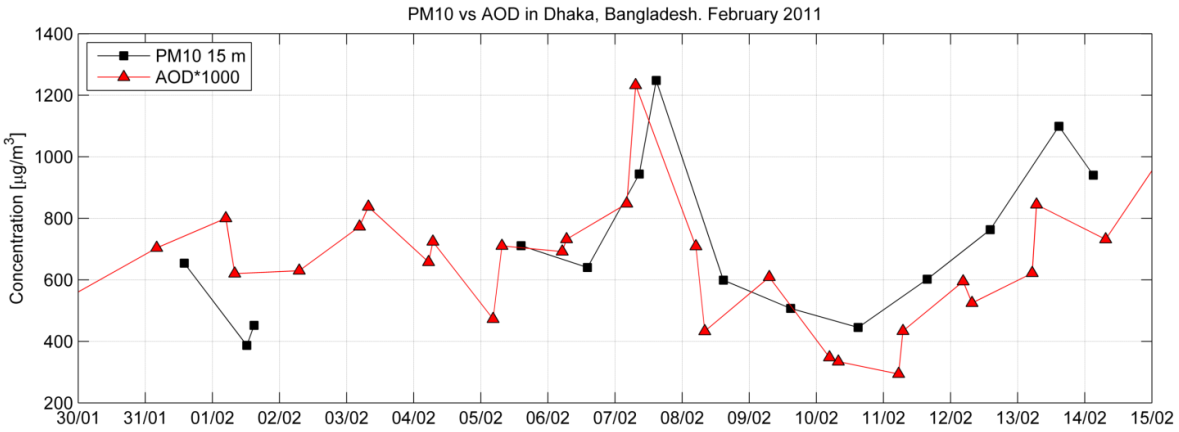

Figure 36: Temporal comparison of daily PM_{10} samples and AOD derived from MODIS. Note that AOD was multiplied by a factor of 1000 for scaling purposes. A few in situ samples had to be removed due to contamination by a local fire.

After temporally interpolating the AOD time series using linear interpolation to match the PM_{10} observation times, the two parameters were plotted against each other in a scatter plot (Figure 37). Despite the distinct differences in observation methodology, a linear relationship between the two parameters is quite obvious. A linear regression analysis of the data revealed an R^2 value of 0.55.

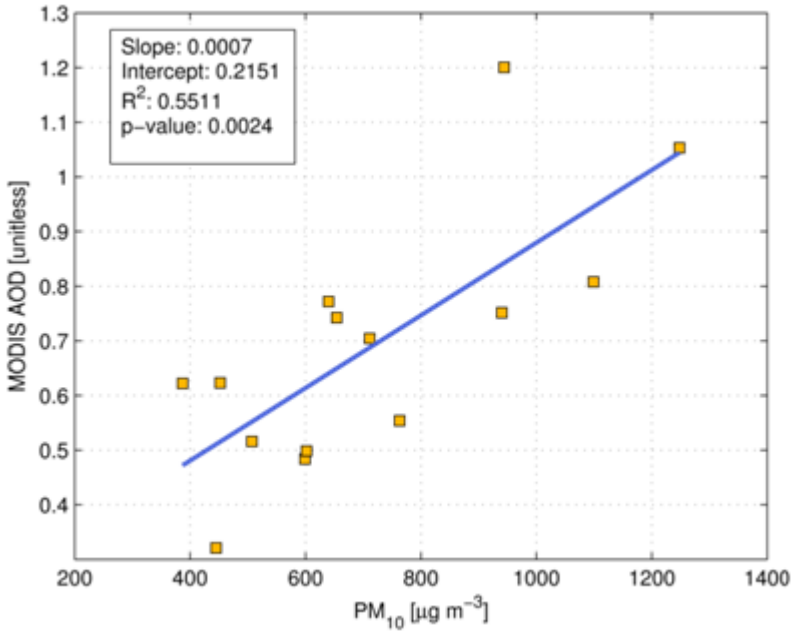

Figure 37: In situ observations of PM_{10} plotted against MODIS AOD. AOD was linearly interpolated to provide a matchup at the same time at which the in situ samples were taken. A few in situ samples had to be removed due to contamination by a local fire.

The coefficients of the linear regression analysis further resulted in a very simplified model for PM_{10} as a function of AOD as in

$$AOD = 0.000664 \cdot PM_{10} + 0.21509 \quad (1)$$

and thus

$$PM_{10} = \frac{AOD - 0.21509}{0.000664} \quad (2)$$

A relationship such as this has been previously used for the purpose of mapping PM from space (Glantz et al., 2009). The model given in Equation 2 was then used map mean PM_{10} over Dhaka during the period of the screening study (Figure 38). It should be noted that, while this method of estimating PM_{10} from AOD is in principle scientifically sound and has been applied in many previous studies (Wang and Christopher, 2003; Glantz et al., 2009; van Donkelaar et al., 2010), it makes several simplifying assumptions about aerosols. The uncertainty of the resulting PM_{10} map is therefore quite high, which is furthermore exacerbated by limited in situ data and vastly different sampling methodologies for the two datasets. Nonetheless, this is an example of what can be accomplished with respect to mapping PM levels from space, and a more comprehensive analysis in addition to the availability of more suitable in situ data would be able to significantly decrease the uncertainty and thus enhance the value of PM_{10} mapping from space.

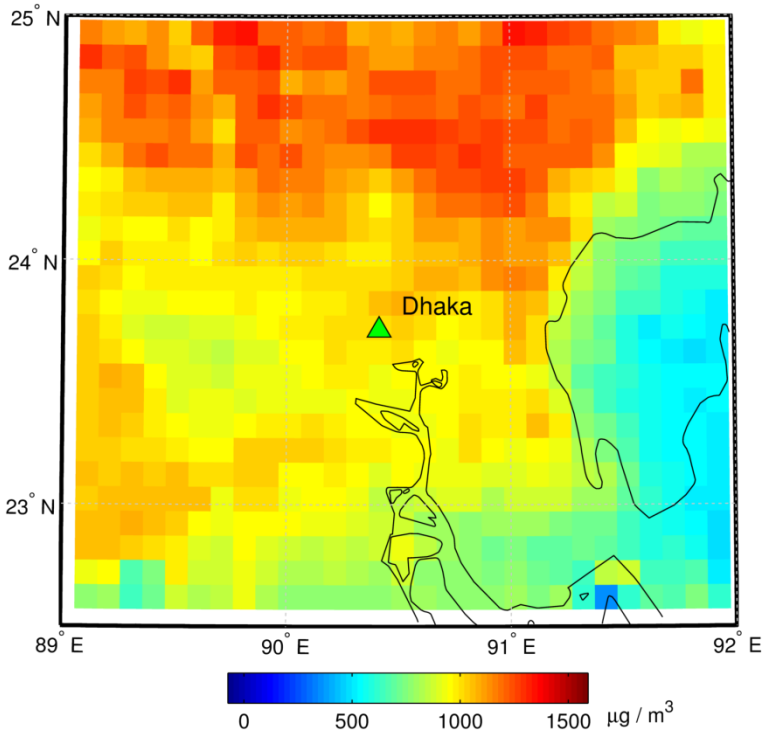

Figure 38: Mean PM_{10} concentrations over the Dhaka region between 31 January 2011 and 15 February 2011. The concentrations were estimated based on the empirical relationship given in Equation 2. Note that due to the scarcity of available in situ measurements and the associated uncertainty in the empirical relationship, the modeled PM_{10} values are only very rough estimates and should be treated with caution.

5.5.2 Tropospheric NO_2 Trends

In order to obtain an overview of the spatial patterns of NO_2 levels throughout Bangladesh, a monthly mean of NO_2 for the month of the screening study was mapped. Figure 39 shows the average concentration of tropospheric NO_2 over Bangladesh during February 2011 derived from the SCIAMACHY sensor. The units used in this and the following figures are given as the total number of tropospheric NO_2 molecules per square centimeter. A direct conversion into concentration into µg m^{-3} as measured at the ground is not possible at this point. As would be expected, a distinct hotspot can be observed over the metropolitan area of Dhaka with the levels dropping rapidly with distance from the city. The center of the hotspot exhibited a mean NO_2 level of 12.39×10^{15} molecules cm^{-2} during the month of the screening study.

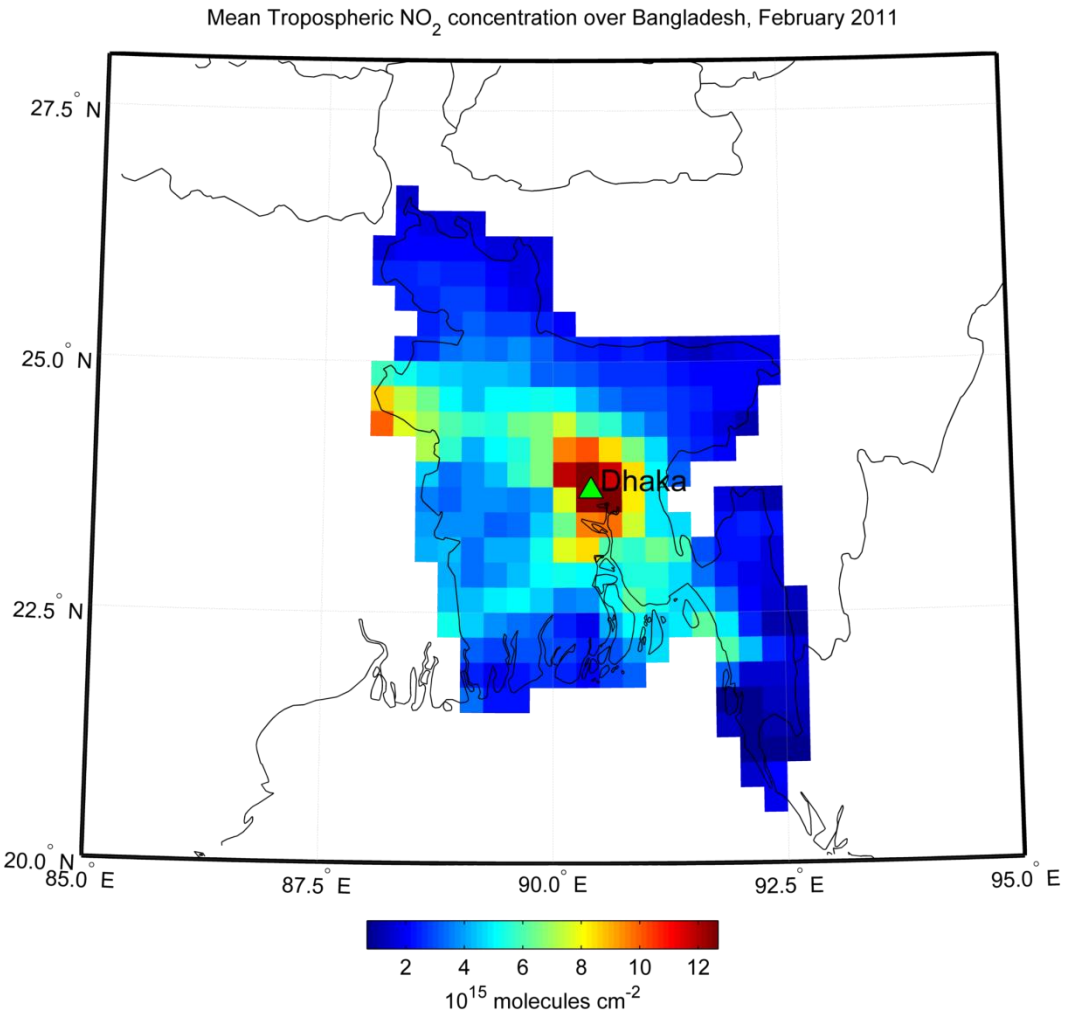

Figure 39: Average levels of NO_2 over Bangladesh in February 2011 derived from SCIAMACHY.

SCIAMACHY data can be used to derive time series of NO_2 over any location worldwide since the year 2002. For this study we used the full 9 years of currently available monthly SCIAMACHY NO_2 retrievals to extract a time series of NO_2 over Dhaka (Figure 40). An annual cycle with an NO_2 maximum in the winter months and a minimum in summer is clearly visible. However, the most striking feature of the graph is that it also shows an overall increase of the NO_2 levels over Dhaka, particularly between the years 2007 and 2011.

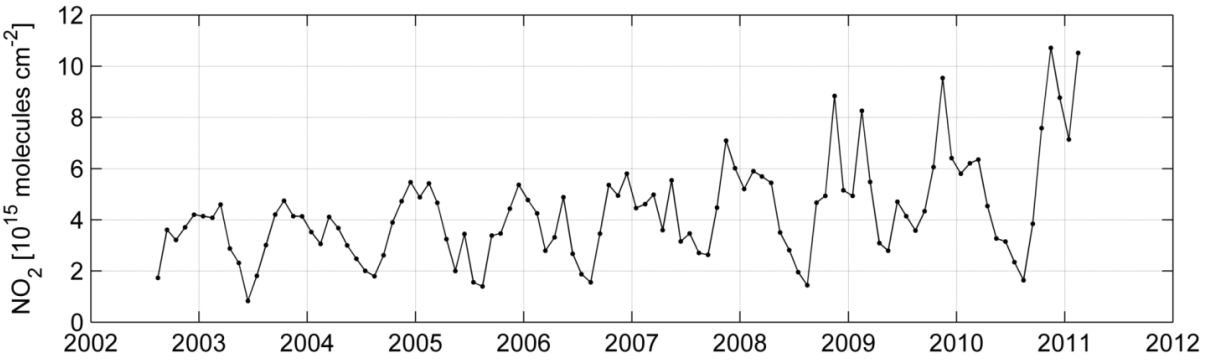

Figure 40: Monthly time series of NO_2 concentration over Dhaka, Bangladesh. Derived from SCIAMACHY data.

In order to further analyze and quantify the increasing trend observed in Figure 40, annual mean concentrations of NO_2 over Dhaka were computed and a linear regression analysis performed. Figure 41 shows the resulting values of annual mean NO_2 concentration over Dhaka between 2003 and 2010. The values were averaged over an array of 3 × 3 pixels centered at 23.715° N and 90.413° E. The figure shows a clearly increasing trend towards higher NO_2 concentrations from around 3.0×10^{15} molecules cm^{-2} in 2003 to 5.3×10^{15} molecules cm^{-2} in 2010. A linear regression analysis revealed a mean rate of increase of 0.33×10^{15} molecules cm^{-2} yr^{-1} between 2003 and 2010. The corresponding p-value was found to be less than 0.001, thus indicating a highly significant trend.

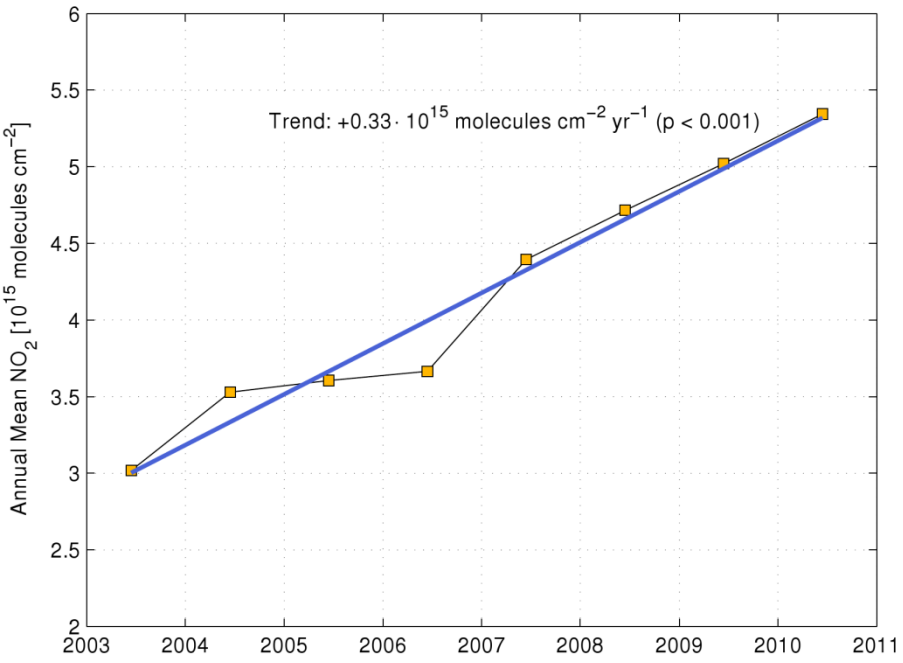

Figure 41: SCIAMCHY-derived time series of annual mean concentrations of NO_2 over Dhaka, Bangladesh and the results of a linear regression analysis.

5.6 Traffic flows and vehicle distributions

Traffic counting at 13 unique sites during the Screening Study shows that traffic flows are variable, see Figure 42. It should be noted that these traffic results are highly dependent on the road type, sample date/time, and flow direction which are not addressed in detail with this traffic sampling and warrants a more comprehensive traffic sampling study. See Appendix F for detailed site information and results.

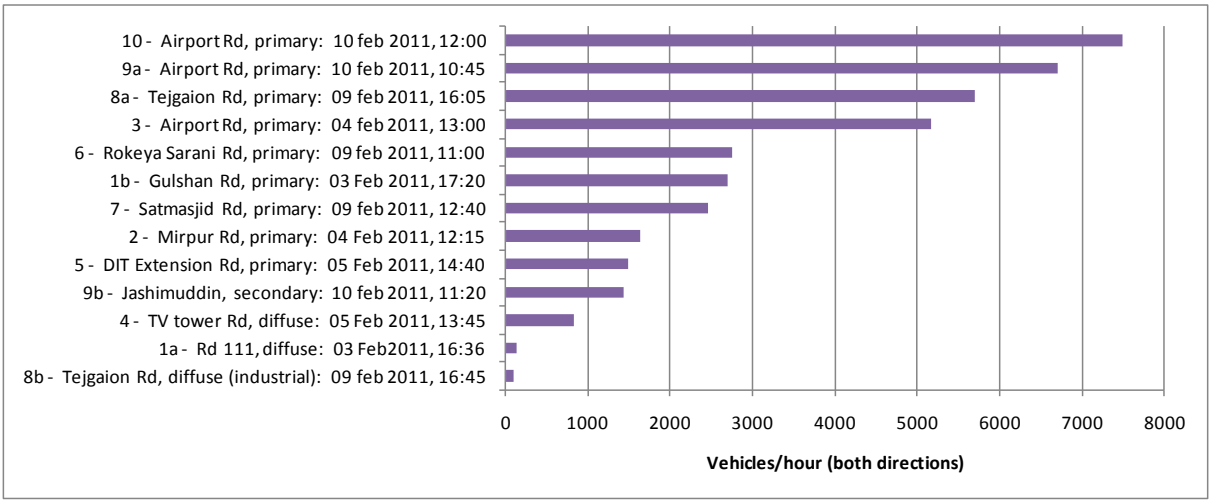

Figure 42: Traffic flows in total vehicles per hour for all stations (in both directions).

Despite the roughness of the traffic counting (screening) design, some basic analysis can be made. Figure 43 shows the total vehicle flow rates for per hour for each road class divided into each vehicle class for all sites. The greatest flow rates are *cars* on *primary* roads, followed by *auto-rickshaws* on *primary* roads (60% less flow than cars). *Motorcycles* and *busses* have similar flow rates on *primary* roads (10% of the *car* flow rates), and *trucks* and *taxis* have similar flow rates on *primary* roads (less than 5% of the *car* flow rates).

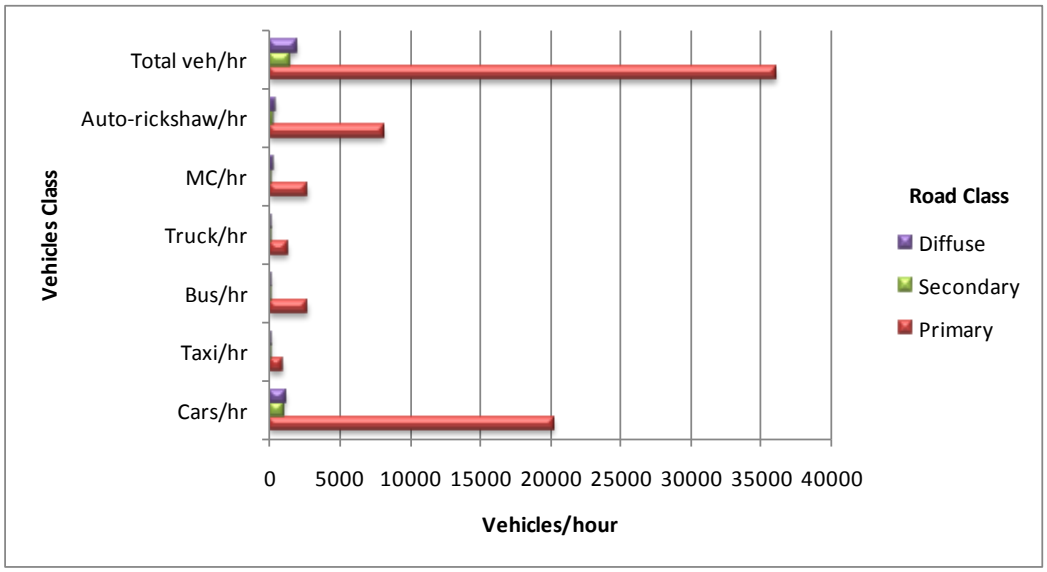

Figure 43: Vehicle flows for each vehicle class within each road class.

Vehicle class distributions for each road class type can be seen in Figure 44, showing the distribution of cars ranges from 56% (primary roads) to 70% (secondary roads), with an average of 61% for all road classes. Auto-rickshaws make up about ¼ of the vehicles on all roads, with slightly more on primary roads.

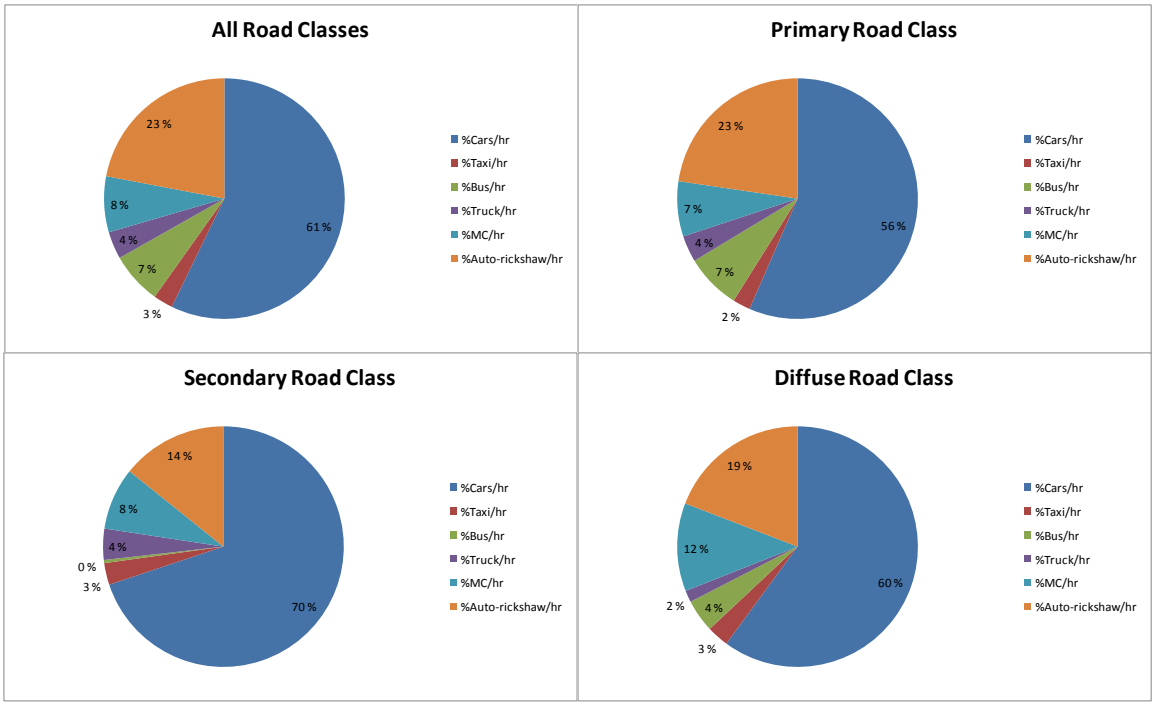

Figure 44: Vehicle class distributions for each road class.

6 Discussion and Conclusions

The AQ results presented can only confirm claims that Dhaka can certainly be considered to be one of the world's top polluted mega-cities (or potentially the worst during winter months). All components measured far exceed the AQG's set by WHO, which puts the health of the cities approximate 12+ million residents in certain harm.

Measured SO_2 values averaged over 12 days were somewhat high on average (86.9 µg/m^3) ranging from 38.0 µg/m^3 to 199.3 µg/m^3. Exceedance of the WHO guideline values could be expected at most sites. Few sites, however, exceeded local Bangladeshi standards with most of the higher values coming from sites in industrial areas. NO_2 values were relatively high on average (83.6 µg/m^3) ranging from 35.6 µg/m^3 to 161.3 µg/m^3, where many of the sites may have exceeded international standard and guideline values. At some sites the 12 day average concentrations indicated exceeding of local established standards. Most of the highest concentrations were at traffic sites. Both the typical SO_2 and the NO_2 concentrations as measured during the Screening Study in Dhaka seem to be somewhat higher than in the other cities NILU has performed similar studies, such as Cairo, HCMC, Dakar, and Abu Dhabi.

Measured 12 day average O_3 concentrations were moderate on average (47 µg/m^3), ranging from 18 µg/m^3 to 62 µg/m^3, with the highest values found at background sites. The average ozone concentrations in Dhaka are also slightly less than those found in HCMC on average. However, because of the large variations in ozone concentrations from day to night and from winter to summer we cannot specify any possible exceedings of the one-hour or eight-hour limit values for O_3 in Dhaka.

Half hour average PM_{10} concentrations ranged from 258 µg/m^3 to 2039 µg/m^3, with an average concentration of 613 µg/m^3 for all sites, and $PM_{2.5}$ concentrations ranged from 216 µg/m3 to 1131 µg/m3, with an average concentration of 439 µg/m^3. This shows that a large majority of the PM sampled was of the smaller fraction size (<$PM_{2.5}$). High PM values were found in all types of sites throughout the entire city, with some variations occurring over time and correlated to increases in visible haze. Short term concentrations of PM_{10} and $PM_{2.5}$ were higher than NILU has seen in any of the cities we have compared to. It is also clear that the concentrations of PM frequently exceeded any national and international limit values (especially during the winter months). Local sources to these values include the numerous brick kiln fields, motorized diesel vehicles, and re-suspension of dust is a very localized issue as well. However, it also was clear that a large portion of the PM concentrations was due to regional haze and a large scale cloud of dust covering a large portion of the northern Indian continent.

Large scale impact from regional sources of PM can be of equal or more importance than local sources emitting PM in the Dhaka area. The spatial distribution of small particles on this scale can be a result of regional topography

and meteorology which allows cold air from the Himalayas to flow down into Northeastern India, creating a super inversion layer which traps all pollution in this vicinity. Then, the typical winds blow first eastward along the mountains and then towards the south over Bangladesh and transport the pollution with them. The north-south gradient over Bangladesh is thus simply a function of distance from the mountain foothills.

Analysis of MODIS-derived AOD data over Bangladesh shows that, on a regional scale, patterns of AOD and thus PM over Bangladesh and the surrounding areas are highly variable in space and time. During the period of the screening study, there was generally a North-South gradient of PM with the highest values found in Northern Bangladesh (and zonally along the Himalaya in Northern India and Nepal) and the lowest values in the southern coastal plains of Bangladesh. A direct comparison of satellite-derived AOD with ground observations of PM_{10} made during the screening study showed that temporal patterns agree quite well, with an R^2 value of 0.55. Based on the results of a linear regression analysis, a very simplified model to translate MODIS AOD into PM_{10} for the Dhaka area was developed.

While it is challenging to visually track individual plumes of aerosols in the daily series of AOD data due to the high temporal variability as well as gaps in the satellite data record, it is clear that AOD and thus PM exhibit distinct spatial patterns over Bangladesh. Since long-range transport of pollutants is likely to affect air quality in Dhaka in addition to local emission sources (Begum et al., 2010), it is critical to map regional pollution levels from space. A more thorough analysis using backward trajectories, for example using the HYSPLIT model (Draxler and Rolph, 2011), can then further clarify to which extent pollution levels in Dhaka are indeed influenced by regional transport.

Analysis of satellite data from the SCIAMACHY sensors indicates that spatial patterns of NO_2 over Bangladesh exhibit a distinct hotspot over the Dhaka area. More importantly, a time series analysis revealed that annual average tropospheric NO_2 levels over Dhaka have increased by approximately 75% between the years 2003 and 2010. The trend was found to be about 0.33×10^{15} molecules cm^{-2} yr^{-1} (or about 10% per year) and is highly significant at the $p < 0.001$ level.

Traffic volume and vehicle distributions are as expected; an approximate 60:20:20 ratio for cars: auto-rickshaw: other vehicles are most likely a good average ratio to depend upon. It should also be noted that some locations are dominated solely by human-powered rickshaws.

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Appendix A

Meteograms for Screening Study Period

Weather Dhaka 5-7 Feb 2011

Varsel for Dhaka lørdag 05.02.2011

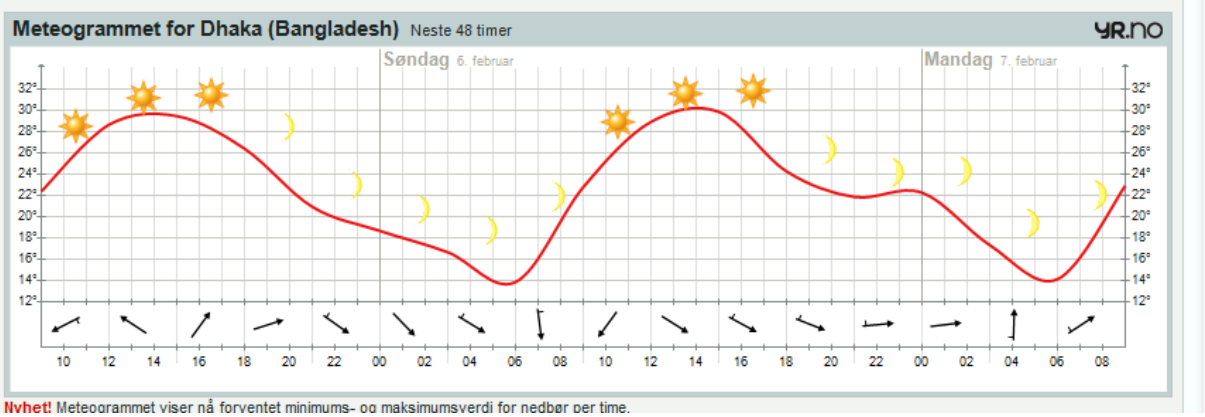
Morgen kl 9 – kl 12	Dagtid kl 12 – kl 18	Kveld kl 18 – kl 24
22°	29°	26°
Klarvær. Svak vind, 2 m/s fra øst-nordøst. 0 mm nedbør.	Klarvær. Flau vind, 1 m/s fra øst-sørøst. 0 mm nedbør.	Klarvær. Flau vind, 1 m/s fra vest-sørvest. 0 mm nedbør.

Varsel for Dhaka søndag 06.02.2011

Morgen kl 6 – kl 12	Dagtid kl 12 – kl 18	Kveld kl 18 – kl 24
14°	29°	24°
Klarvær. Svak vind, 2 m/s fra nord. 0 mm nedbør.	Klarvær. Flau vind, 1 m/s fra vest-nordvest. 0 mm nedbør.	Klarvær. Svak vind, 3 m/s fra vest-nordvest. 0 mm nedbør.

Varsel for Dhaka mandag 07.02.2011

Morgen kl 6 – kl 12	Dagtid kl 12 – kl 18	Kveld kl 18 – kl 24
14°	30°	24°
Klarvær. Svak vind, 2 m/s fra vest-sørvest. 0 mm nedbør.	Klarvær. Svak vind, 2 m/s fra vest-nordvest. 0 mm nedbør.	Klarvær. Svak vind, 3 m/s fra vest. 0 mm nedbør.



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Weather Dhaka 6-9 Feb 2011

Forecast for Dhaka Sunday 06/02/2011

Hourly forecast

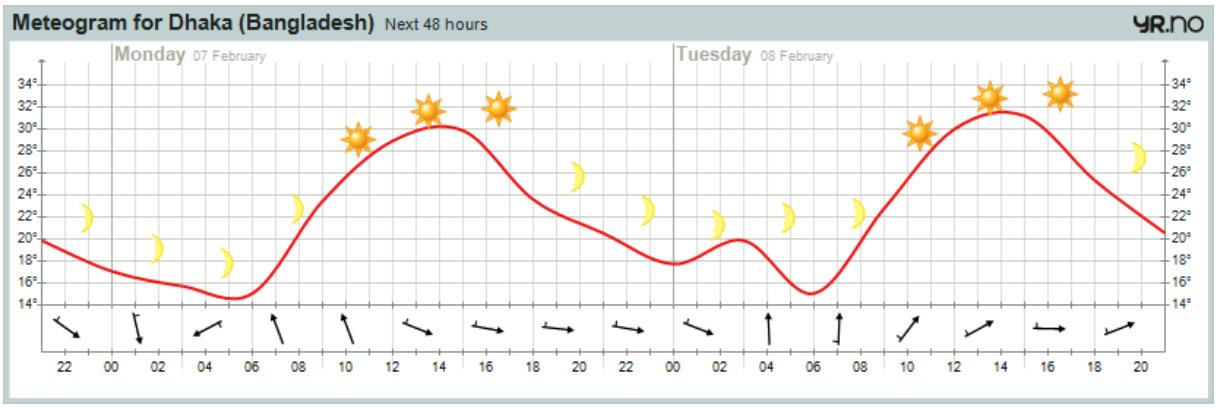
		Night 21:00 – 00:00
		20°
		Fair. Light breeze, 3 m/s from northwest. 0 mm precipitation.

Forecast for Dhaka Monday 07/02/2011

Morning 06:00 – 12:00	Midday 12:00 – 18:00	Night 18:00 – 00:00
15°	29°	24°
Fair. Light air, 1 m/s from south-southeast. 0 mm precipitation.	Fair. Light breeze, 2 m/s from west-northwest. 0 mm precipitation.	Fair. Light breeze, 3 m/s from west. 0 mm precipitation.

Forecast for Dhaka Tuesday 08/02/2011

Morning 06:00 – 12:00	Midday 12:00 – 18:00	Night 18:00 – 00:00
15°	30°	25°
Fair. Light breeze, 2 m/s from south. 0 mm precipitation.	Fair. Light breeze, 3 m/s from west-southwest. 0 mm precipitation.	Fair. Light breeze, 3 m/s from west-southwest. 0 mm precipitation.



Weather Dhaka 9-10 Feb 2011

Forecast for The Westin Dhaka Tuesday 08/02/2011

Hourly forecast

		Night 21:00 – 00:00
		21°
		Fair. Light breeze, 3 m/s from south-southwest. 0 mm precipitation.

Forecast for The Westin Dhaka Wednesday 09/02/2011

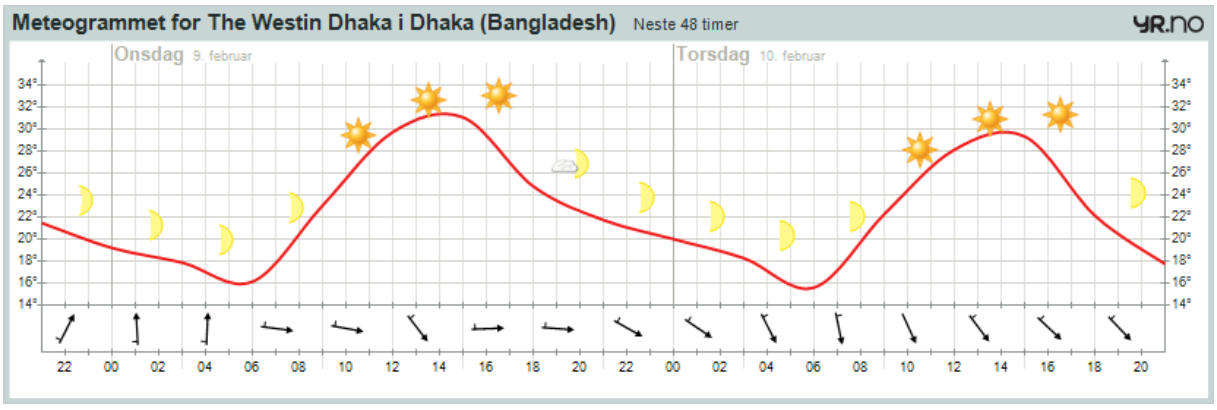
Morning 06:00 – 12:00	Midday 12:00 – 18:00	Night 18:00 – 00:00
16°	30°	25°
Fair. Light breeze, 2 m/s from west. 0 mm precipitation.	Fair. Light breeze, 2 m/s from northwest. 0 mm precipitation.	Fair. Light breeze, 3 m/s from west. 0 mm precipitation.

Forecast for The Westin Dhaka Thursday 10/02/2011

Morning 06:00 – 12:00	Midday 12:00 – 18:00	Night 18:00 – 00:00
16°	28°	22°
Fair. Light breeze, 3 m/s from north-northwest. 0 mm precipitation.	Fair. Light breeze, 2 m/s from northwest. 0 mm precipitation.	Fair. Light breeze, 3 m/s from northwest. 0 mm precipitation.

See also: Forecast Hour by Hour Weekend Forecast Long Term Forecast

Sun and moon Sunrise 06:36, Sunset 17:49 Moonrise 09:08, Moonset 22:19



Weather Dhaka 10-12 Feb 2011

Forecast for Dhaka Thursday 10/02/2011

Hourly forecast

		Night 21:00 – 00:00
		18°
		Fair. Light breeze, 3 m/s from west-northwest. 0 mm precipitation.

Forecast for Dhaka Friday 11/02/2011

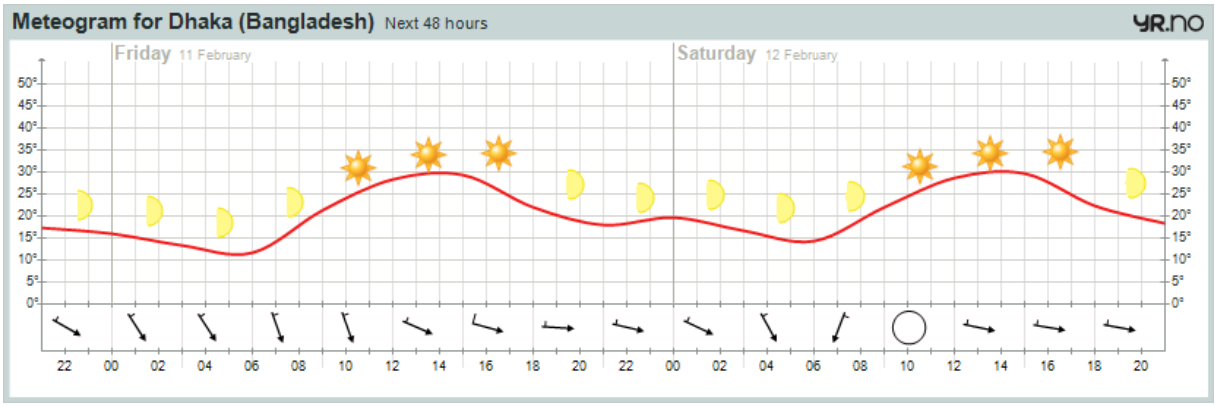
Morning 06:00 – 12:00	Midday 12:00 – 18:00	Night 18:00 – 00:00
12°	28°	22°
Fair. Light breeze, 3 m/s from north-northwest. 0 mm precipitation.	Fair. Light breeze, 2 m/s from west-northwest. 0 mm precipitation.	Fair. Light breeze, 3 m/s from west. 0 mm precipitation.

Forecast for Dhaka Saturday 12/02/2011

Morning 06:00 – 12:00	Midday 12:00 – 18:00	Night 18:00 – 00:00
14°	29°	22°
Fair. Light breeze, 2 m/s from north-northeast. 0 mm precipitation.	Fair. Light breeze, 2 m/s from west-northwest. 0 mm precipitation.	Fair. Gentle breeze, 4 m/s from west. 0 mm precipitation.

See also: Forecast Hour by Hour Weekend Forecast Long Term Forecast

Sun and moon Sunrise 06:34, Sunset 17:50 Moonrise 10:20, Moonset 00:04



Weather Dhaka 12-14 Feb 2011

Forecast for Dhaka Saturday 12/02/2011

Hourly forecast

		Night 21:00 – 00:00
		18°
		Fair. Gentle breeze, 4 m/s from northwest. 0 mm precipitation.

Forecast for Dhaka Sunday 13/02/2011

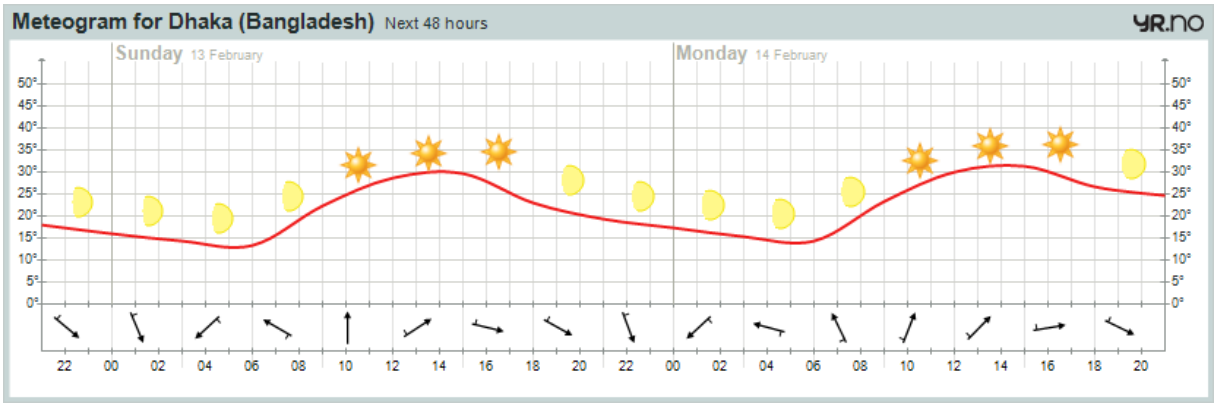
Morning 06:00 – 12:00	Midday 12:00 – 18:00	Night 18:00 – 00:00
13°	28°	23°
Fair. Light breeze, 2 m/s from east-southeast. 0 mm precipitation.	Fair. Light breeze, 2 m/s from west-southwest. 0 mm precipitation.	Fair. Gentle breeze, 4 m/s from west-northwest. 0 mm precipitation.

Forecast for Dhaka Monday 14/02/2011

Morning 06:00 – 12:00	Midday 12:00 – 18:00	Night 18:00 – 00:00
14°	30°	27°
Fair. Light breeze, 2 m/s from south-southeast. 0 mm precipitation.	Fair. Light breeze, 3 m/s from southwest. 0 mm precipitation.	Fair. Light breeze, 3 m/s from west-northwest. 0 mm precipitation.

See also: Forecast Hour by Hour Weekend Forecast Long Term Forecast

Sun and moon Sunrise 06:33, Sunset 17:51 The moon does not rise.



Appendix B

Screening Study Design and Planning Memorandum

	Bangladesh Department of Environment/CASE Project Poribesh Bhaban E-16, Agargaon, Shere Bangla Nagar Dhaka 1207 Bangladesh	**Norwegian Institute for Air Research** PO Box 100 2027 Kjeller Norway	

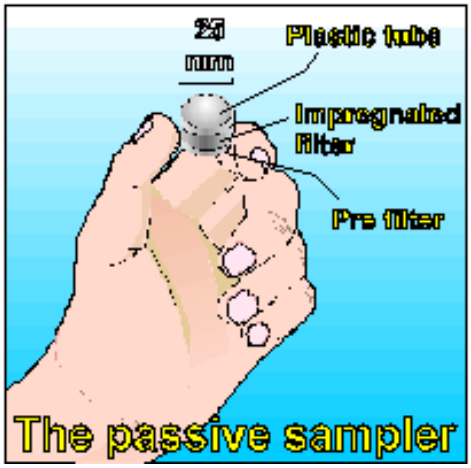
Financed by: Norwegian Agency for Development Cooperation (NORAD)	BAPMAN MEMO	NORAD DIREKTORATET FOR UTVIKLINGSSAMARBEID NORWEGIAN AGENCY FOR DEVELOPMENT COOPERATION

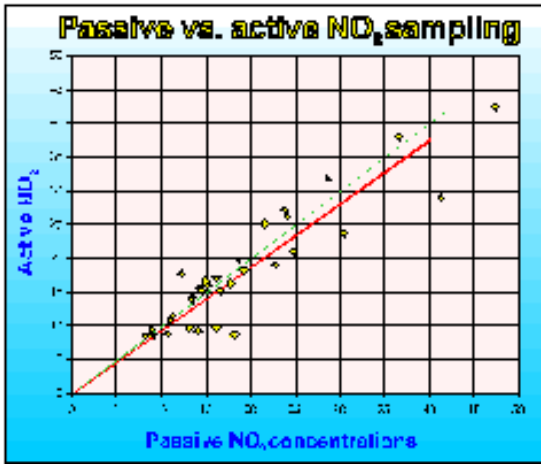
Project:	**Bangladesh Air Pollution Management (BAPMAN)**

Prepared by NILU:

Bjarne Sivertsen and Scott Randall

Screening study
Design and planning





REPORT NO.:	Memo 2010
NILU REFERENCE:	O-110055
REV. NO.:	November 2010

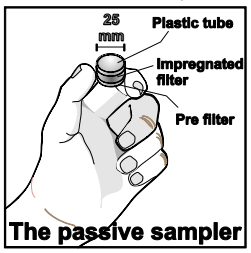
BAPMAN Screening Study Design Plan

Introduction

An air quality screening study will be performed in order to establish a baseline air quality information and lend guidance to the design of the air quality monitoring network for Dhaka. The data shall give a simplified picture of the average concentration distribution of air pollutants over the city. The screening will be performed in February 2011 by NILU with assistance from DoE/CASE under the BAPMAN project.

Passive samplers

Simple samplers for measurements of time integrated concentrations of sulphur, nitrogen and particles are being used. This method has been used worldwide in industrial areas, in urban areas and for studies of indoor/outdoor exposures



These samplers have been used by NILU in a number of studies (Hak, 2010; Hak and Sivertsen, 2010). For sampling of gases they include an impregnated filter inside a small plastic tube. To avoid turbulent diffusion inside the sampler, the inlet is covered by a thin porous membrane filter. Gases are transported and collected by molecular diffusion.

The methods require that these samplers are exposed for at least one week.

Dust track and mini vol samplers for PM

A Real-Time Dust Monitor will be used to monitor ambient PM concentrations. The new DustTrak™ DRX Aerosol Monitor can simultaneously measure both mass and size fraction - no other monitor can do both. The DustTrak DRX handheld monitor is a battery operated, data-logging, light-scattering laser photometers that gives you real-time aerosol mass readings.

Simple time integrated mini-vol samplers have been used in Dhaka in previous studies. We will try to identify how many of these samplers can be used as part of the screening study.

List of instruments used for screening.

Component	Sampler	Number	Sampling period	Resolution
SO2	Passive sampler	50	Two weeks	Average for sampling period
NO2	Passive sampler	50	Two weeks	Average for sampling period
O3	Passive sampler	20	Two weeks	Average for sampling period
PM10	Minivol	?	24 h aver 2 weeks	24 h averages
PM	Dust-track	20	Two weeks	Grab samples (typical 30 min aver.)=

A number of selected points in Dhaka

We will select a number of sampling positions in the Dhaka area. We depend upon the positive response from owners of buildings where we might need to place a sampler.

We thus appreciate the co-operation with local authorities and individuals, who will contribute to a better understanding of the air pollution in the area.The small instruments are totally unharmful, and they will be collected by experts after a sampling period of about two weeks.

Passive samplers of NO_2, SO_2, O_3 will be placed in up to 50 locations in Dhaka city and surrounding suburban areas (see *Table 1*).

In addition we will use an automatic hand held sequential PM sampler (DustTrak) at a selected number of monitoring sites in the city centre of Dhaka. These instruments will measure 30 min average concentrations of PM10 and PM2.5.

We will also be interested in placing as many Minivol samplers for PM10 as possible in Dhaka. These instruments may be available at DoE.

The map in Figure 1 gives a picture of the spatial distribution of the preliminary sampling sites selected for Dhaka.

Site location design parameters:

1. City Transects (Dhaka has primary northerly wind)
    a. North of city suburban (but south of brick kilns)
    b. North of city urban
    c. City Center
    d. South of city urban
2. Microclimates
    a. Roadside
    b. Street canyons
    c. Urban
3. Vertical
    a. 2-3 meters over street level (majority)
    b. 5 meters over street level (some)
    c. High over street level (one or two) – all components
4. Also at existing and planned monitoring station locations

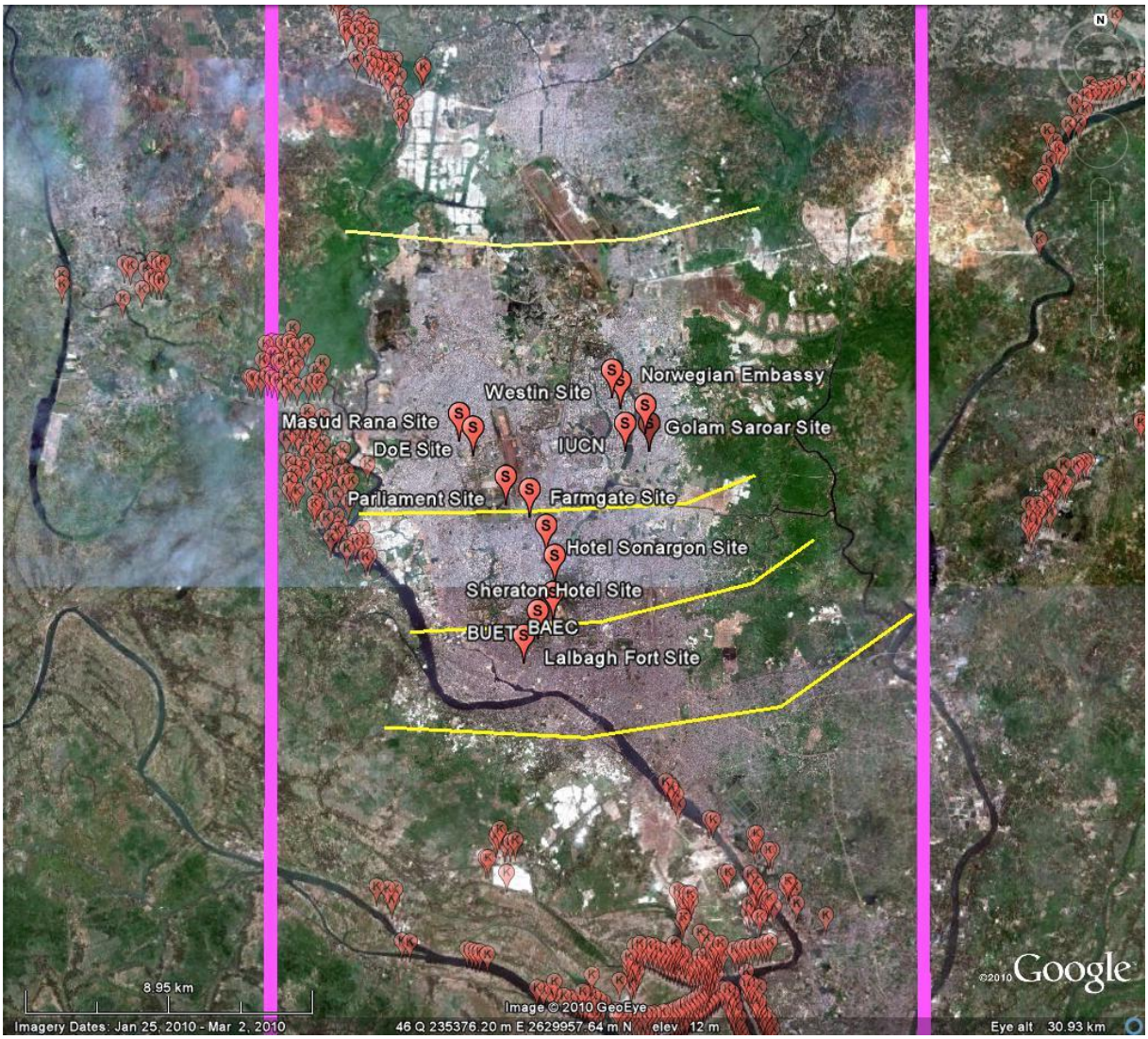


Figure 1: Prelim picture showing transects (Yellow lines), prelim sites (S Markers), and grid (Pink).

So far 14 sites have been appointed as possible measurement sites for the screening study (See Table 2).

These sites were identified during the training seminar at NILU in October 2010. They were selected at points in the city where we know that we have people that can take care of the samplers and some of them are located hotels, where permissions can easily be taken.

We further want to identify another 30-40 sites preferably in areas where we know that people can take care of the samplers (private homes or offices). Locations also have to meet the criteria of spreading out samplers along traverses to obtain a good and representative concentration distribution over the city.Some samplers should also be located within a kilometre downwind from large industrial sources.

The 14 sites selected so far are presented in Table 2 below.

Table 2: Preliminary selection of sites for the screening study.

Site #	Site Name	Responsible	Location	Address	Long	Lat
	BAEC	Scott Randall			90.39671578	23.73044127
	BUET	Scott Randall			90.3929339	23.72649122
	Masud Rana Site	Masud Rana			90.36780797	23.78101156
	DoE Site	Masud Rana			90.37247542	23.77697864
	Westin Site	Scott Randall			90.41511871	23.79245226
	Lalbagh Fort Site				90.38733361	23.71894983
	Parliament Site				90.38770402	23.76003501
	Farmgate Site				90.39292872	23.75912323
	Hotel Sonargon Site	Scott Randall			90.39445639	23.74982247
	Sheraton Hotel Site	Scott Randall			90.39704585	23.74144747
	Golam Saroar Site	Golar Saroar			90.42494955	23.78332682
	Saroar Uncle Market Site	Golar Saroar			90.42604765	23.77798141
	IUCN	Scott Randall			90.41732907	23.77813959
	Norwegian Embassy	Scott Randall			90.41721013	23.79027722

All sites have to be classified according the international classification procedures as given in the table below.

Type of zone	Type of station	Characterisation of zone
Urban (U)	Traffic (T)	Residential (R)
Suburban (S)	Industrial (I)	Commercial (C)
Rural (R)	Background (B)	Industrial (I)
		Agricultural (A)
		Natural (N)
		Res. / Comm. (RC)
		Comm. / Ind. (CI)
		Ind. / Res. (IR)
		Res. / Comm. / Ind. (RCI)
		Agri. / Nat. (AN)

Sampling procedures

All participants will be introduced to the sampling procedures used in screening studies. A specific form will have to be filled in for each of the sampling locations.An example of this form is given on the next page.

PASSIVE SAMPLER FORM FOR BANGLADESH

Norwegian Institute for Air Research

NILU

Passive air pollution sampling

Field observations Dhaka, Bangladesh

Observer: ____________________

Sampling period				Site name	Location		*Sampler identification*				
From:		To:		(position)			SO_2	NO2	Ozone	PM	comments
date	hr.	date	hr.		North	East	(red)	(blue)			

*) comments

Developed by: Norwegian Institute for Air Research (NILU), POBox 100, N-2007 Kjeller, Norway

References

Guerreiro, C., Laupsa, H. and Sivertsen, B. (2005). Passive sampling of SO_2 and NO_2 in ambient air in Dakar. Kjeller (NILU OR 46/2005).

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Hak, C. and Sivertsen, B. (2010). *Ambient air pollution screening study in Burgas March 2010*. Kjeller (NILU OR 40/2010).

Appendix C

Screening Study Procedures

Norwegian Institute for Air Research NILU

SAMPLING INSTRUCTIONS FOR A DIFFUSIVE SAMPLER

1. Sampling equipment

The sampler is a little round plastic container with the dimensions 1.2 cm * 2.5 cm (height, diameter). It consists of a steel net placed in front (opening) of the sampler, a Teflon filter and an impregnated filter to absorb gases, in addition to the container. Together with the steel net, the teflon filter will prevent turbulent transport to the active filter.

2. Sampling

2.1 Reception of the samplers

- The samplers must be stored in their transport boxes in a cool spot (ex. in a refrigerator) until exposure takes place.
- If any of the different items are loose at reception, this should be noted on the drift form that follows the samplers.

2.3 Outdoor sampling

- The samplers should be located about 2 meters above the ground, ex. Under the tip of a roof, under a fence or under a shelter roof etc.
- The samplers schould be attached up side down underneath the horizontal plane with a two-sided adhesive tape, with the filter side (the opening) turned down.
- It is of extreme importance to mount the samplers in such way they are not getting wet!

2.4 Ending the exposure

- After exposure, the samplers should immediately be placed in its transport box in which they were received.
- The samplers schould again be stored in a cool spot until they are sent back to NILU.
- The samplers schould be sent back to NILU as soon as possible after exposure.

3. Marking the diffusive samplers

- Mark the transport box, not the sampler, because of the size of the samplers.

- A little label is attached to the transport box. This label contains the name of the station, sample type (code for SO2, NO2 etc the number of the sampler. The sampling start and end time has to be filled in to the form. Note the position AND the number of the samplers.

4. Filling out the drift forms

- The drift form shall always be filled with a ball pen.
- When error in writing, cross out the error and write the correction beside.
- The drift form shall always be returned to NILU together with the samplers the driftform refers to.
- The station holder must write readably on the drift form, preferably with block letters.
- The following fields shall always be filled out:

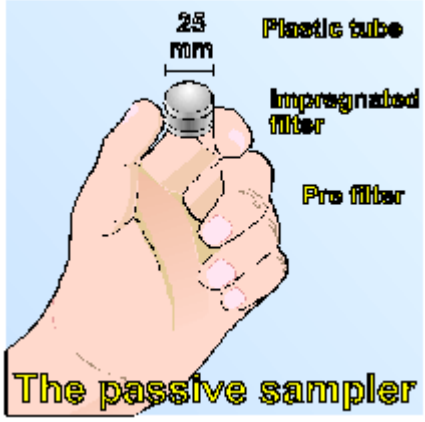
Observer:	Name of the person that has carried out the fieldwork.
Date:	Date that the sample is exposed from start and to collection day (write while in the field)
Station name:	Name of the station
Position:	When there are more than one sampler that are placed at the same spot, the samplers have to be numbered.
Sampler identification:	The number on the sampler must be noted on the drift form, (red samplers are for SO2 , blue samplers are for NO2 , white for ozone). We prefer to write the number of the sampler when starting the sampler. Remember to bring the correct box (numbered) back when you collect the sampler.
Sample type:	Diffusive samplers can be used to sample different types of gases. One must therefor note on the form which type of sample the form refers to The code is noted on the transport box.
Comments:	Comments may contain weather, errors, dust etc..

5. Fieldblanks

- The field blanks are marked with a red Label!! or with a note on the transport box, marked “FBL”.
- The filed blank is not to be taken out of the transport box.
- The field blank is stored in a measure stall (for outdoor measurements) or near the measure place (for indoor measurements).
  The field blanks are packed whit the exposed samples after ended sampling period, and the whole thing is returned to NILU.

About the passive sampler

A simple sampler for surveillance of time integrated SO_2 and NO_2 concentration distributions has been developed. The sampler is inexpensive in use, simple to handle and have a good overall precision and accuracy. This method has been used in industrial areas, in urban areas and for studies of indoor/outdoor exposures

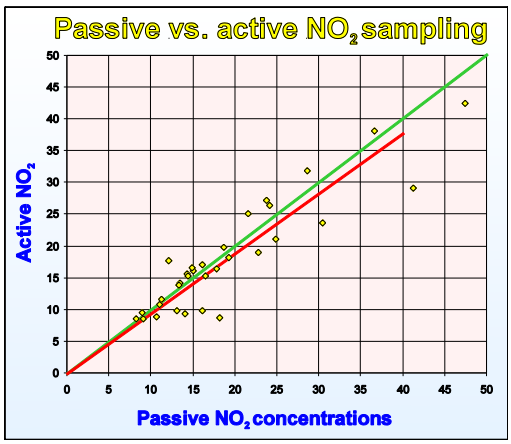


A sensitive diffusion sampler for sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) in ambient air has been used in several investigations to undertake a screening of the spatial concentration distribution.

The sampler was developed by the Swedish Environmental Research Institute (IVL) and has been used in several cases by NILU. The sampler includes an impregnated filter inside a small plastic tube. To avoid turbulent diffusion inside the sampler, the inlet is covered by a thin porous membrane filter. Gases are transported and collected by molecular diffusion. The uptake rate is only dependant upon the diffusion rate of the gas.

The collection rate is 31 l/24h for SO_2 and 36 l/24h for NO2. Also NH3 can be collected at a rate of 59 l/24h.

Comparison with monitors



The integrated passive sampling of SO_2 and NO_2 is well correlated with available active sampling methods.

For SO_2 the measuring ranges are approximately 0,1-80 ppb for a sampling period of one month. The corresponding range for NO_2 is 0,02-40 ppb.The passive samplers are assembled and made ready for use at NILU .After exposure the samplers are usually returned to NILU where concentrations of SO_2 are determined as sulphate by ion chromatography. NO_2 and NH3 is determined by spectrophotometry.

Appendix D

Passive Sampling Site Profiles

Sampling Site Profile (1A)

Sampling period				Site name		Location		Sampler identification					Other Info.		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	22:35	13.feb	20:00	1a	Westin hotel 23rd	23°47'35.61"	90°24'52.60"	10	12	05 BS	Yes	Balcony N.	90m	U/T/C	

Pictures:

Maps:

Comments:

Samplers placed at the balcony 23th floor, north side of the building. The samplers are placed vertically due to space limits.

Sampling Site Profile (1B)

Sampling period				Site name		Location		Sampler identification					Other Info.		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
7feb	14:45	14.feb	18:45	1b	Westin hotel 2nd	23°47'35.61"	90°24'52.60"	08	-	-	Yes	Balcony S.	15m	U/T/C	Yes

Pictures:

Maps:

Comments:

Sampling Site Profile (2)

Sampling period				Site name		Location		Sampler identification					Other Info.		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	13:00	13.feb	10:15	2	BSMMU	23°44'19.49"	90°23'44.71"	25	05	01SR		Guard house	3m	U/T/C	Yes
Pictures:						Maps:						Comments:			

Sampling Site Profile (3)

Sampling period				Site name		Location		Sampler identification					Other Info.		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	14:25	13.feb	10:55	3	Postogola	23°41'30.43"	90°25'57.19"	29	04	02SR		Front door	3m	U/T/C	Yes
Pictures:						Maps:						Comments:			

Sampling Site Profile (4)

Sampling period				Site name		Location		Sampler identification					Other Info.		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	15:00	13.feb	10:40	4	Smiling Sun Clinic	23°42'11.93"	90°25'41.29"	23	02	-		Up stairs	6m	U/T/C	Yes

Pictures:

Maps:

Comments:

Sampling Site Profile (5)

Sampling period				Site name		Location		Sampler identification					Other Info.		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2feb	11:00	13feb	12:45	5	Health Aid Clinic	23°43'16.49"	90°23'16.15"	22	03	03SR		Front door	3m	U/T/C	Yes

Pictures:

Maps:

Comments:

Sampling Site Profile (6)

Sampling period				Site name		Location		Sampler identification					Other Info.		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2feb	11:45	13.feb	14:45	6	Power St. Haziabag	23°43'25.26"	90°22'20.42"	17	22	04SR		Inside gate	4m	S/I/I	Yes

Pictures:

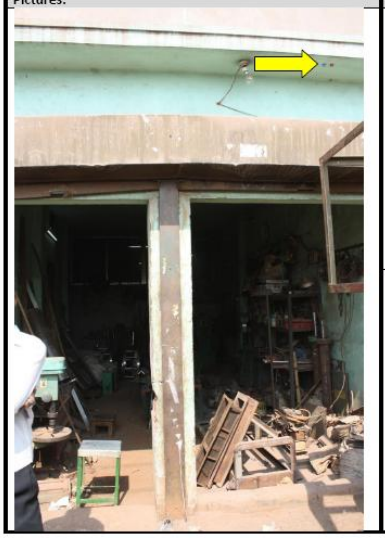
Maps:

Comments:

Sampling Site Profile (7)

Sampling period				Site name		Location		Sampler identification					Other Info.		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2feb	12:05	13.feb	14:30	7	Machine Workshop	23°42'44.01"	90°23'23.20"	01	21	-		Above gate	6m	U/I/I	Yes

Pictures:



Maps:

Comments:

Friends of Halil

Sampling Site Profile (8)

Sampling period				Site name		Location		Sampler identification					Other Info.		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2feb	13:10	13.feb	13:55	8	Pink Palace	23°42'30.56"	90°24'21.18"	15	17	05SR		Left front	5m	U/B/NRC	Yes

Pictures:

Maps:

Comments:

Sampling Site Profile (9)

Sampling period				Site name		Location		Sampler identification					Other Info.		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2feb	14:45	13.feb	12:05	9	Guliztan Monkies	23°43'37.32"	90°24'37.86"	09	01	06SR		Left up	4m	U/T/C	Yes

Pictures:

Maps:

Comments:

Sampling Site Profile (10)

Sampling period				Site name		Location		Sampler identification					Other Info.		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2feb	15:15	13.feb	15:25	10	Rainbow Heart	23°45'11.97"	90°22'36.59"	21	20	07SR		Back camera	3m	U/T/C	Yes

Pictures:

Maps:

Comments:

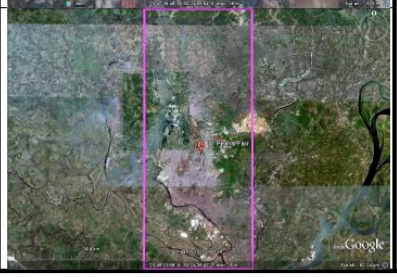
Friend of Jalil

Sampling Site Profile (11)

Sampling period				Site name		Location		Sampler identification					Other Info.		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
3feb	11:20	14.feb	18:20	11	Pearls Fair	23°47'38.19"	90°24'54.58"	03*	29	-	Yes	Above door	3m	U/T/C	Yes

Pictures:

Maps:



Comments:

*placed 7Feb 15:30, retrieved same time

Sampling Site Profile (12)

Sampling period				Site name		Location		Sampler identification					Other Info.		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
3feb	14:15	15.feb	13:14	12	Norwegian Embasy	23°47'25.12"	90°25'1.86"	40	42	-	Yes	Lund balcony	7m	R/B/R	Yes

Pictures:

Maps:

Comments:

Sampling Site Profile (13)

Sampling period				Site name		Location		Sampler identification					Other Info.		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
01.feb	19:59	14.feb	07:22	13	Ashraf - SBanasree	23°45'34.83"	90°26'11.55"	16	28	-			Xm	R/B/R	no

Pictures:

Maps:

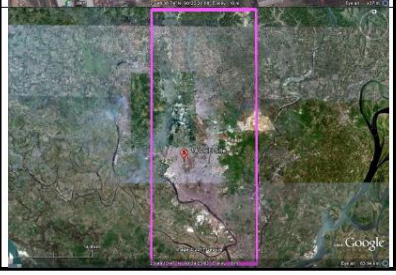
Comments:

Sampling Site Profile (14)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	11:38	13.feb	17:26	14	DoE	23°46'36.88"	90°22'19.85"	20	30	01 BS		At fence	4m	U/B/C	yes

Pictures:

Maps:



Comments:

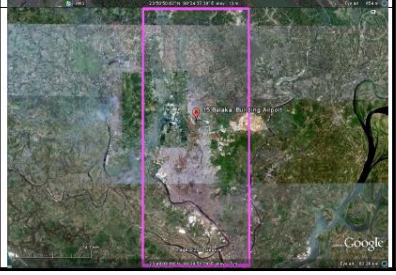
On tree near gate and along fence to DoE office.

Sampling Site Profile (15)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1 feb	12:45	13.feb	11:32	15	Balaka build.Airpor	23°50'50.58"	90°24'36.71"	39	43	02 BS		Behind recept	2m	X	Yes

Pictures:

Maps:



Comments:

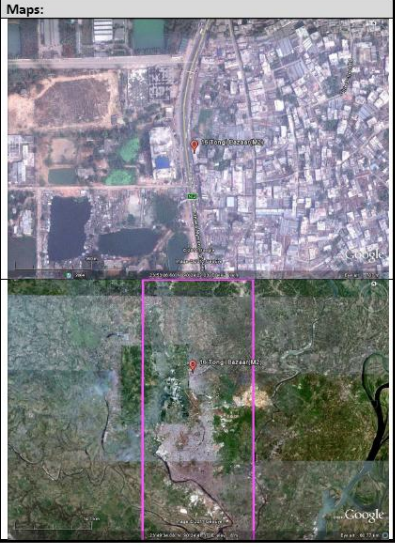
Samplers placed behind the reception at the entrance to the Balaka building close to the international airport.

Sampling Site Profile (16)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	13:35	13.feb	11:54	16	Tongi Bazaar	23°53'6.31"	90°24'1.69"	38	16	03 BS			5m	X	Yes

Pictures:

Maps:



Comments:

Samplers placed above the balcony about 50 m north of bridge over the road. Placed at Sultan Marked outside small shop inside the balcony. Sewing maskin repair shop inside?

Sampling Site Profile (17)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	14:38	13.feb	12:19	17	Sector14,Road 17	23°52'4.38"	90°23'2.09"*	34	19	04 BS		Balcony 3 fl	14m	X	Yes

Pictures:

Maps:

Comments:

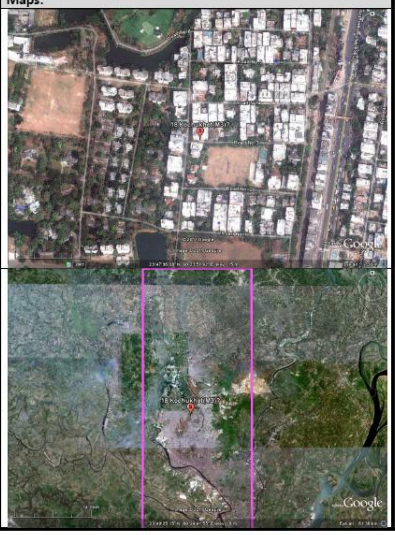
Samplers placed on balcony third floor in private home in Sector 14

Sampling Site Profile (18)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	16:20	13.feb	13:12	18	Kochukhet(M3)	23°47'36.00"	90°23'52.08"	31	14	-			3m	U/T	Yes

Pictures:

Maps:



Comments:

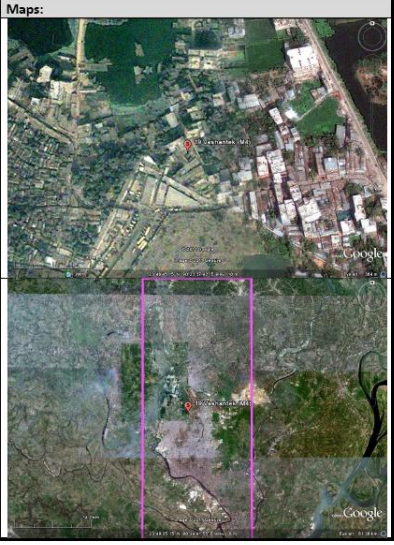
Samplers placed under the roof outside a shop near the Kochukhet marked. A friend of Masud is running the shop.

Sampling Site Profile (19)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	16:46	13.feb	12:58	19	Vashantek (M4)	23°48'45.00"	90°23'37.00"	7	15	-			12m	S/B/R	Yes

Pictures:

Maps:



Comments:

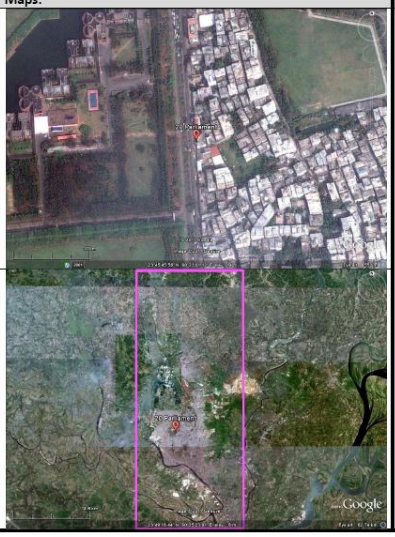
Samplers placed at the balcony in the third floor.

Sampling Site Profile (20)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2feb	10:15	15.feb	08:45	20	Parliament site	23.762607	90.383600	32	47	06 BS			6m	U/B/C	Yes

Pictures:

Maps:



Comments:

Samples placed on the roof of the monitoring station at the Parliament site

Sampling Site Profile (21)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2feb	10:40	15.feb	07:35	21	BARC, Farmgate	23.710343	90.389446	36	50	07 BS			10m	U/T/C	Yes

Pictures:

Maps:

Comments:

The samples are placed on the wind mast on top of the monitoring station at Farmgate

Sampling Site Profile (22)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2feb	12:10	13.feb	17:10	22	Newspaper, Mas 10	23.710342	90.446725	37	41	08 BS			3m	U/B	Yes

Pictures:

Maps:

Comments:

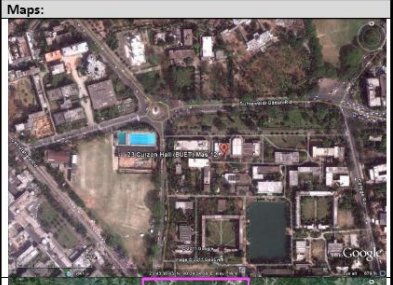
Samplers placed on roof of the Intefaqq Newspaper building. Samplers under the roof

Sampling Site Profile (23)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2feb	13:10	14.feb	13:55	23	Karzon Hall, Mas12	23.727222	90.40167	33	46	09 BS		University	8m	U/B	Yes

Pictures:

Maps:



Comments:

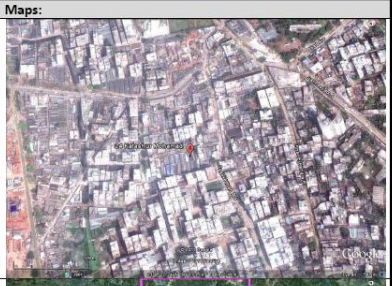
Samplers placed under window second floor of the University building, Chemical Dept. Facing south

Sampling Site Profile (24)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2feb	14:30	14.feb	09:35	24	Katashur Mohamad	23.755501	90.359738	35	48	10 BS		Private house	12m	S/B/R	

Pictures:

Maps:



Comments:

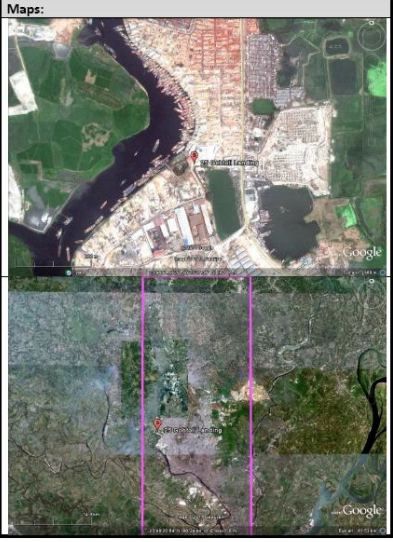
Samplers placed on the balcony third floor in private home, at Mr Onindo-
The house owner kept the sampler boxes until collection.

Sampling Site Profile (25)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2feb	15:30	13.feb	16:30	25	Gobtoli Landing	23.777883	90.338051	19	49	-		On post	2m	S/I	Yes

Pictures:

Maps:



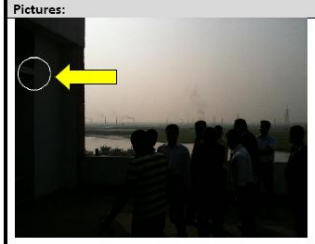
Comments:

Samplers placed on the back of a pole along right side of the walk road from building towards the sea.

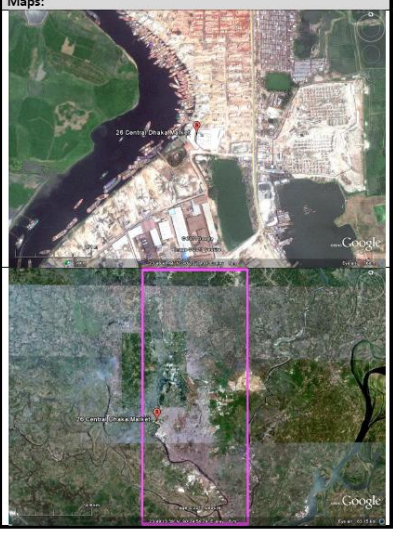
Sampling Site Profile (26)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2feb	15:35	13.feb	16:36	26	Central Dh marked	23.778272	90.338114	02	-	-		On roof	12m	S/I	Yes

Pictures:



Maps:



Comments:

One sampler placed above right hand window at the second floor (balcony platform) of the Cental Dhaka Marked building. Sampler on the top outside one window.

Sampling Site Profile (27)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	16:44	14.feb	13:55	27	S-18(Shamim_Sis)	23°45'38.41"	90°21'57.73"	24	07	-		2nd floor	8m	U(R)	

Pictures:	Maps:	Comments:
		

Sampling Site Profile (28)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1 feb	17:06	14.feb	13:30	28	S-16(Shamim)	23°45'59.29"	90°21'27.75"	27	09	-		2nd floor	U/R	U/R	

Pictures:	Maps:	Comments:
		

Sampling Site Profile (29)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	20:15	14.feb	20:56	29	S-04(Tech)	23°43'55.65"	90°25'45.00"	28	34	-		2^{nd} floor	8m	U/R	

Pictures:

Maps:

Comments:

Sampling Site Profile (30)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	17:44	13.feb	20:11	30	S-07(Faruq)	23°44'49.25"	90°23'11.21"	30	08	-		2^{nd} floor	8m	U/R	

Pictures:

Maps:

Comments:

Sampling Site Profile (31)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	20:18	13.feb	21:58	31	S-06(paps)	23°44'54.76"	90°22'5.63"	26	06	-		1st floor	9m	U/R	

Pictures:	Maps:	Comments:
		

Sampling Site Profile (32)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	22:00	13.feb	23:20	32	S-01(Mine)	23°47'0.38"N	90°25'30.27"	41	32	-		1st floor	6m	U/R	

Pictures:	Maps:	Comments:
		

Sampling Site Profile (33)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2 Feb	13:17	14.feb	16:40	33	S-25(AECD)	23°43'51.32"	90°23'47.32"	50	39	20 S		1st floor	5m	U/R	
Pictures:						Maps:							Comments:		

Sampling Site Profile (34)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2 Feb	14:23	14.feb	14:03	34	S-26(S.Bank)	23°45'24.33"	90°22'29.22"	49	37	-		1st floor	5m	U/T	
Pictures:						Maps:							Comments:		

Sampling Site Profile (35)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2 Feb	17:35	14.feb	10:25	35	S-23(IUCN)	23°46'40.06"	90°25'7.13"	46	40	21S		2nd floor	8m	U/R	

Pictures:

Maps:

Comments:

Sampling Site Profile (36)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2 Feb	18:17	13.feb	17:50	36	S-08(Bilkis)	23°46'54.14"	90°24'4.26"	45	33	22S		1st floor	6m	U/R	

Pictures:

Maps:

Comments:

Sampling Site Profile (37)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2 Feb	20:45	14.feb	09:10	37	S-02(Uncle)	23°46'35.04"	90°25'25.94"	44	10	-		1st floor	5m	U/R	

Pictures:

Maps:

Comments:

Sampling Site Profile (38)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2 Feb	21:35	15.feb	08:10	38	S-03(Bro)	23°46'50.71"	90°25'40.93"	43	36	-		2nd floor	8m	U/R	

Pictures:

Maps:

Comments:

Sampling Site Profile (39)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2 Feb	23:47	14.feb	13:15	39	S-27(Sumon)	23°44'43.19"	90°22'10.23"	47	38	-		1st floor	6m	U/R	

Pictures:

Maps:

Comments:

Sampling Site Profile (40)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
5 Feb	12:57	14.feb	06:58	40	S-20 (Jahur_Frn)	23°43'42.01"	90°23'4.28"E	48	35	-		2nd floor	8m	U/T	

Pictures:

Maps:

Comments:

Sampling Site Profile (41)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
6 Feb	23:30	13.feb	22:45	41	S-28 (Dr.Nasir)	23°44'30.76"	90°22'46.24"	42	31			2nd floor	8m	U/R	

Pictures:

Maps:

Comments:

Sampling Site Profile (42)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	21:25	14.feb	07:25	42	S_10(SKB)	23°43'53.29"	90°23'8.02"	14	25	-		1st floor	5m	U	

Pictures:

Maps:

Comments:

Sampling Site Profile (43)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2 Feb	08:35	13.feb	09:15	43	S_11(SKB)	23°44'11.98"	90°23'14.34"	12	27	-		2nd floor	11m	U	
Pictures:						Maps:							Comments:		

Sampling Site Profile (44)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2 Feb	20:45	12.feb	17:25	44	S_13(SKB)	23°45'1.81"	90°21'58.16"	13	24	-		3rd floor	9m	U	
Pictures:						Maps:							Comments:		

Sampling Site Profile (45)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
3 Feb	18:30	13.feb	20:35	45	S_12(SKB)	23°43'6.32"	90°24'42.38"	11	26	-		1st floor	5m	U	

Pictures:	Maps:	Comments:
		

Sampling Site Profile (46)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
1feb	21:36	13feb	15:15	46	Masuds house	23°46'51.75"	90°22'4.11"	5	18					S/B/R	

Pictures:	Maps:	Comments:
		

Sampling Site Profile (47)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2 Feb	19:00	14feb	19:02	47	Shapan Shirdo med	23°43'60.00"	90°21'43.00"	4	13						

Pictures:	Maps:	Comments:
		

Sampling Site Profile (48)

Sampling period				Site name		Location		Sampler identification					Other Info		
From:		To:						SO_2	NO2	Ozone	PM	comments			
date	hr.	date	hr.	#	Name	North	East	(red)	(blue)				Hgt.	Class	Pic
2 Feb	20:50	13feb	18:45	48	Liton's house	23°48'12.00"	90°22'22.00"	6	11						

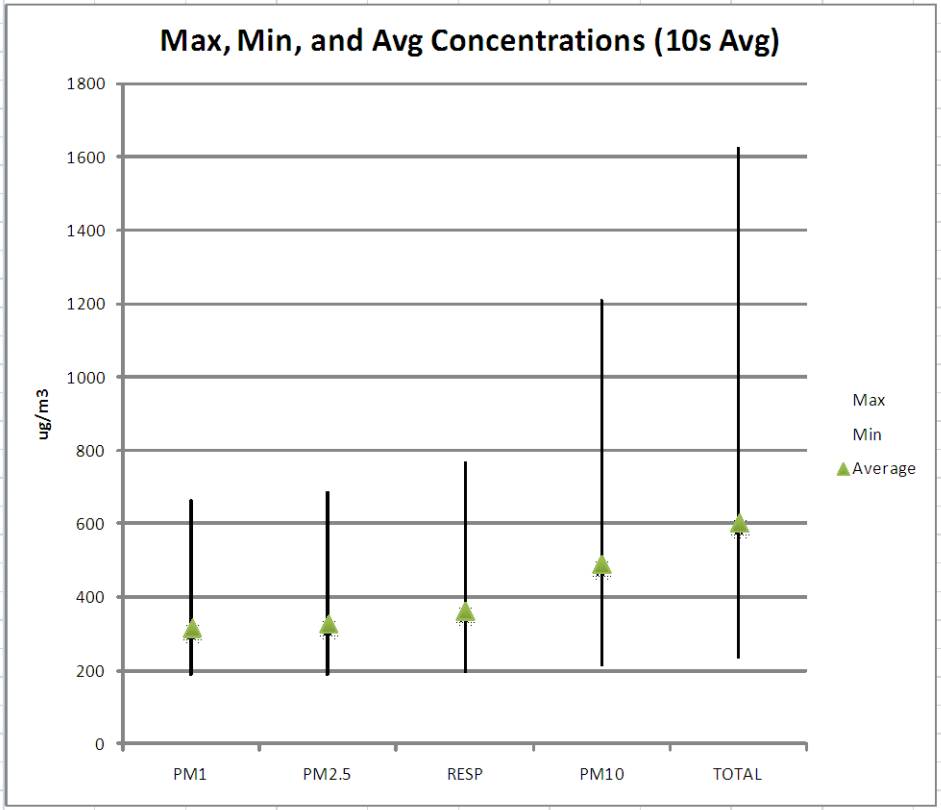
Pictures:	Maps:	Comments:
		

Appendix E

PM Sampling Site Profiles

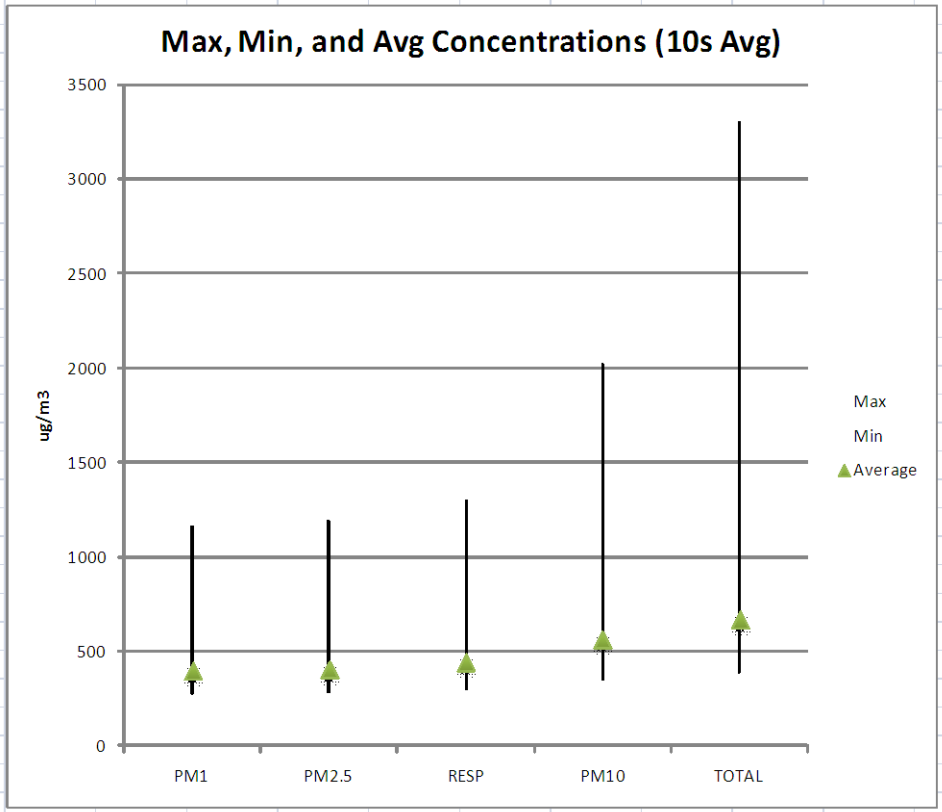
SITE 1A

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	2				
Test Abbreviation:	MANUAL_002				
Start Date:	03.02.2011				
Start Time:	16:41:06			SITE 1A	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°47'25.12"N	
Log Interval (mm:ss):	00:01:00		Long	90°25'1.86"E	
Number of points:	1800				
Notes:	On Road 111 in Gulshan in front of Norwegian Embassy				
	h=1m, SR/BS				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	319	328	361	491	603
10s Average Minimum:	186	189	196	215	233
Time of Minimum:					
Date of Minimum:	03.02.2011	03.02.2011	03.02.2011	03.02.2011	03.02.2011
10s Average Maximum:	665	686	769	1211	1624
Time of Maximum:					
Date of Maximum:	03.02.2011	03.02.2011	03.02.2011	03.02.2011	03.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	665.2	686.1	769.1	1211	1624
Min	186.2	188.7	195.9	214.6	232.7
Average	318.6533333	328.335	361.483889	491.1955556	603.242222



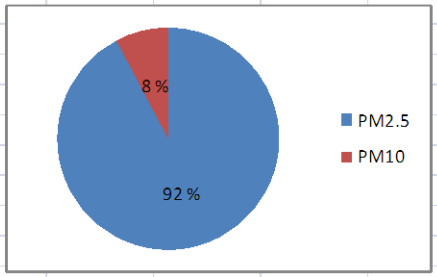
SITE 1B

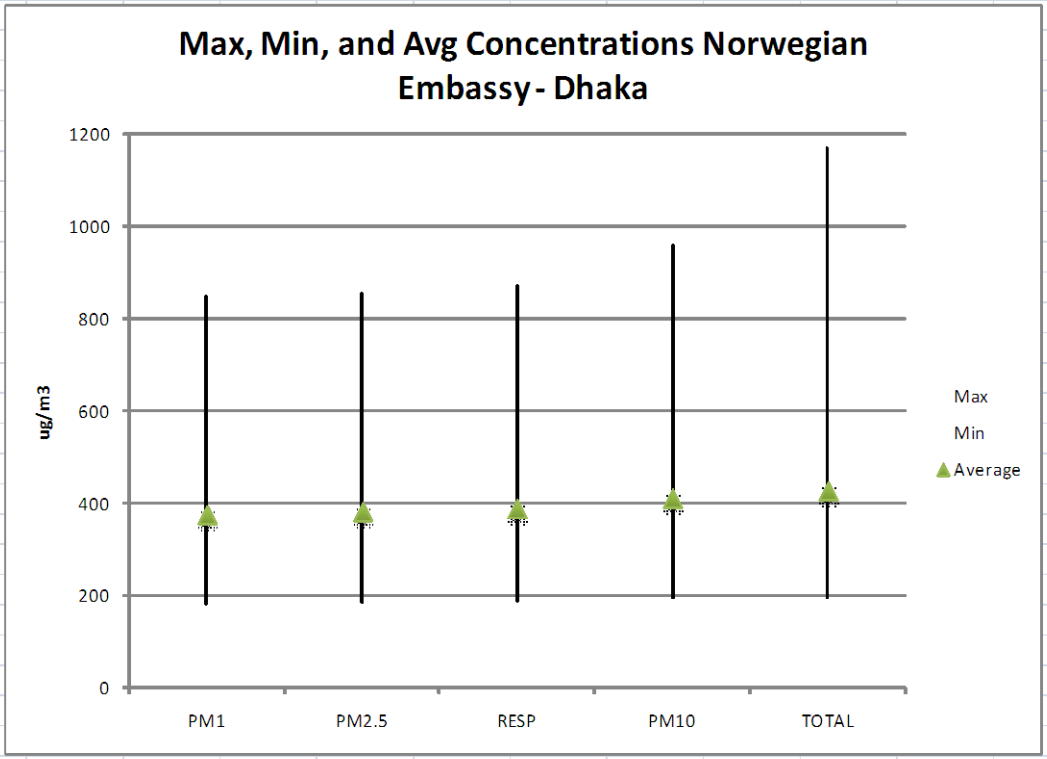
TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	3				
Test Abbreviation:	MANUAL_003				
Start Date:	03.02.2011				
Start Time:	17:18:05			SITE 1B	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°47'23.48"N	
Log Interval (mm:ss):	00:01:00		Long	90°24'58.93"E	
Number of points:	1800				
Notes:	On Gulshan Ave (at Rd 111) over from Norwegian Embassy				
	h=1.5m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	399	409	440	564	666
10s Average Minimum:	272	278	294	348	386
Time of Minimum:					
Date of Minimum:	03.02.2011	03.02.2011	03.02.2011	03.02.2011	03.02.2011
10s Average Maximum:	1164	1190	1298	2021	3303
Time of Maximum:					
Date of Maximum:	03.02.2011	03.02.2011	03.02.2011	03.02.2011	03.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	1163.8	1189.7	1297.8	2021	3303
Min	271.6	277.8	294.2	348.4	386
Average	398.9866667	408.765	440.025556	563.6866667	665.588889



SITE 1C

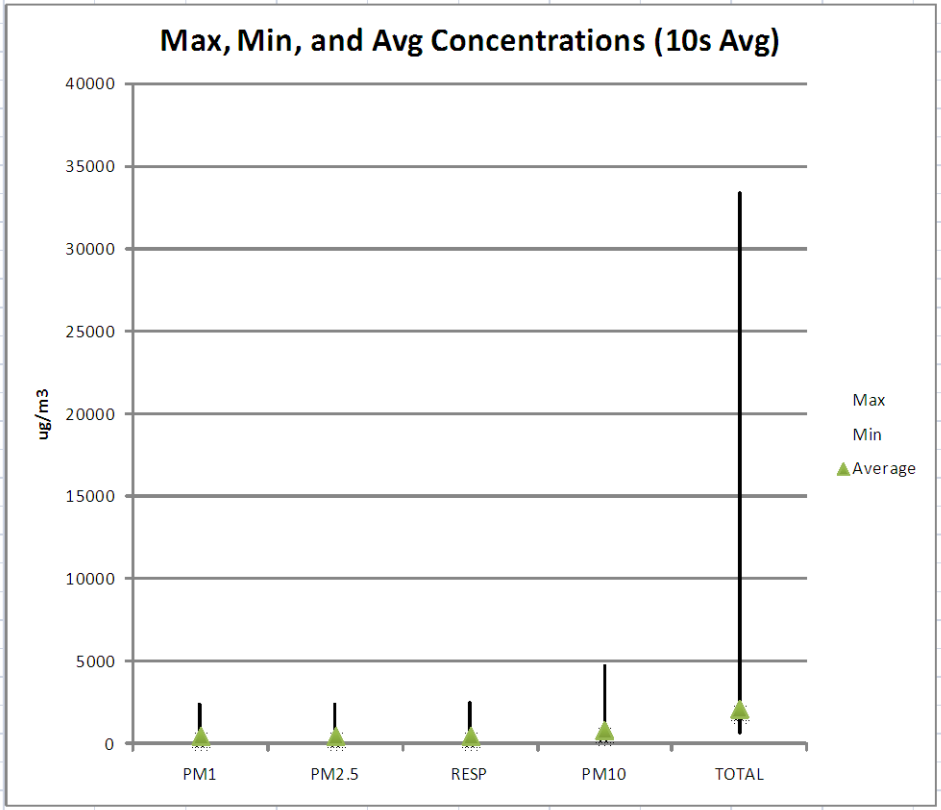
TrakPro Version 4.41 ASCII Data File					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	1				
Test Abbreviatio	MANUAL_001				
Start Date:	14.02.2011				
Start Time:	11:46:29				
Duration (dd:hh:	1:00:00:00				
Log Interval (mm	00:10:00				
Number of point	8640				
Notes:	24hour sample at the Norwegian Embassy Dhaka - Gulshan				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
Average:	376	381	389	413	429
Minimum:	181	183	186	193	193
Time of Minimur	09:54:19	09:54:19	09:55:29	09:56:09	09:56:09
Date of Minimun	15.02.2011	15.02.2011	15.02.2011	15.02.2011	15.02.2011
Maximum:	850	856	871	961	1170
Time of Maximur	20:23:49	20:23:49	20:23:49	07:28:19	07:28:29
Date of Maximur	14.02.2011	14.02.2011	14.02.2011	15.02.2011	15.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	850	856	871	961	1170
Min	181	183	186	193	193
Average	376	381	389	413	429
		92 %		8 %	





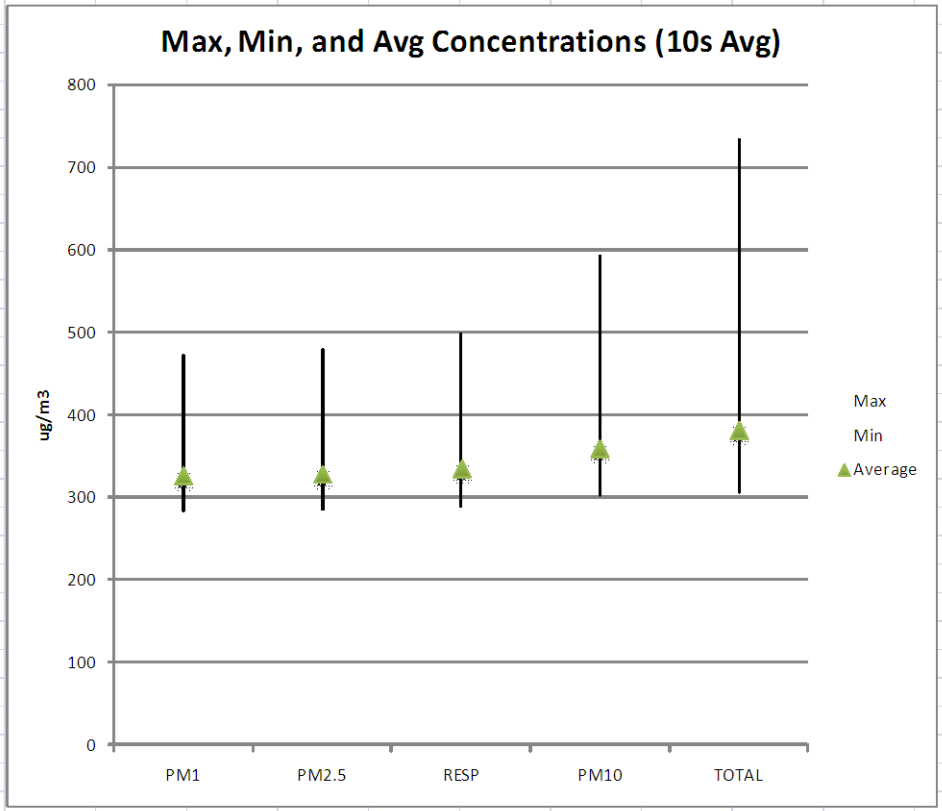
SITE 2

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	6				
Test Abbreviation:	MANUAL_006				
Start Date:	04.02.2011				
Start Time:	11:55:52			SITE 2	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°47'23.35"N	
Log Interval (mm:ss):	00:01:00		Long	90°19'20.49"E	
Number of points:	1800				
Notes:	Along Mirpur Road after bridge on left-hand side, next to billboard				
	h=.3m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	470	487	504	806	2104
10s Average Minimum:	321	333	339	434	623
Time of Minimum:					
Date of Minimum:	04.02.2011	04.02.2011	04.02.2011	04.02.2011	04.02.2011
10s Average Maximum:	2428	2458	2513	4783	33460
Time of Maximum:					
Date of Maximum:	04.02.2011	04.02.2011	04.02.2011	04.02.2011	04.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	2428.1	2457.7	2513	4783	33460
Min	321.3	332.5	339.4	434.3	622.7
Average	469.9411111	486.928889	503.615556	806.0461111	2103.785



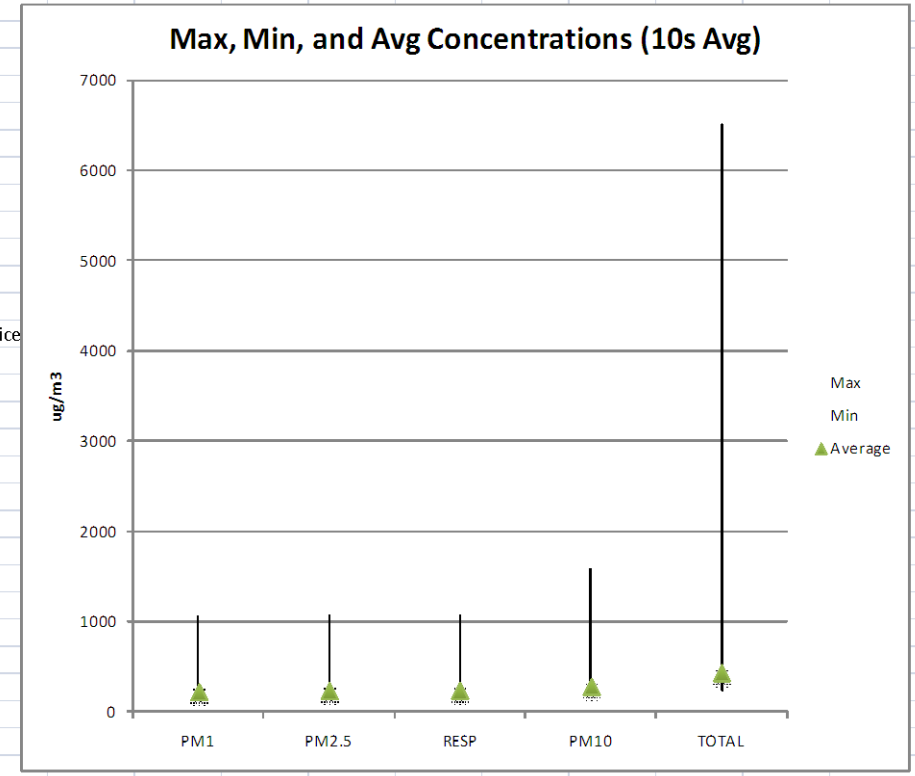
SITE 3

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	7				
Test Abbreviation:	MANUAL_007				
Start Date:	04.02.2011				
Start Time:	13:01:30			SITE 3	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°45'34.95"N	
Log Interval (mm:ss):	00:01:00		Long	90°23'21.89"E	
Number of points:	1800				
Notes:	On roof of Farmgate CAMS station				
	h=9m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	326	329	335	359	381
10s Average Minimum:	283	285	288	303	305
Time of Minimum:					
Date of Minimum:	04.02.2011	04.02.2011	04.02.2011	04.02.2011	04.02.2011
10s Average Maximum:	473	479	498	593	735
Time of Maximum:					
Date of Maximum:	04.02.2011	04.02.2011	04.02.2011	04.02.2011	04.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	472.9	478.9	498.3	593.3	734.6
Min	282.5	285	288.3	302.6	305.1
Average	326.1227778	328.755556	335.041667	359.2427778	381.306667



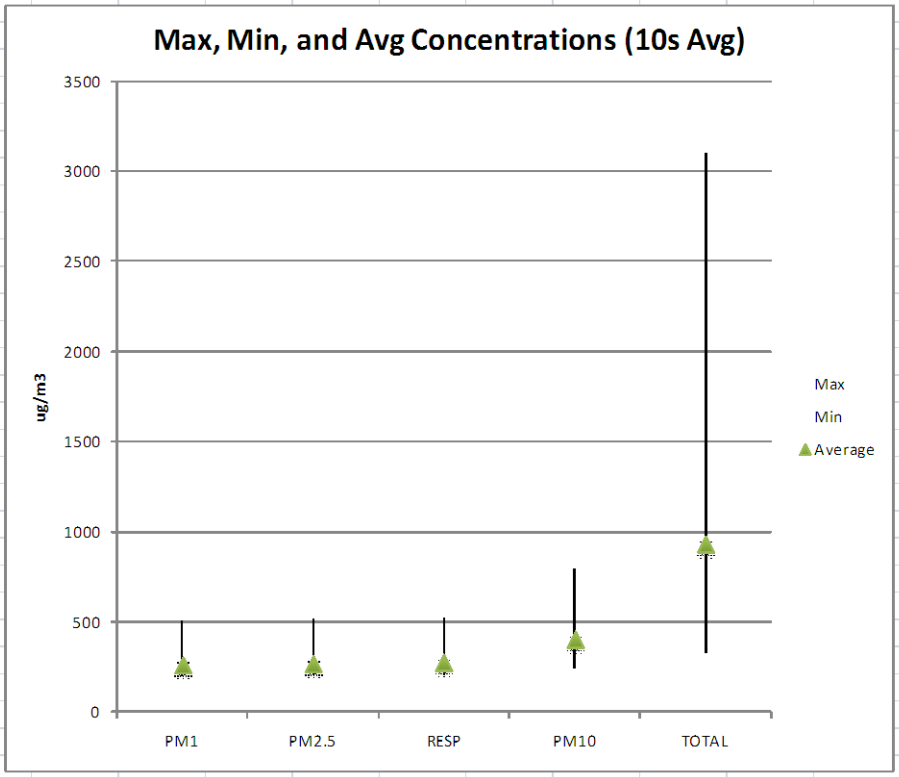
SITE 4

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	1				
Test Abbreviation:	MANUAL_001				
Start Date:	05.02.2011				
Start Time:	13:35:14			SITE 4	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°45'51.54"N	
Log Interval (mm:ss):	00:01:00		Long	90°25'48.64"E	
Number of points:	1800				
Notes:	Down road from TV tower inAftabnagar, along river (Note: small open air burning notice				
	h=.5m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	231	236	239	288	433
10s Average Minimum:	199	202	205	224	232
Time of Minimum:					
Date of Minimum:	05.02.2011	05.02.2011	05.02.2011	05.02.2011	05.02.2011
10s Average Maximum:	1065	1073	1083	1588	6507
Time of Maximum:					
Date of Maximum:	05.02.2011	05.02.2011	05.02.2011	05.02.2011	05.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	1065	1072.5	1083	1588.2	6507
Min	198.5	202.1	205	224.1	231.7
Average	231.49	235.737778	239.231111	287.8222222	433.013333



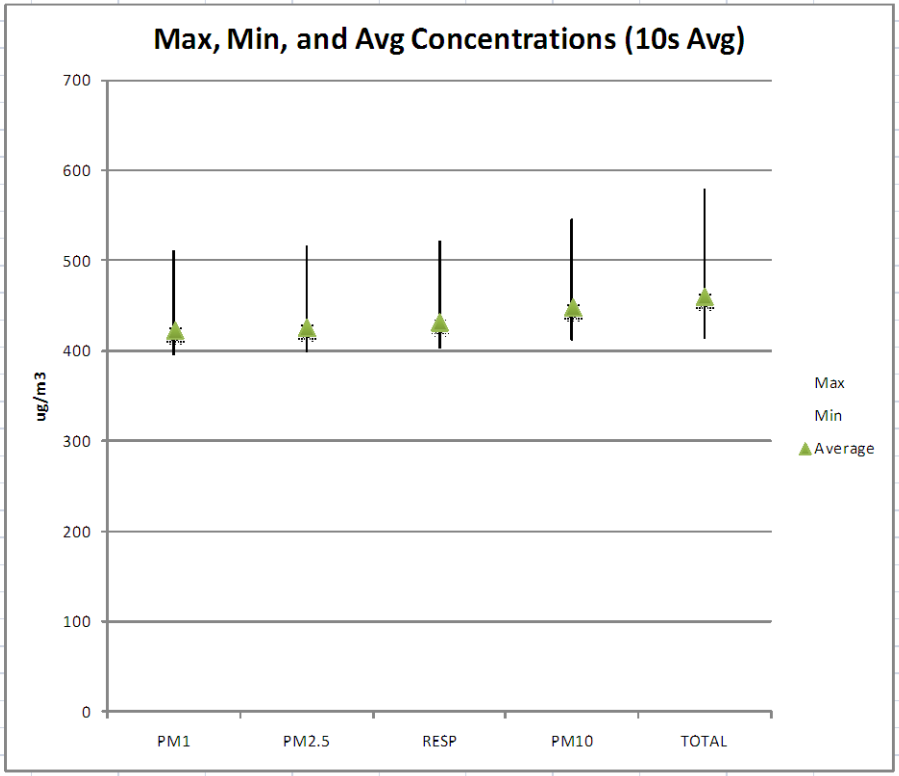
SITE 5

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	2				
Test Abbreviation:	MANUAL_002				
Start Date:	05.02.2011				
Start Time:	14:26:03			SITE 5	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°44'22.20"N	
Log Interval (mm:ss):	00:01:00		Long	90°25'11.17"E	
Number of points:	1800				
Notes:	Along DIT Extension Road in Paltan area, across from Rajarbag police line				
	h=1.5m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	266	272	278	409	934
10s Average Minimum:	201	205	208	243	328
Time of Minimum:					
Date of Minimum:	05.02.2011	05.02.2011	05.02.2011	05.02.2011	05.02.2011
10s Average Maximum:	506	512	520	794	3102
Time of Maximum:					
Date of Maximum:	05.02.2011	05.02.2011	05.02.2011	05.02.2011	05.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	505.5	511.7	519.5	794.3	3102
Min	200.8	204.7	207.5	243.3	328.4
Average	266.2333333	271.825556	278.115556	409.4905556	933.830556



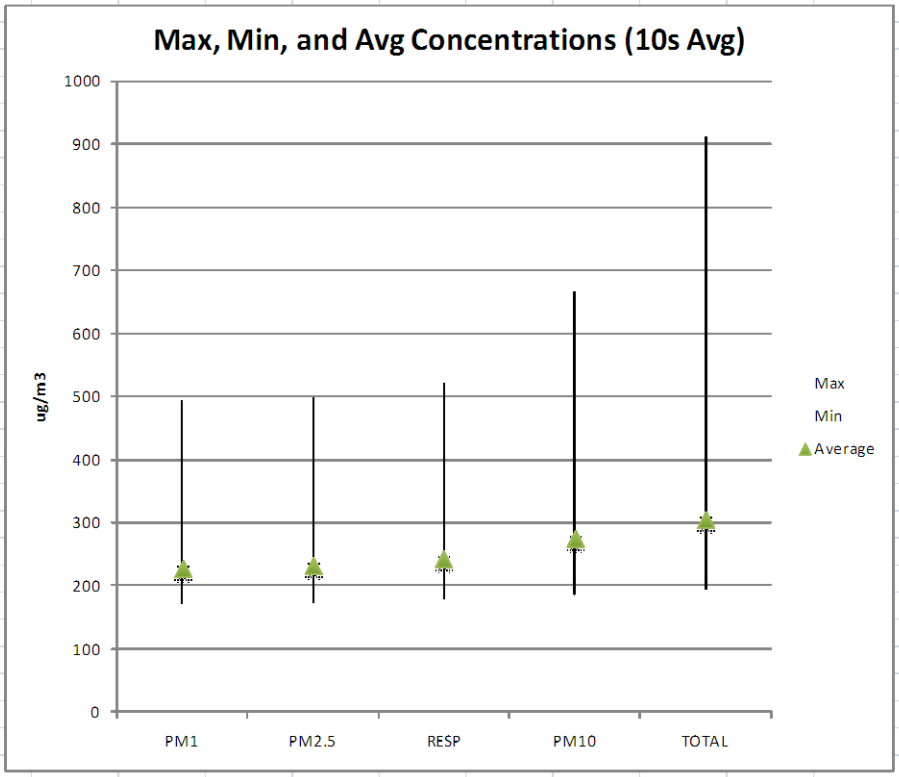
SITE 6

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	1				
Test Abbreviation:	MANUAL_001				
Start Date:	09.02.2011				
Start Time:	10:44:13			SITE 6	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°45'44.90"N	
Log Interval (mm:ss):	00:01:00		Long	90°23'0.16"E	
Number of points:	1800				
Notes:	On Rokeyasmarony Rd, 130m east from CAMS station				
	h=1.5m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	424	427	432	448	460
10s Average Minimum:	396	399	403	412	414
Time of Minimum:					
Date of Minimum:	09.02.2011	09.02.2011	09.02.2011	09.02.2011	09.02.2011
10s Average Maximum:	512	515	521	546	579
Time of Maximum:					
Date of Maximum:	09.02.2011	09.02.2011	09.02.2011	09.02.2011	09.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	511.9	515.4	521.4	546	578.7
Min	395.9	398.7	402.7	412.4	413.6
Average	423.8977778	426.89	431.978889	448.1755556	460.109444



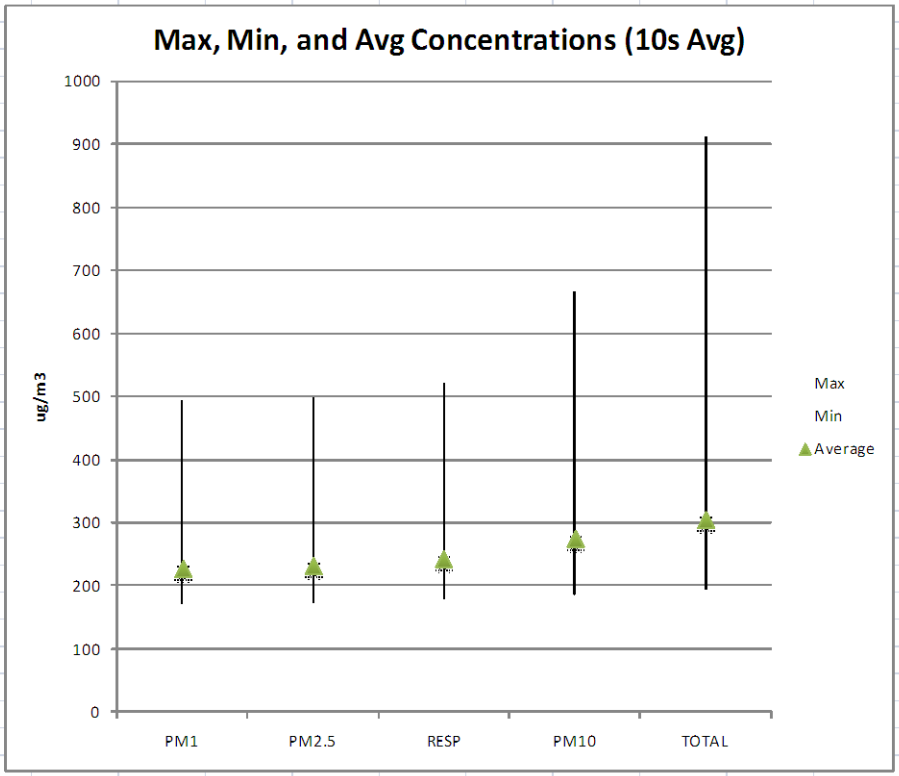
SITE 7

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	3				
Test Abbreviation:	MANUAL_003				
Start Date:	09.02.2011				
Start Time:	12:38:26			SITE 7	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°44'54.85"N	
Log Interval (mm:ss):	00:01:00		Long	90°22'11.76"E	
Number of points:	1800				
Notes:	On satmasjid road (primary road side)				
	h=3m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	229	233	242	275	305
10s Average Minimum:	171	174	179	185	195
Time of Minimum:					
Date of Minimum:	09.02.2011	09.02.2011	09.02.2011	09.02.2011	09.02.2011
10s Average Maximum:	493	499	521	666	912
Time of Maximum:					
Date of Maximum:	09.02.2011	09.02.2011	09.02.2011	09.02.2011	09.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	492.8	498.9	521.2	666	912
Min	171.2	173.9	178.5	185.3	194.6
Average	228.9055556	232.921667	242.232222	275.2983333	304.685



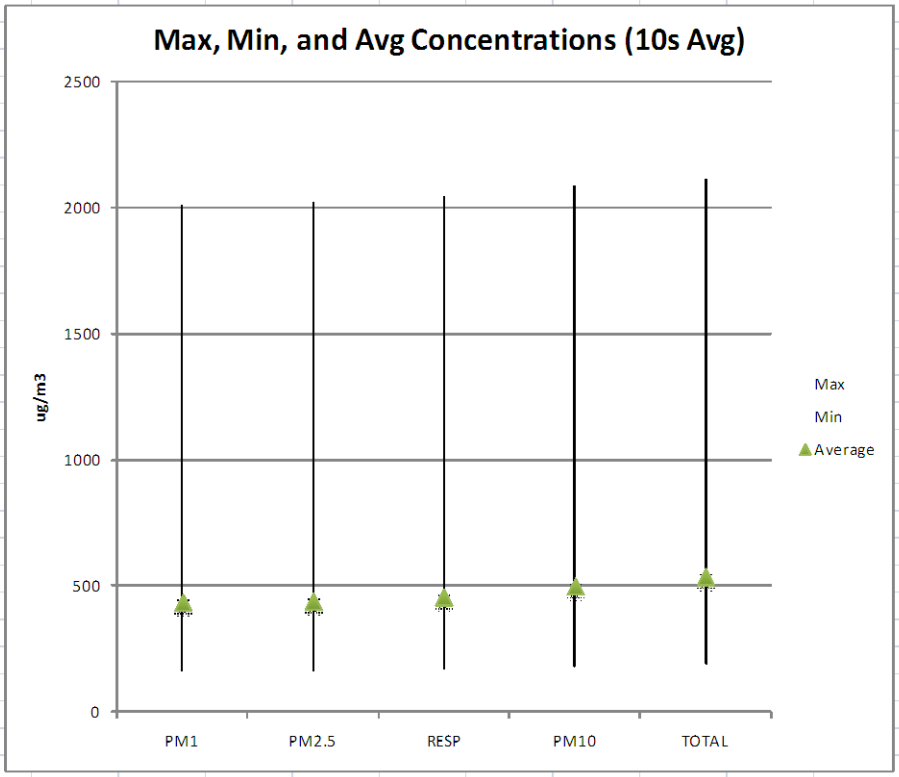
SITE 7

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	3				
Test Abbreviation:	MANUAL_003				
Start Date:	09.02.2011				
Start Time:	12:38:26			SITE 7	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°44'54.85"N	
Log Interval (mm:ss):	00:01:00		Long	90°22'11.76"E	
Number of points:	1800				
Notes:	On satmasjid road (primary road side)				
	h=3m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	229	233	242	275	305
10s Average Minimum:	171	174	179	185	195
Time of Minimum:					
Date of Minimum:	09.02.2011	09.02.2011	09.02.2011	09.02.2011	09.02.2011
10s Average Maximum:	493	499	521	666	912
Time of Maximum:					
Date of Maximum:	09.02.2011	09.02.2011	09.02.2011	09.02.2011	09.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	492.8	498.9	521.2	666	912
Min	171.2	173.9	178.5	185.3	194.6
Average	228.9055556	232.921667	242.232222	275.2983333	304.685



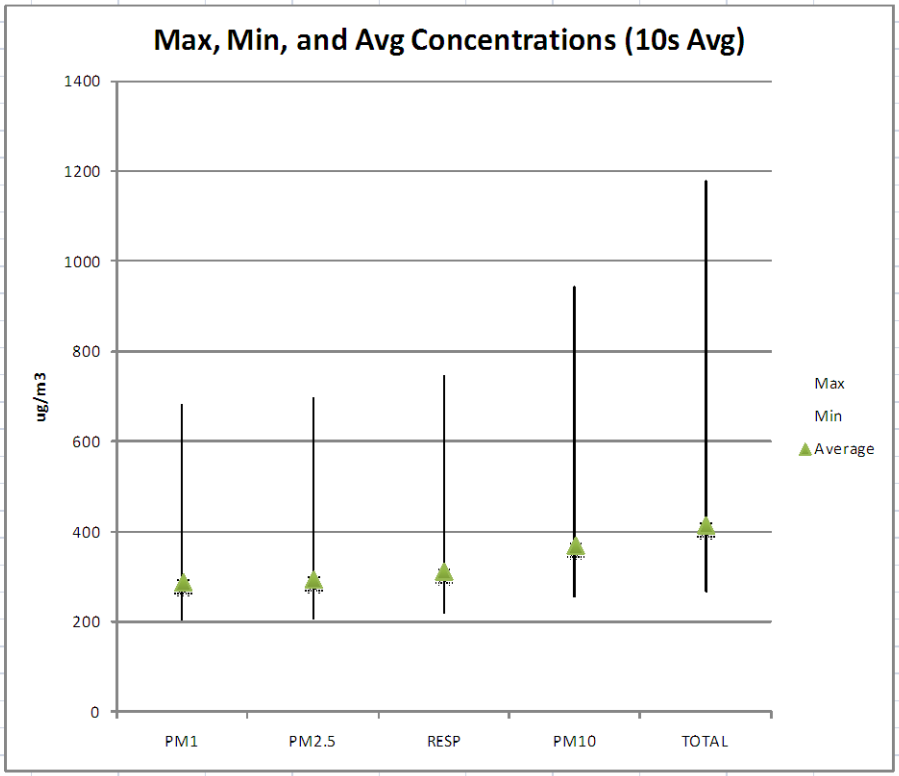
SITE 8A

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	4				
Test Abbreviation:	MANUAL_004				
Start Date:	09.02.2011				
Start Time:	15:57:17			SITE 8A	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°45'34.12"N	
Log Interval (mm:ss):	00:01:00		Long	90°23'58.34"E	
Number of points:	1800				
Notes:	Along Tejgaion Road (primary road side) (NOTE: open fire 150m North)				
	h=				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	435	442	455	501	539
10s Average Minimum:	163	165	170	181	190
Time of Minimum:					
Date of Minimum:	09.02.2011	09.02.2011	09.02.2011	09.02.2011	09.02.2011
10s Average Maximum:	2009	2022	2040	2082	2112
Time of Maximum:					
Date of Maximum:	09.02.2011	09.02.2011	09.02.2011	09.02.2011	09.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	2009	2022	2040	2082	2112
Min	162.7	165.1	169.7	180.5	190.2
Average	435.4588889	441.709444	454.862222	501.1761111	539.048889



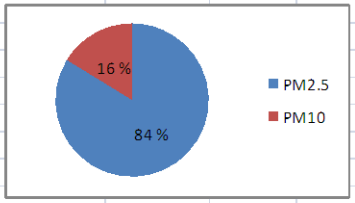
SITE 8B

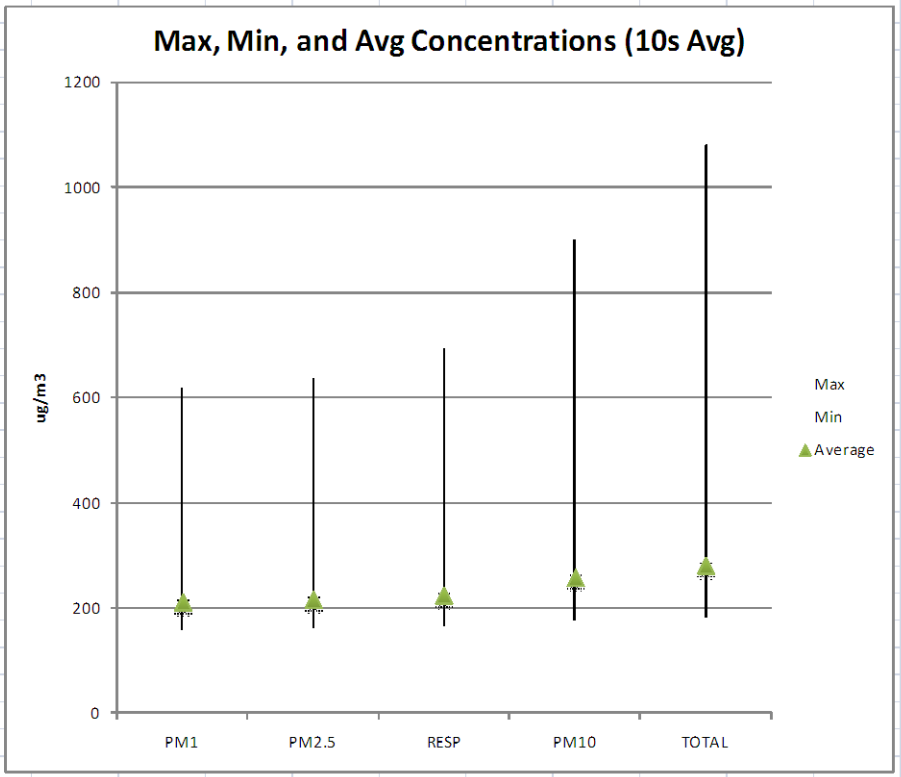
TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	5				
Test Abbreviation:	MANUAL_005				
Start Date:	09.02.2011				
Start Time:	16:33:23			SITE 8B	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°45'34.42"N	
Log Interval (mm:ss):	00:01:00		Long	90°24'1.53"E	
Number of points:	1800				
Notes:	Off Tejgaoin Road (Diffuse industry road)				
	h=				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	289	295	312	372	416
10s Average Minimum:	203	207	218	256	267
Time of Minimum:					
Date of Minimum:	09.02.2011	09.02.2011	09.02.2011	09.02.2011	09.02.2011
10s Average Maximum:	682	697	745	943	1180
Time of Maximum:					
Date of Maximum:	09.02.2011	09.02.2011	09.02.2011	09.02.2011	09.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	682.4	696.8	744.7	942.9	1180.1
Min	203.1	207.3	218.3	255.6	267.1
Average	288.5044444	295.378889	311.9	371.5905556	416.173333



SITE 9A

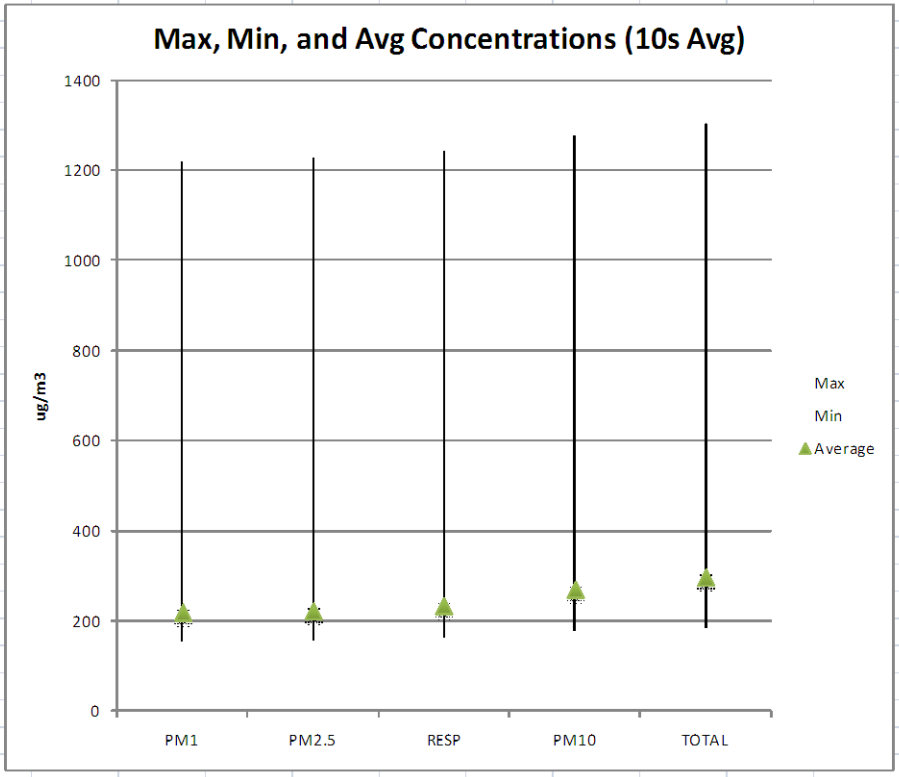
TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	1				
Test Abbreviation:	MANUAL_001				
Start Date:	10.02.2011				
Start Time:	10:35:41			SITE 9A	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°51'32.91"N	
Log Interval (mm:ss):	00:01:00		Long	90°24'3.76"E	
Number of points:	1800				
Notes:	North of Main Airport on Airport Road on west side of road.				
	h=1.5m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	212	216	226	258	282
10s Average Minimum:	158	162	168	178	181
Time of Minimum:					
Date of Minimum:	10.02.2011	10.02.2011	10.02.2011	10.02.2011	10.02.2011
10s Average Maximum:	618	636	692	900	1080
Time of Maximum:					
Date of Maximum:	10.02.2011	10.02.2011	10.02.2011	10.02.2011	10.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	618.3	636.2	691.9	899.5	1079.6
Min	158.1	161.5	167.6	177.8	180.7
Average	212.1261111	216.398889	225.596111	258.3805556	282.086667
		84 %		16 %	





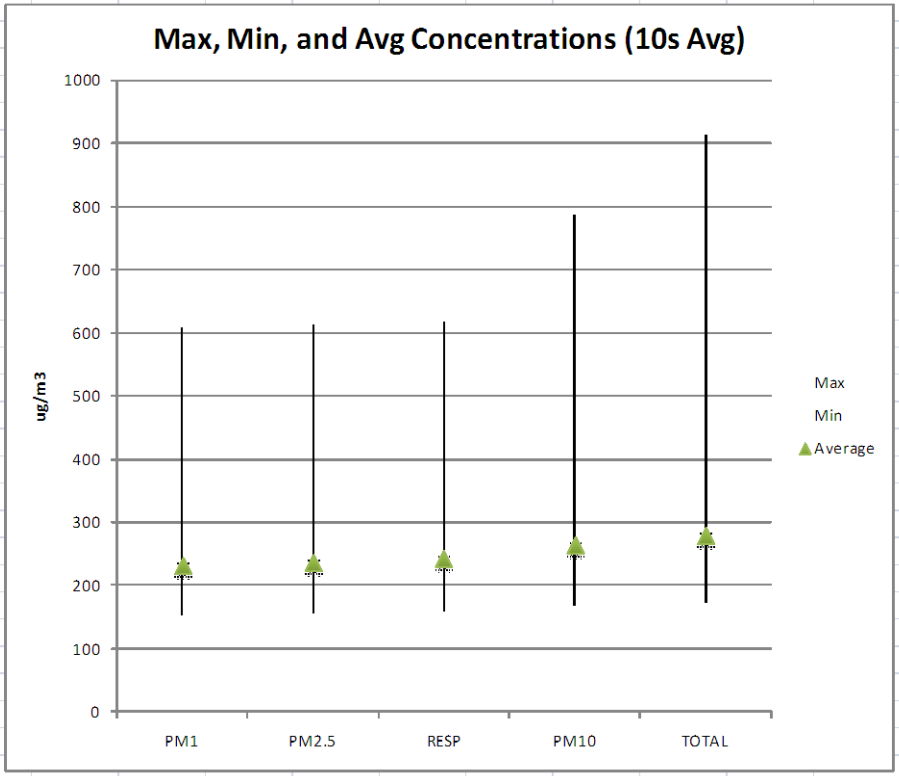
SITE 9B

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	2				
Test Abbreviation:	MANUAL_002				
Start Date:	10.02.2011				
Start Time:	11:12:07			SITE 9B	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°51'39.37"N	
Log Interval (mm:ss):	00:01:00		Long	90°23'49.15"E	
Number of points:	1800				
Notes:	Along Jashimuddin Rd (off of Airport Road)				
	h=1.5m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	219	224	234	272	297
10s Average Minimum:	156	159	163	179	184
Time of Minimum:					
Date of Minimum:	10.02.2011	10.02.2011	10.02.2011	10.02.2011	10.02.2011
10s Average Maximum:	1217	1227	1242	1275	1301
Time of Maximum:					
Date of Maximum:	10.02.2011	10.02.2011	10.02.2011	10.02.2011	10.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	1217.1	1226.6	1241.8	1274.6	1301.3
Min	156.2	159	163.3	179.1	184
Average	219.0261111	223.65	234.268333	271.9972222	297.285



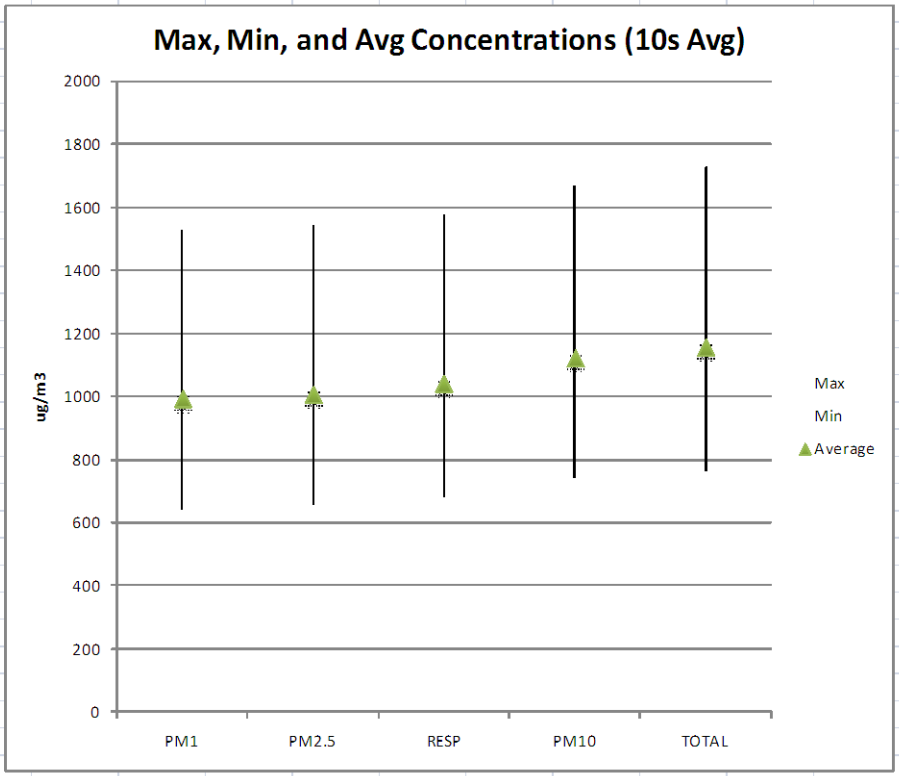
SITE 10

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	3				
Test Abbreviation:	MANUAL_003				
Start Date:	10.02.2011				
Start Time:	11:56:55			SITE 10	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°48'34.74"N	
Log Interval (mm:ss):	00:01:00		Long	90°24'13.38"E	
Number of points:	1800				
Notes:	Along Airport road on east side before train tracks (in Banani)				
	h=1.5m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	232	236	242	265	280
10s Average Minimum:	154	156	160	169	173
Time of Minimum:					
Date of Minimum:	10.02.2011	10.02.2011	10.02.2011	10.02.2011	10.02.2011
10s Average Maximum:	607	611	617	787	913
Time of Maximum:					
Date of Maximum:	10.02.2011	10.02.2011	10.02.2011	10.02.2011	10.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	606.8	611	617.1	787.4	912.9
Min	153.9	155.9	160.1	168.6	173.2
Average	232.4144444	235.631667	242.140556	264.9327778	280.076111



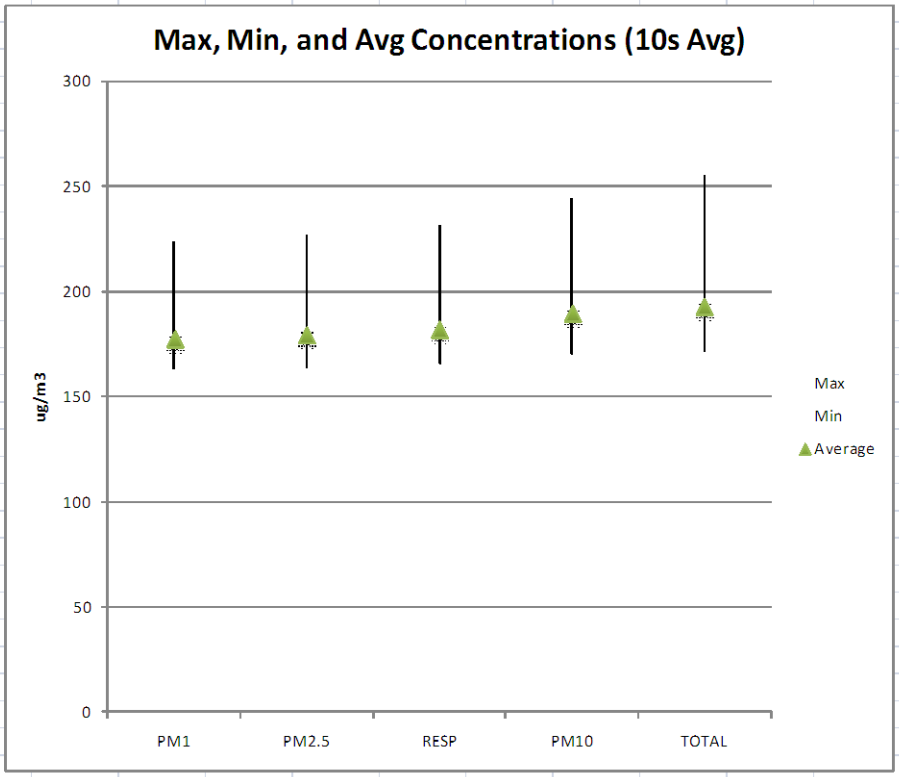
SITE 11A

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	1				
Test Abbreviation:	MANUAL_001				
Start Date:	04.02.2011				
Start Time:	20:04:24			SITE 11A	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°47'35.61"N	
Log Interval (mm:ss):	00:01:00		Long	90°24'52.60"E	
Number of points:	1800				
Notes:	Westin Hotel, 2nd floor balcony facing East (note: 20:15 down wind of open air burning)				
	h=15m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	992	1008	1041	1121	1157
10s Average Minimum:	642	655	682	741	763
Time of Minimum:					
Date of Minimum:	04.02.2011	04.02.2011	04.02.2011	04.02.2011	04.02.2011
10s Average Maximum:	1524	1543	1575	1666	1727
Time of Maximum:					
Date of Maximum:	04.02.2011	04.02.2011	04.02.2011	04.02.2011	04.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	1524	1543	1575	1666	1727
Min	642.1	654.8	682.3	741	762.6
Average	992.3572222	1008.43444	1040.71389	1121.356667	1157.36333



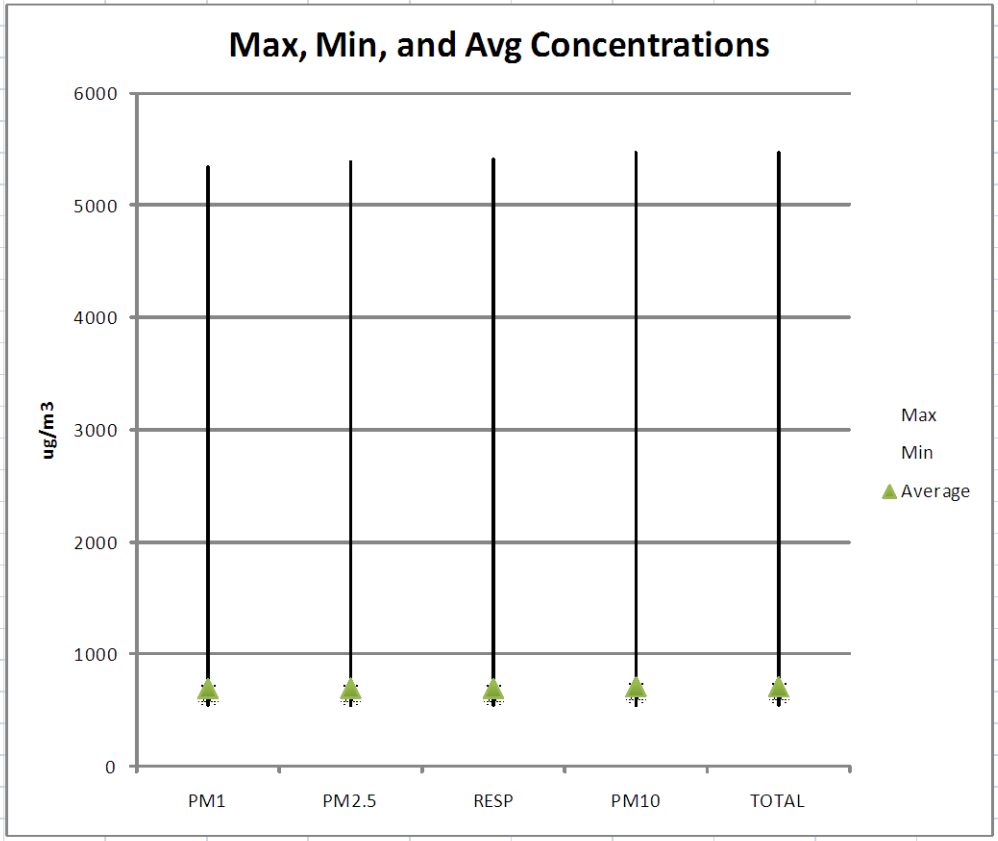
SITE 11B

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	3				
Test Abbreviation:	MANUAL_003				
Start Date:	01.02.2011				
Start Time:	17:31:45			SITE 11B	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°47'35.61"N	
Log Interval (mm:ss):	00:01:00		Long	90°24'52.60"E	
Number of points:	1800				
Notes:	Westin Hotel, 23rd floor				
	h=150m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	178	179	182	190	193
10s Average Minimum:	163	164	166	170	171
Time of Minimum:					
Date of Minimum:	01.02.2011	01.02.2011	01.02.2011	01.02.2011	01.02.2011
10s Average Maximum:	224	227	231	244	255
Time of Maximum:					
Date of Maximum:	01.02.2011	01.02.2011	01.02.2011	01.02.2011	01.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	223.5	226.9	231.2	244.1	255.3
Min	163	163.8	165.5	170	171.1
Average	177.7744444	179.253333	181.820556	189.55	193.110556



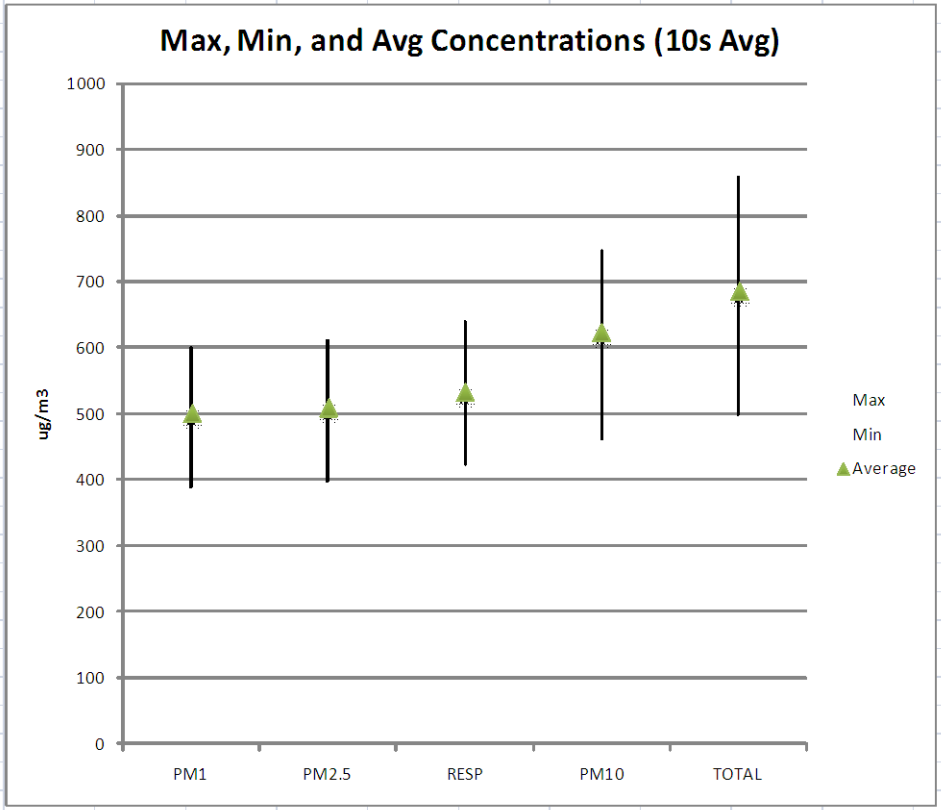
SITE 12

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	1				
Test Abbreviation:	MANUAL_001				
Start Date:	01.02.2011				
Start Time:	09:46:54				
Duration (dd:hh:mm:ss):	0:01:00:00			SITE 12	
Log Interval (mm:ss):	00:01:00		Lat	23°46'36.88"N	
Number of points:	3600		long	90°22'19.85"E	
Notes:	DoE				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
Average:	702	705	708	715	715
Minimum:	537	539	541	544	544
Time of Minimum:	10:36:55	10:36:55	10:36:55	10:36:55	10:36:55
Date of Minimum:	01.02.2011	01.02.2011	01.02.2011	01.02.2011	01.02.2011
Maximum:	5350	5380	5410	5470	5470
Time of Maximum:	10:45:43	10:45:43	10:45:43	10:45:43	10:45:43
Date of Maximum:	01.02.2011	01.02.2011	01.02.2011	01.02.2011	01.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	5350	5380	5410	5470	5470
Min	537	539	541	544	544
Average	702	705	708	715	715



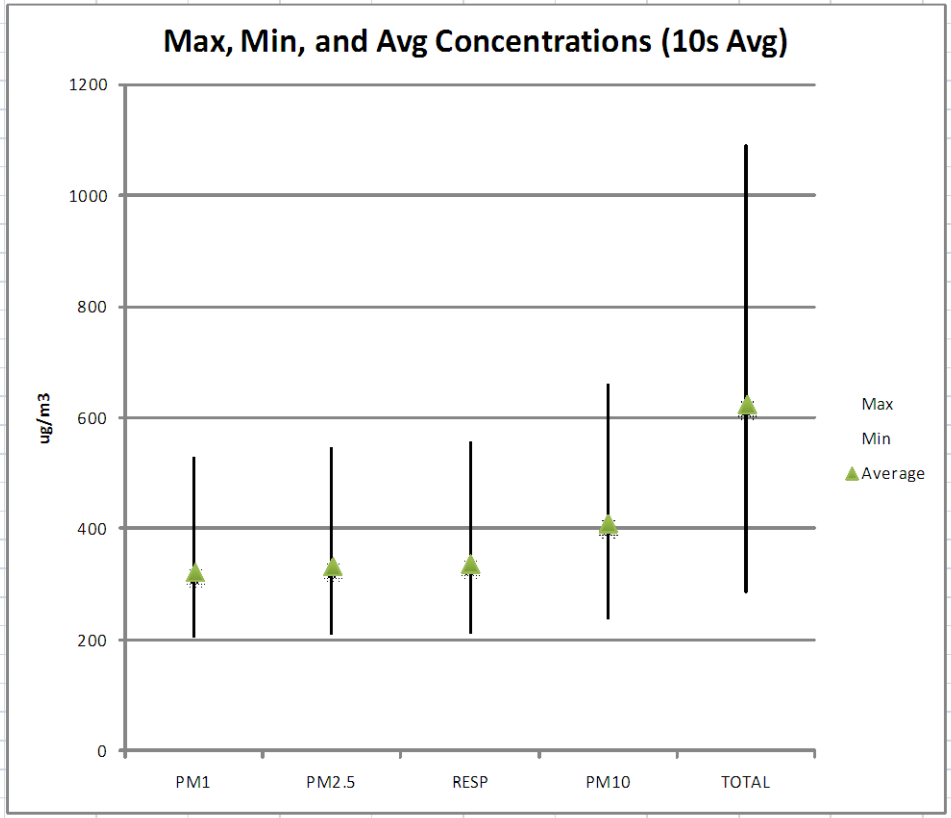
SITE 13

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	4				
Test Abbreviation:	MANUAL_004				
Start Date:	03.02.2011				
Start Time:	18:01:03			SITE 13	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°47'37.96"N	
Log Interval (mm:ss):	00:01:00		Long	90°24'55.47"E	
Number of points:	1800				
Notes:	DCC Market Gulshan, 100m from Gulshan Avenue				
	h=6m (balcony on 2nd floor)				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	500	509	534	624	685
10s Average Minimum:	388	397	422	462	499
Time of Minimum:					
Date of Minimum:	03.02.2011	03.02.2011	03.02.2011	03.02.2011	03.02.2011
10s Average Maximum:	602	611	640	748	859
Time of Maximum:					
Date of Maximum:	03.02.2011	03.02.2011	03.02.2011	03.02.2011	03.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	601.6	611.1	639.8	747.6	859.3
Min	387.6	397.1	421.9	461.9	498.7
Average	500.3644444	509.094444	534.258889	623.5383333	684.994444



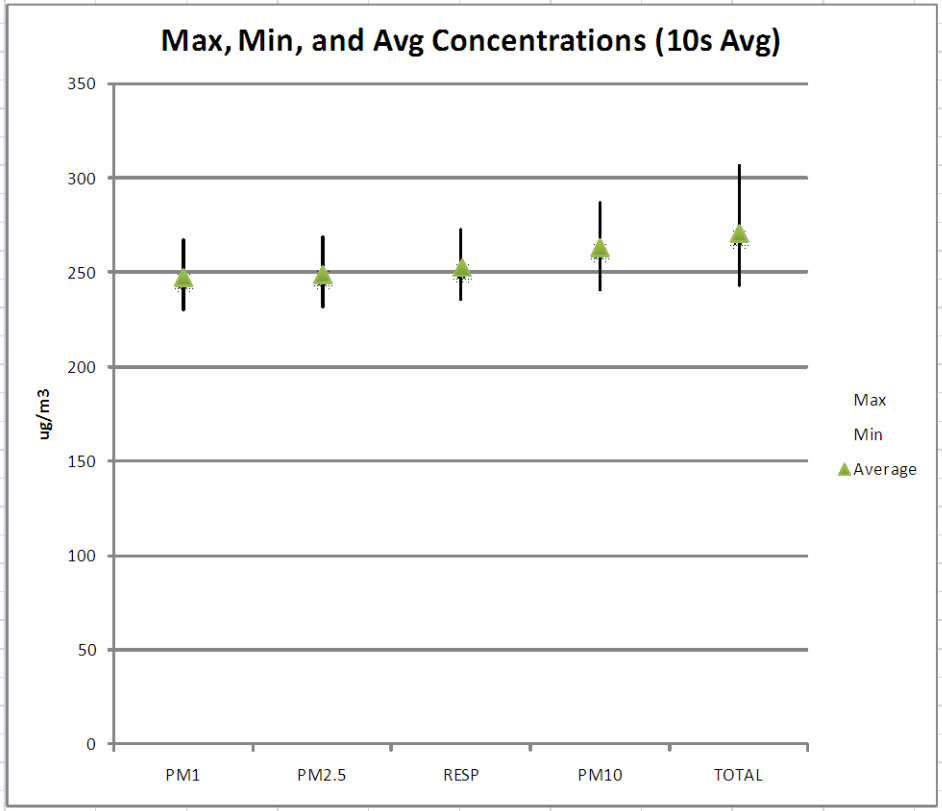
SITE 14

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	5				
Test Abbreviation:	MANUAL_005				
Start Date:	04.02.2011				
Start Time:	11:03:25			SITE 14	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°46'41.32"N	
Log Interval (mm:ss):	00:01:00		Long	90°20'17.88"E	
Number of points:	1800				
Notes:	Top floor of white building in Amin Bazaar (passive sampling here also)				
	h=20m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	322	332	338	410	625
10s Average Minimum:	204	209	212	238	285
Time of Minimum:					
Date of Minimum:	04.02.2011	04.02.2011	04.02.2011	04.02.2011	04.02.2011
10s Average Maximum:	528	545	557	660	1091
Time of Maximum:					
Date of Maximum:	04.02.2011	04.02.2011	04.02.2011	04.02.2011	04.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	528.3	545.1	556.5	660.4	1091.4
Min	203.9	209.4	212	237.8	284.6
Average	321.8855556	331.605	337.915556	409.565	624.945



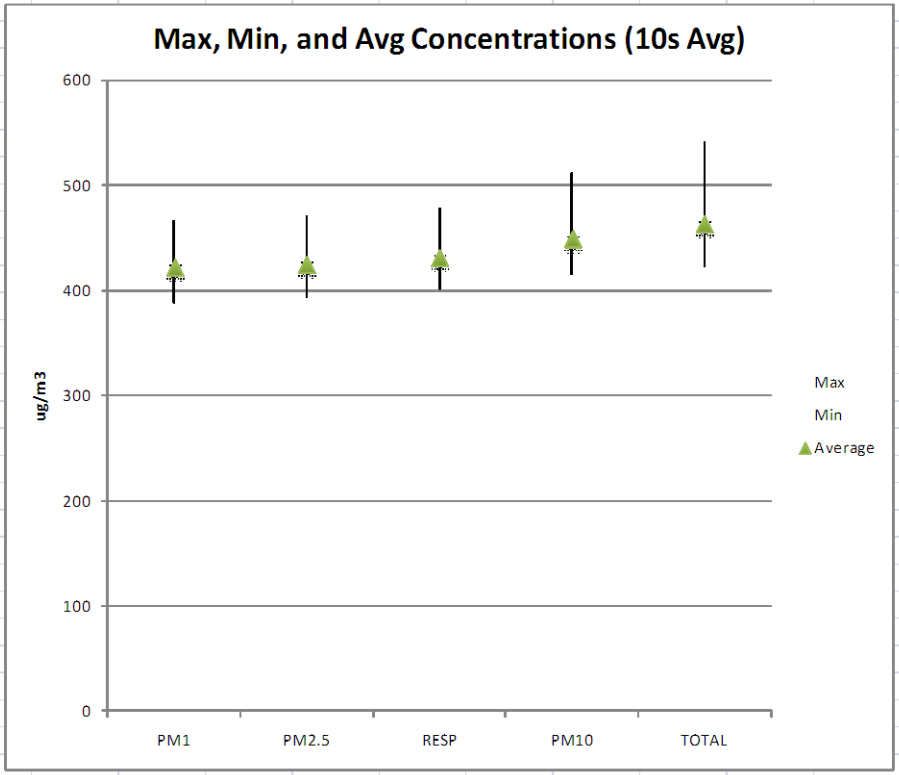
SITE 15

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	8				
Test Abbreviation:	MANUAL_008				
Start Date:	04.02.2011				
Start Time:	14:12:08			SITE 15	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°43'9.32"N	
Log Interval (mm:ss):	00:01:00		Long	90°23'16.54"E	
Number of points:	1800				
Notes:	Near center of Lalberg Fort complex				
	h=2m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	248	249	253	263	271
10s Average Minimum:	230	232	235	240	243
Time of Minimum:					
Date of Minimum:	04.02.2011	04.02.2011	04.02.2011	04.02.2011	04.02.2011
10s Average Maximum:	268	269	273	287	306
Time of Maximum:					
Date of Maximum:	04.02.2011	04.02.2011	04.02.2011	04.02.2011	04.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	267.5	269.4	272.8	287.4	306.4
Min	230.3	231.8	235.2	240.3	242.7
Average	247.8144444	249.488889	252.678889	263.1605556	271.096111



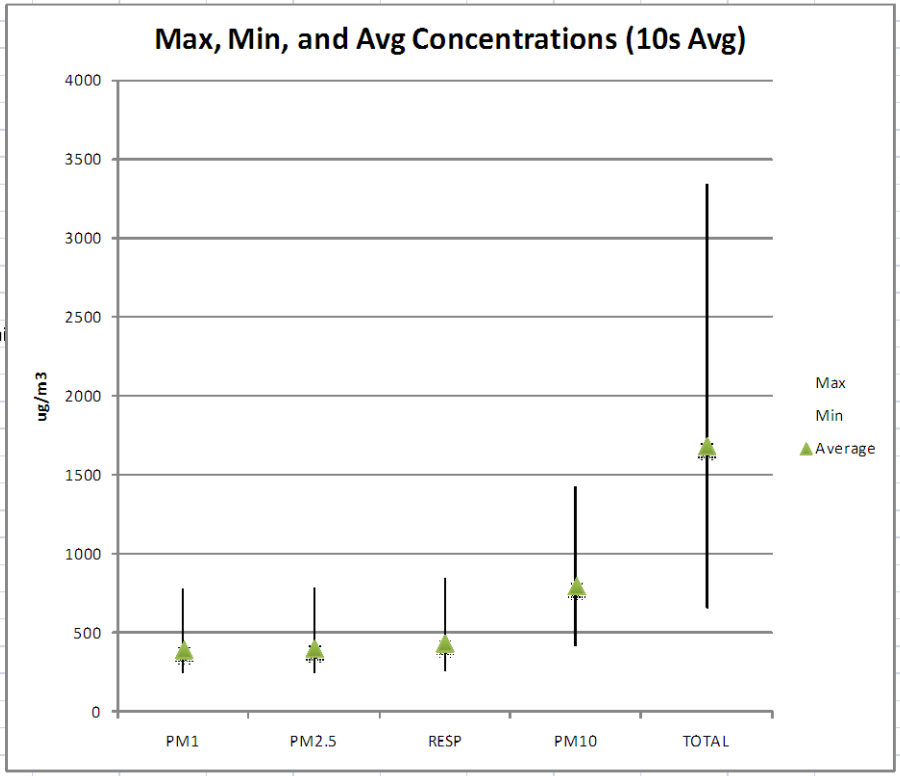
SITE 16

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	2				
Test Abbreviation:	MANUAL_002				
Start Date:	09.02.2011				
Start Time:	11:40:00			SITE 16	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°45'45.13"N	
Log Interval (mm:ss):	00:01:00		Long	90°22'55.55"E	
Number of points:	1800				
Notes:	On roof of Parliament CAMS station				
	h=5m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	422	425	431	450	463
10s Average Minimum:	389	393	401	415	423
Time of Minimum:					
Date of Minimum:	09.02.2011	09.02.2011	09.02.2011	09.02.2011	09.02.2011
10s Average Maximum:	466	470	478	512	541
Time of Maximum:					
Date of Maximum:	09.02.2011	09.02.2011	09.02.2011	09.02.2011	09.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	466.4	470.2	478	511.8	541.3
Min	388.5	392.7	400.8	415.4	423
Average	421.7627778	425.265556	431.286111	449.505	462.816111



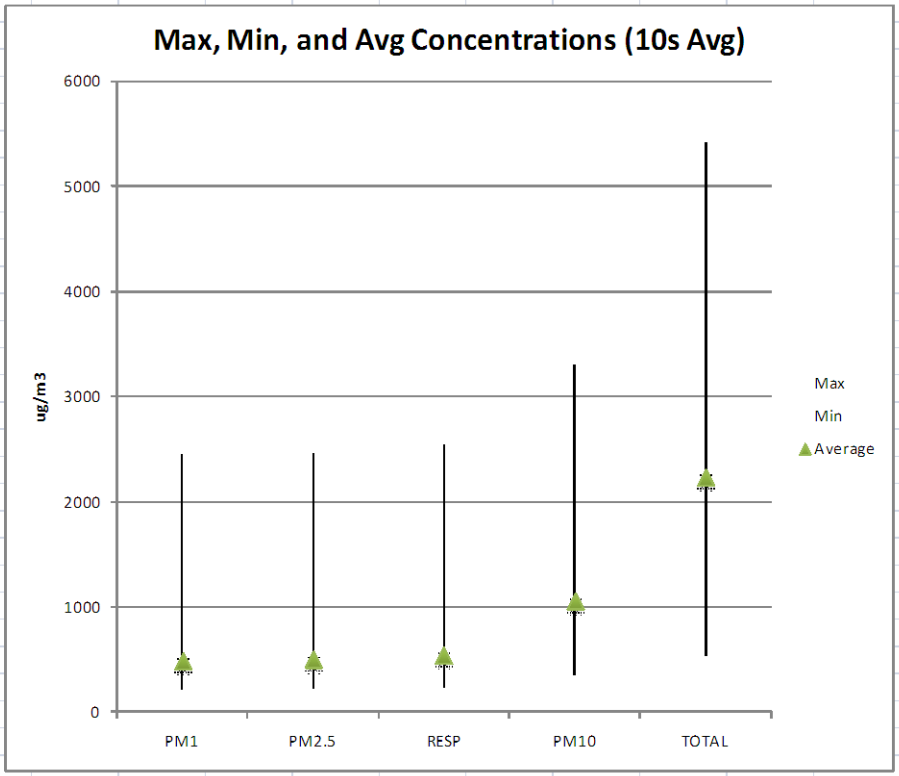
SITE 17A

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	1				
Test Abbreviation:	MANUAL_001				
Start Date:	12.02.2011				
Start Time:	12:07:36			SITE 17A	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°43'25.21"N	
Log Interval (mm:ss):	00:01:00		Long	90°24'21.26"E	
Number of points:	1800				
Notes:	In middle of Banga Market (semi-indoor), with lots of linens and other cloths, fibers in ai				
	h=1m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	393	401	436	799	1685
10s Average Minimum:	242	246	261	413	654
Time of Minimum:					
Date of Minimum:	12.02.2011	12.02.2011	12.02.2011	12.02.2011	12.02.2011
10s Average Maximum:	775	785	843	1422	3344
Time of Maximum:					
Date of Maximum:	12.02.2011	12.02.2011	12.02.2011	12.02.2011	12.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	774.7	785.4	843.3	1421.7	3344
Min	241.5	245.7	261.4	412.9	653.8
Average	393.2377778	400.678889	435.777222	798.93	1685.36778



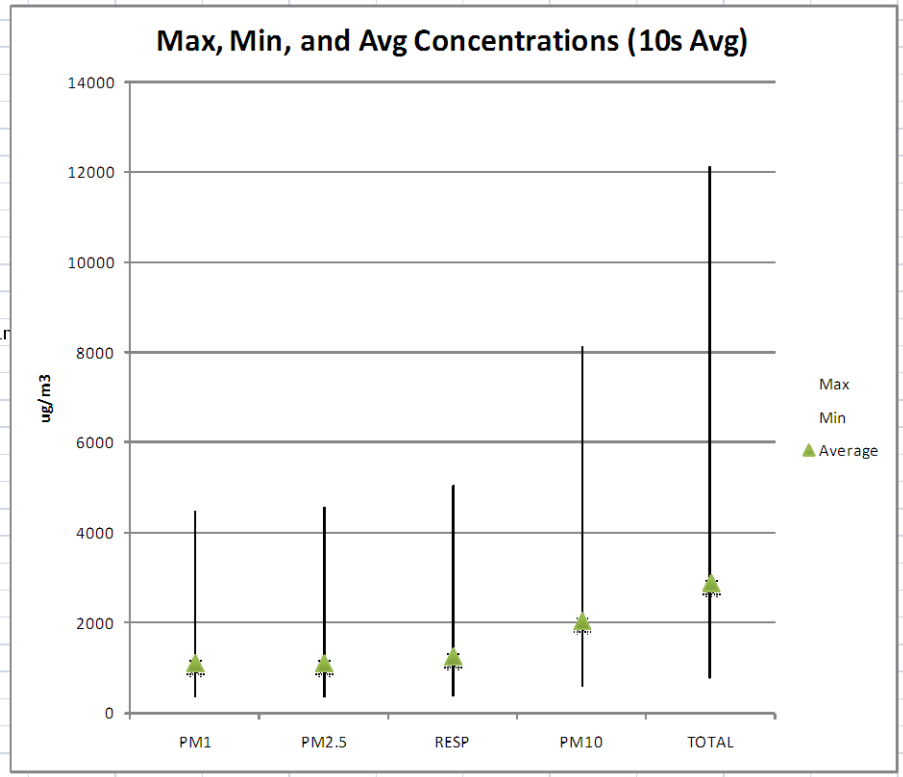
SITE 17B

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	2				
Test Abbreviation:	MANUAL_002				
Start Date:	12.02.2011				
Start Time:	12:46:01			SITE 17B	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°43'23.83"N	
Log Interval (mm:ss):	00:01:00		Long	90°24'21.26"E	
Number of points:	1800				
Notes:	Just outside of Banga Market, very dusty area, some small construction 20m away				
	h=1m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	488	497	544	1054	2229
10s Average Minimum:	218	222	234	360	535
Time of Minimum:					
Date of Minimum:	12.02.2011	12.02.2011	12.02.2011	12.02.2011	12.02.2011
10s Average Maximum:	2445	2459	2540	3304	5419
Time of Maximum:					
Date of Maximum:	12.02.2011	12.02.2011	12.02.2011	12.02.2011	12.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	2445.1	2458.9	2539.6	3304.1	5419
Min	218.1	221.7	233.5	359.8	535.1
Average	488.2338889	497.287222	544.037778	1053.97	2229.02389



SITE 18

TrakPro Version 4.41 ASCI					
Model:	DustTrak DRX				
Model Number:	8534				
Serial Number:	8534105201				
Test ID:	4				
Test Abbreviation:	MANUAL_004				
Start Date:	12.02.2011				
Start Time:	13:55:23			SITE 18	
Duration (dd:hh:mm:ss):	0:00:30:00		Lat	23°42'56.18"N	
Log Interval (mm:ss):	00:01:00		Long	90°23'45.22"E	
Number of points:	1800				
Notes:	On corner in old town area with outdoor markets, dusty streets, people walking within 1r				
	h=1m				
Channel:	PM1	PM2.5	RESP	PM10	TOTAL
Units:	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
10s Average:	1104	1131	1265	2039	2907
10s Average Minimum:	346	353	386	586	759
Time of Minimum:					
Date of Minimum:	12.02.2011	12.02.2011	12.02.2011	12.02.2011	12.02.2011
10s Average Maximum:	4480	4565	5042	8121	12135
Time of Maximum:					
Date of Maximum:	12.02.2011	12.02.2011	12.02.2011	12.02.2011	12.02.2011
	PM1	PM2.5	RESP	PM10	TOTAL
Max	4480	4565	5042	8121	12135
Min	346.1	352.9	385.9	586.1	758.8
Average	1103.974444	1130.72444	1264.89278	2038.758889	2906.91722

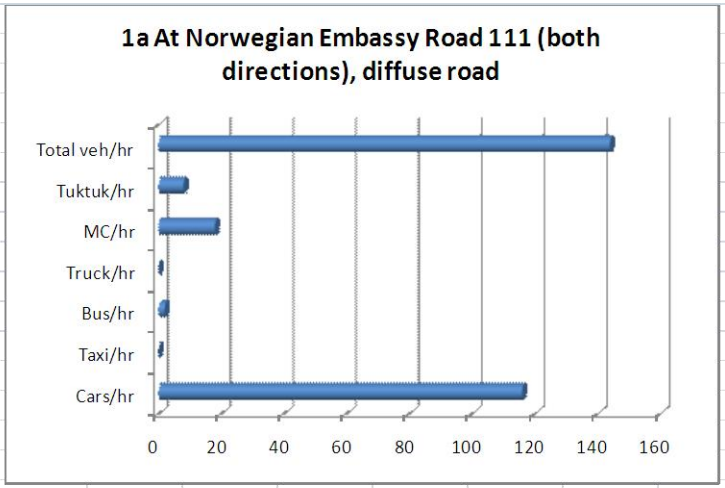


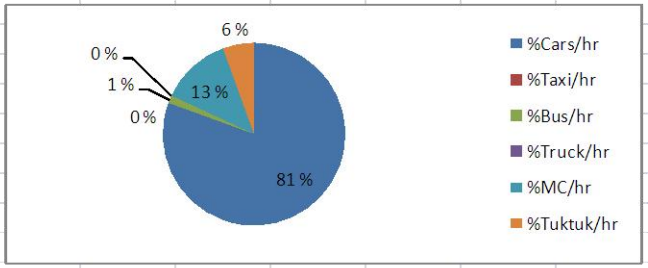
Appendix F

Traffic Sampling Site Profiles

SITE 1A

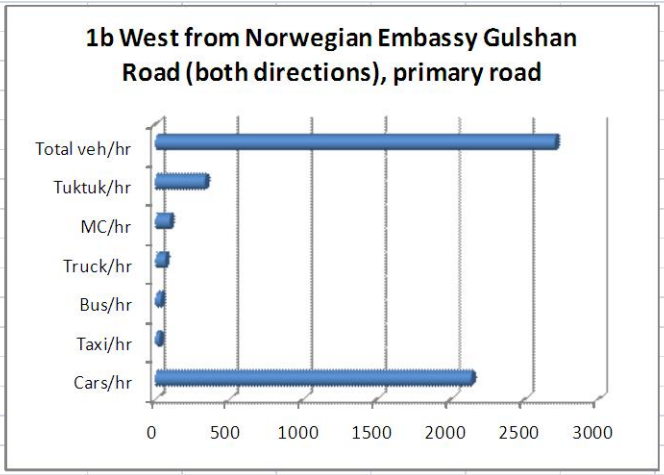
Site#	1a
Description	At Norwegian Embassy
Road	Road 111 (both directions)
Lat	23°47'24.59"N
Long	90°25'1.86"E
Road type	diffuse
Traffic flow	very light
Observer	BS
Date/time	3 Feb2011: 16:36
Cars/hr	116
Taxi/hr	0
Bus/hr	2
Truck/hr	0
MC/hr	18
Tuktuk/hr	8
Total veh/dir/hr	n/a
Total veh/hr	144
PM	Yes
Comments	
%Cars/hr	81 %
%Taxi/hr	0 %
%Bus/hr	1 %
%Truck/hr	0 %
%MC/hr	13 %
%Tuktuk/hr	6 %

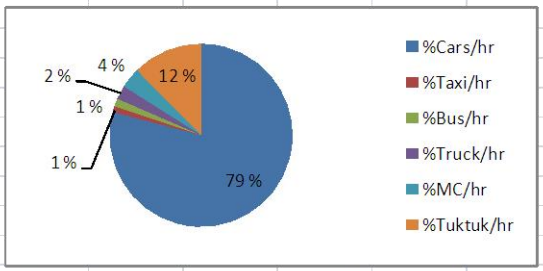


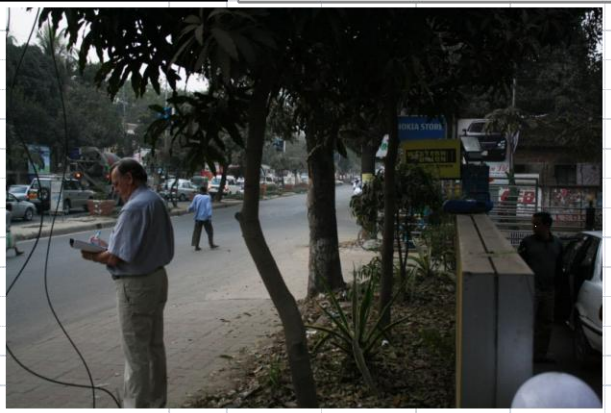


SITE 1B

Site#	1b	1b	Sum
Description	West from Norwegian Embassy	West from Norwegian Embassy	
Road	Gulshan Road (Northbound)	Gulshan Road (Southbound)	
Lat	23°47'23.48"N	23°47'23.48"N	
Long	90°24'58.93"E	90°24'58.93"E	
Road type	primary	primary	
Traffic flow	very heavy	light	
Observer	BS	SR	
Date/time	3 Feb 2011; 17:20	3 Feb 2011; 17:20	
Cars/hr	964	1176	2140
Taxi/hr	4	24	28
Bus/hr	14	24	38
Truck/hr	12	54	66
MC/hr	32	66	98
Tuktuk/hr	80	256	336
Total veh/dir/hr	**1106**	**1600**	
Total veh/hr	**2706**		2706
PM	Yes	Yes	
Comments	during rush hour northbound	during rush hour northbound	
%Cars/hr	87 %	74 %	79 %
%Taxi/hr	0 %	2 %	1 %
%Bus/hr	1 %	2 %	1 %
%Truck/hr	1 %	3 %	2 %
%MC/hr	3 %	4 %	4 %
%Tuktuk/hr	7 %	16 %	12 %

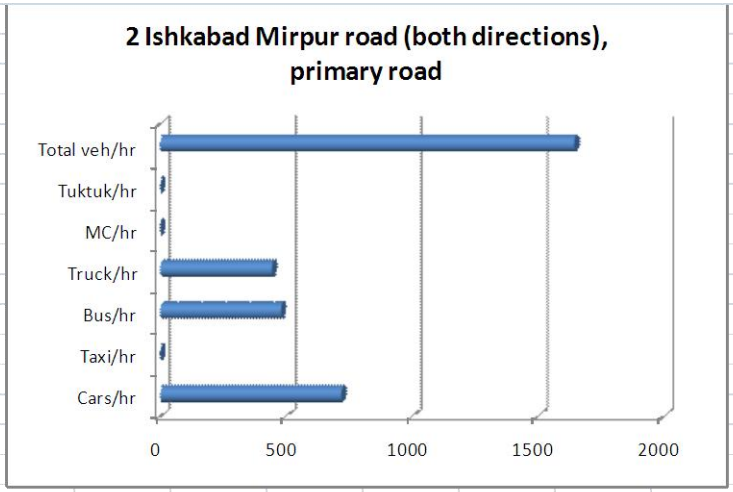


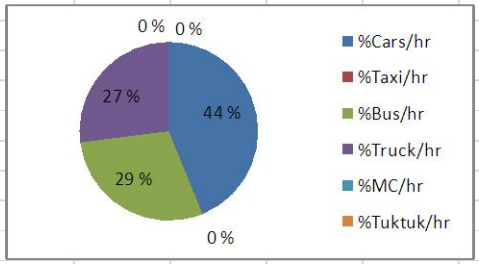




SITE 2

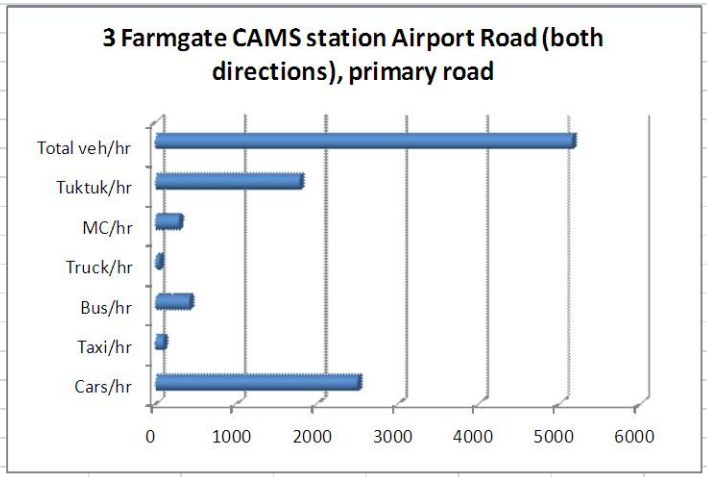
Site#	2
Description	Ishkabad
Road	Mirpur road (both directions)
Lat	23°47'23.35"N
Long	90°19'20.49"E
Road type	primary
Traffic flow	medium
Observer	BS
Date/time	4 Feb 2011; 12:15
Cars/hr	720
Taxi/hr	1
Bus/hr	480
Truck/hr	444
MC/hr	0
Tuktuk/hr	0
Total veh/dir/hr	**n/a**
Total veh/hr	**1645**
PM	Yes
Comments	weekend, near bus stop to countryside
%Cars/hr	44 %
%Taxi/hr	0 %
%Bus/hr	29 %
%Truck/hr	27 %
%MC/hr	0 %
%Tuktuk/hr	0 %

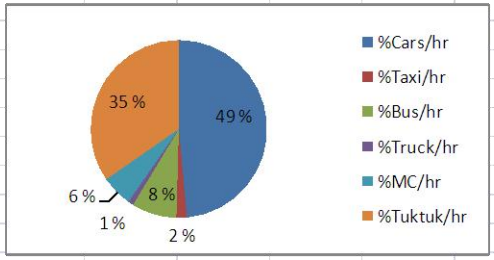




SITE 3

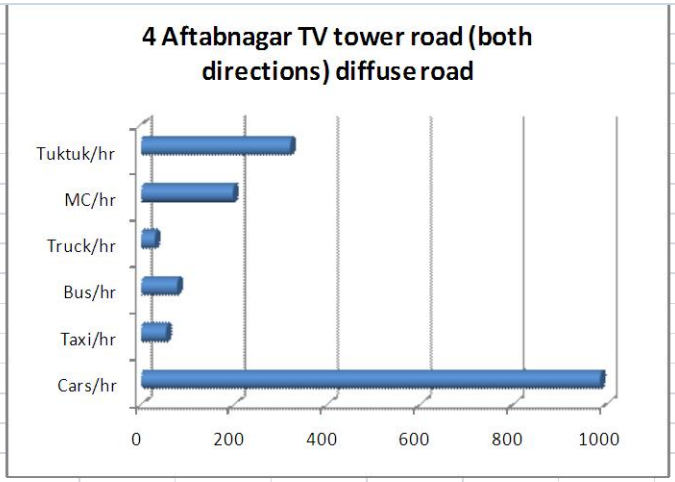
Site#	3	3	3	3
Description	Farmgate CAMS station	Farmgate CAMS station	Farmgate CAMS station	
Road	Airport Road (Northbound)	Airport Road (Southbound)	Airport Road (Southbound)	
Lat	23°45'34.95"N	23°45'34.95"N	23°45'34.95"N	
Long	90°23'21.89"E	90°23'21.89"E	90°23'21.89"E	
Road type	primary	primary	primary	
Traffic flow	light	medium	medium	
Observer	BS	SR	BS	
Date/time	4 feb 2011, 13:00	4 feb 2011, 13:10	4 feb 2011, 13:15	
Cars/hr	1584	1014	828	2505
Taxi/hr	54	78	12	99
Bus/hr	330	150	36	423
Truck/hr	0	54	48	51
MC/hr	180	156	72	294
Tuktuk/hr	1002	912	660	1788
Total veh/dir/hr	**3150**	**2364**	**1656**	
Total veh/hr		**5160**		5160
PM	Yes	Yes	Yes	
Comments	weekend	weekend	weekend	
%Cars/hr	50 %	43 %	50 %	49 %
%Taxi/hr	2 %	3 %	1 %	2 %
%Bus/hr	10 %	6 %	2 %	8 %
%Truck/hr	0 %	2 %	3 %	1 %
%MC/hr	6 %	7 %	4 %	6 %
%Tuktuk/hr	32 %	39 %	40 %	35 %

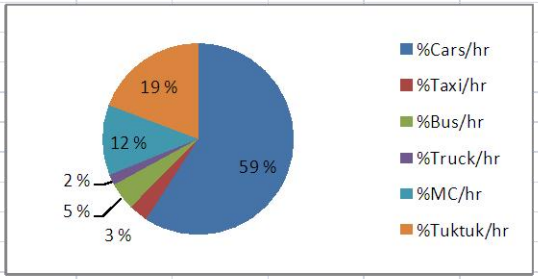




SITE 4

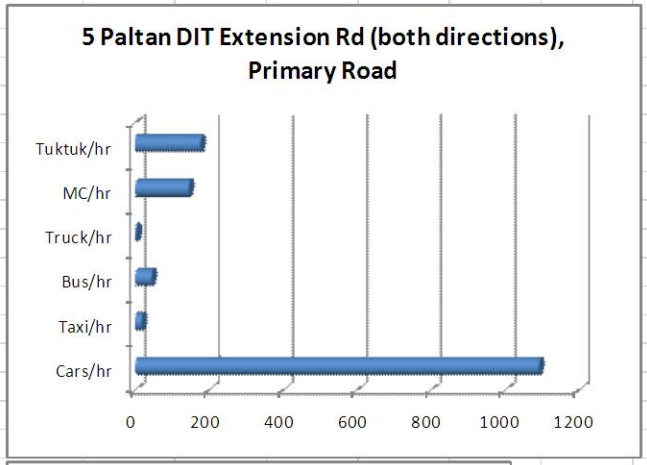
Site#	4	4	4
Description	Aftabnagar	Aftabnagar	
Road	TV tower road (both directions)	TV tower road (both directions)	
Lat	23°45'51.49"N	23°45'51.49"N	
Long	90°25'48.67"E	90°25'48.67"E	
Road type	diffuse	diffuse	
Traffic flow	light	light	
Observer	BS	SR	
Date/time	5 Feb 2011, 13:45	05 feb 2011, 13:30	
Cars/hr	561	426	987
Taxi/hr	24	30	54
Bus/hr	42	36	78
Truck/hr	6	24	30
MC/hr	108	90	198
Tuktuk/hr	183	138	321
Total veh/dir/hr	**924**	**744**	
Total veh/hr	**1668**		1668
PM	Yes	Yes	
Comments	weekend	weekend	
%Cars/hr	61 %	57 %	59 %
%Taxi/hr	3 %	4 %	3 %
%Bus/hr	5 %	5 %	5 %
%Truck/hr	1 %	3 %	2 %
%MC/hr	12 %	12 %	12 %
%Tuktuk/hr	20 %	19 %	19 %

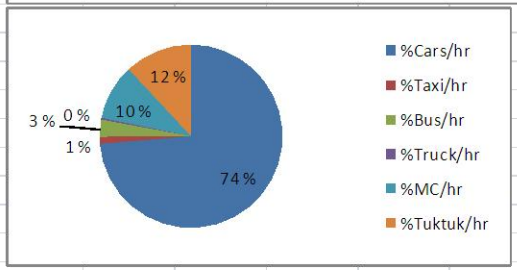




SITE 5

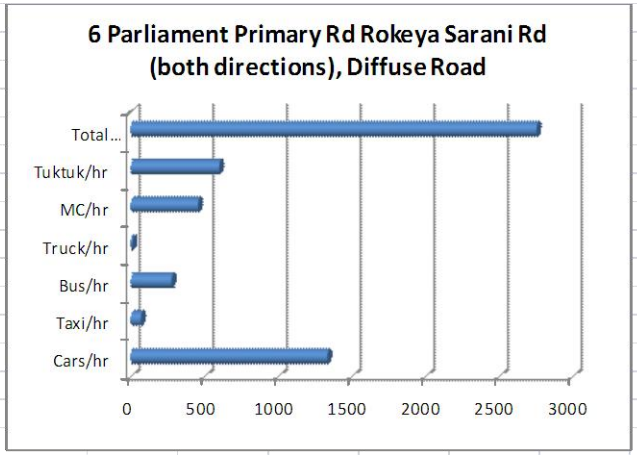
Site#	5	5	5	5
Description	Paltan	Paltan	Paltan	
Road	DIT Extension Rd (Southbound)	DIT Extension Rd (Southbound)	DIT Extension Rd (Northbound)	
Lat	23°44'22.18"N	23°44'22.18"N	23°44'22.18"N	
Long	90°25'11.20"E	90°25'11.20"E	90°25'11.20"E	
Road type	primary	primary	primary	
Traffic flow	medium	medium	medium	
Observer	BS	SR	BS	
Date/time	5 Feb 2011, 1440	05 feb 2011, 14:45	5 Feb 2011, 1440	
Cars/hr	462	390	666	1092
Taxi/hr	12	12	6	18
Bus/hr	18	36	18	45
Truck/hr	3	6	0	4.5
MC/hr	75	66	75	145.5
Tuktuk/hr	66	138	75	177
Total veh/dir/hr	**636**	**648**	**840**	
Total veh/hr		**1482**		**1482**
PM	Yes	Yes	Yes	
Comments	weekend	weekend	weekend	
%Cars/hr	73 %	60 %	79 %	74 %
%Taxi/hr	2 %	2 %	1 %	1 %
%Bus/hr	3 %	6 %	2 %	3 %
%Truck/hr	0 %	1 %	0 %	0 %
%MC/hr	12 %	10 %	9 %	10 %
%Tuktuk/hr	10 %	21 %	9 %	12 %

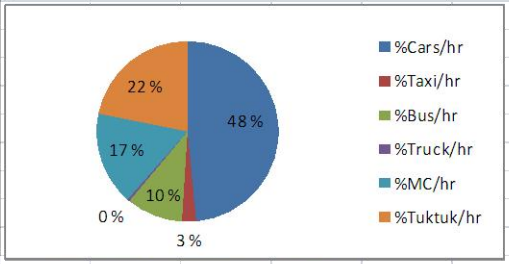




SITE 6

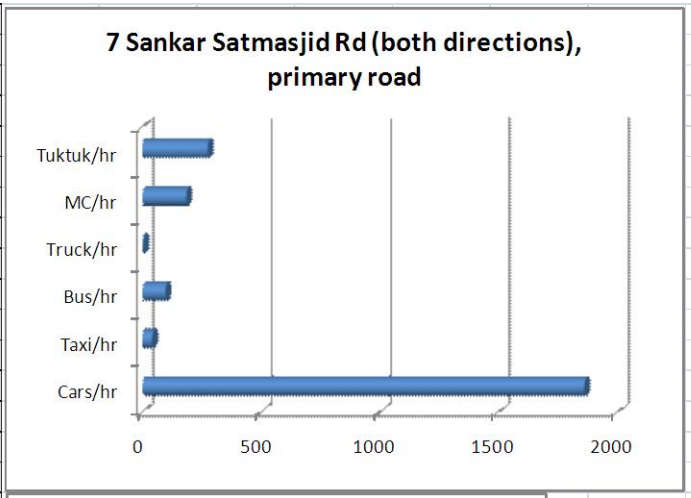
Site#	6	6	6
Description	Parliament Primary Rd	Parliament Primary Rd	
Road	Rokeya Sarani Rd (Northbound)	Rokeya Sarani Rd (southbound)	
Lat	23°45'44.90"N	23°45'44.90"N	
Long	90°23'0.16"E	90°23'0.16"E	
Road type	primary	primary	
Traffic flow	medium	medium	
Observer	SR/Mizan/Khairul	SR/Mizan/Khairul	
Date/time	09 feb 2011, 11:00	09 feb 2011, 11:20	
Cars/hr	568	768	1336
Taxi/hr	28	42	70
Bus/hr	164	114	278
Truck/hr	0	12	12
MC/hr	68	390	458
Tuktuk/hr	320	282	602
Total veh/dir/hr	**1148**	**1608**	
Total veh/hr	**2756**		2756
PM	Yes	Yes	
Comments	after rush-hour	after rush-hour	
%Cars/hr	49 %	48 %	48 %
%Taxi/hr	2 %	3 %	3 %
%Bus/hr	14 %	7 %	10 %
%Truck/hr	0 %	1 %	0 %
%MC/hr	6 %	24 %	17 %
%Tuktuk/hr	28 %	18 %	22 %

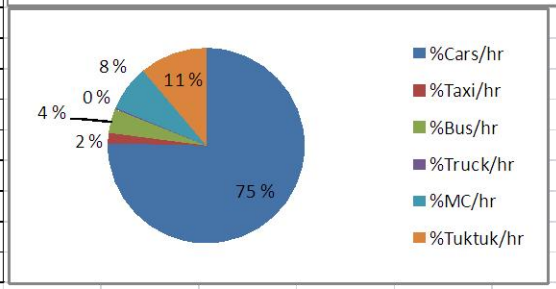




SITE 7

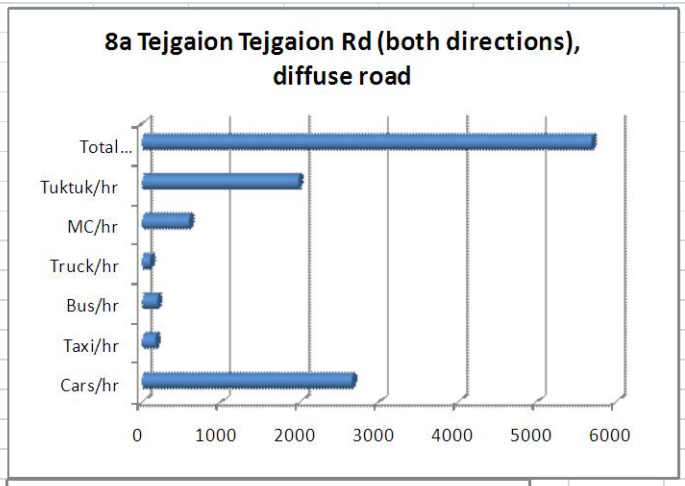
Site#	7	7	7
Description	Sankar	Sankar	
Road	Satmasjid Rd (Southbound)	Satmasjid Rd (Northbound)	
Lat	23°44'54.85"N	23°44'54.85"N	
Long	90°22'11.76"E	90°22'11.76"E	
Road type	primary	primary	
Traffic flow	medium	medium	
Observer	SR/Mizan/Khairul	SR/Mizan/Khairul	
Date/time	09 feb 2011, 12:40	09 feb 2011, 13:40	
Cars/hr	954	906	1860
Taxi/hr	18	24	42
Bus/hr	42	56	98
Truck/hr	0	6	6
MC/hr	30	156	186
Tuktuk/hr	108	168	276
Total veh/dir/hr	**1152**	**1316**	
Total veh/hr	**2468**		2468
PM	Yes	Yes	
Comments			
%Cars/hr	83 %	69 %	75 %
%Taxi/hr	2 %	2 %	2 %
%Bus/hr	4 %	4 %	4 %
%Truck/hr	0 %	0 %	0 %
%MC/hr	3 %	12 %	8 %
%Tuktuk/hr	9 %	13 %	11 %

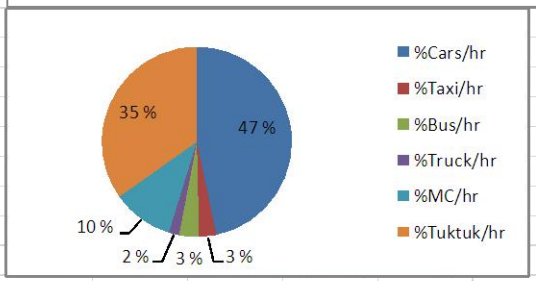




SITE 8A

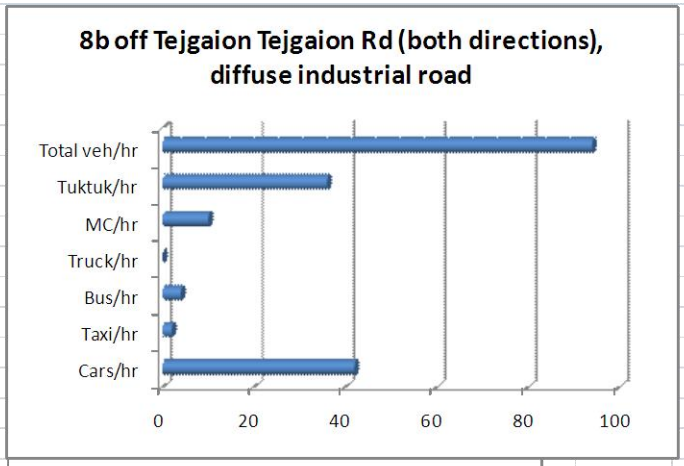
Site#	8a	8a	8a
Description	Tejgaion	Tejgaion	
Road	Tejgaion Rd (Southbound)	Tejgaion Rd (Northbound)	
Lat	23°45'34.12"N	23°45'34.12"N	
Long	90°23'58.34"E	90°23'58.34"E	
Road type	primary	primary	
Traffic flow	medium	medium	
Observer	SR/GS/Mizan/Khairul	SR/Mizan/Khairul	
Date/time	09 feb 2011, 16:05	09 feb 2011, 16:15	
Cars/hr	1446	1212	2658
Taxi/hr	72	96	168
Bus/hr	84	108	192
Truck/hr	48	54	102
MC/hr	270	324	594
Tuktuk/hr	906	1074	1980
Total veh/dir/hr	**2826**	**2868**	
Total veh/hr	5694		5694
PM	Yes	Yes	
Comments	Just before rush-hour	Just before rush-hour	
%Cars/hr	51 %	42 %	47 %
%Taxi/hr	3 %	3 %	3 %
%Bus/hr	3 %	4 %	3 %
%Truck/hr	2 %	2 %	2 %
%MC/hr	10 %	11 %	10 %
%Tuktuk/hr	32 %	37 %	35 %

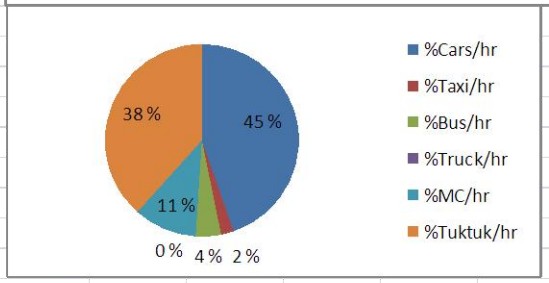




SITE 8B

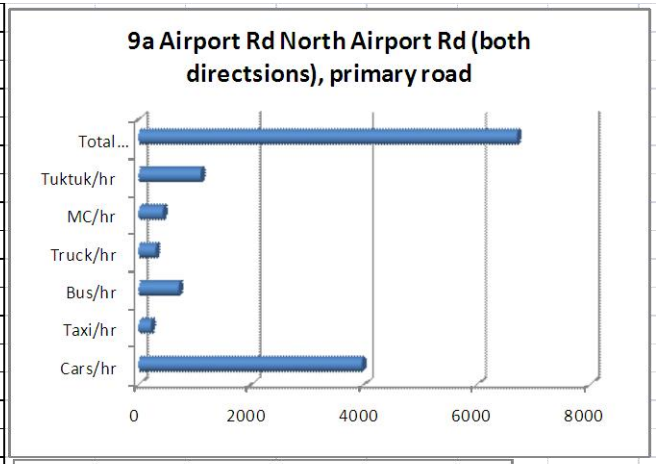
Site#	8b
Description	off Tejgaion
Road	Tejgaion Rd (both directions)
Lat	23°45'34.42"N
Long	90°24'1.53"E
Road type	diffuse (industrial)
Traffic flow	light
Observer	SR/Mizan/Khairul
Date/time	09 feb 2011, 16:45
Cars/hr	42
Taxi/hr	2
Bus/hr	4
Truck/hr	0
MC/hr	10
Tuktuk/hr	36
Total veh/hr	**94**
PM	Yes
Comments	Most veh came last 10% of sample
%Cars/hr	45 %
%Taxi/hr	2 %
%Bus/hr	4 %
%Truck/hr	0 %
%MC/hr	11 %
%Tuktuk/hr	38 %

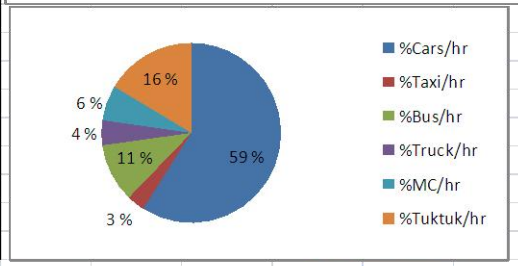




SITE 9A

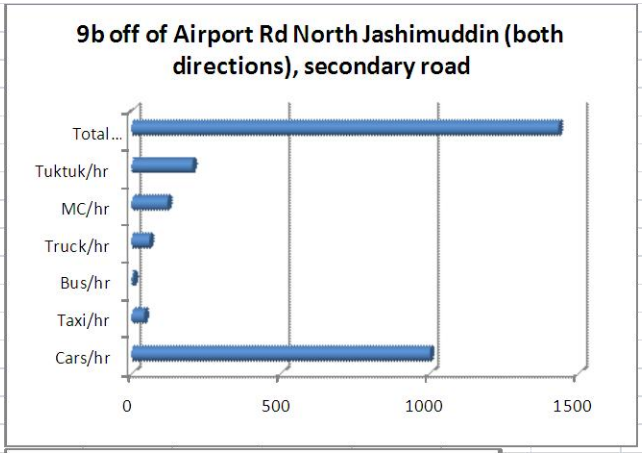
Site#	9a	9a	9a
Description	Airport Rd North	Airport Rd North	
Road	Airport Rd (Northbound)	Airport Rd (Southbound)	
Lat	23°51'32.91"N	23°51'32.91"N	
Long	90°24'3.76"E	90°24'3.76"E	
Road type	primary	primary	
Traffic flow	light	light	
Observer	SR/GS/Salim/Ashraf	SR/GS/Salim/Ashraf	
Date/time	10 feb 2011, 10:45	10 feb 2011, 10:55	
Cars/hr	2232	1722	3954
Taxi/hr	120	96	216
Bus/hr	408	300	708
Truck/hr	162	138	300
MC/hr	216	210	426
Tuktuk/hr	576	522	1098
Total veh/dir/hr	**3714**	**2988**	
Total veh/hr	**6702**		6702
PM	Yes	Yes	
Comments	after rush-hour	after rush-hour	
%Cars/hr	60 %	58 %	59 %
%Taxi/hr	3 %	3 %	3 %
%Bus/hr	11 %	10 %	11 %
%Truck/hr	4 %	5 %	4 %
%MC/hr	6 %	7 %	6 %
%Tuktuk/hr	16 %	17 %	16 %

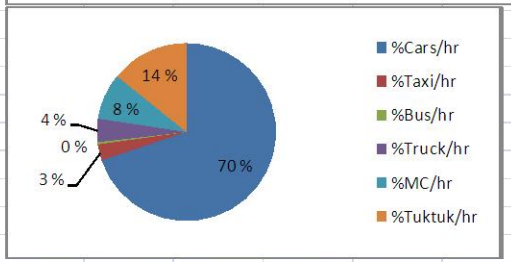




SITE 9B

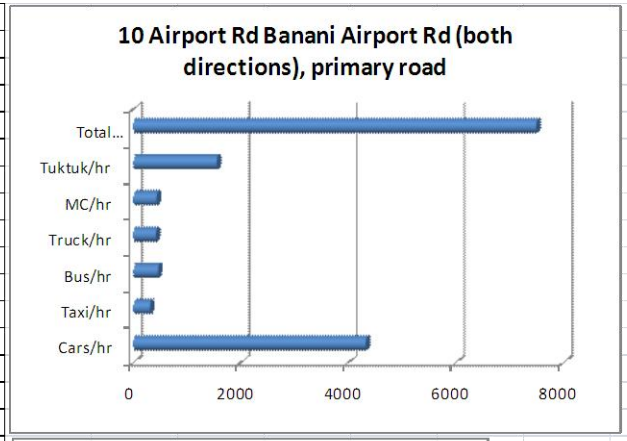
Site#	9b	9b	9b
Description	off of Airport Rd North	off of Airport Rd North	
Road	Jashimuddin (Westbound)	Jashimuddin (Westbound)	
Lat	23°51'39.37"N	23°51'39.37"N	
Long	90°23'49.15"E	90°23'49.15"E	
Road type	secondary	secondary	
Traffic flow	very light	very light	
Observer	SR/GS/Salim/Ashraf	SR/GS/Salim/Ashraf	
Date/time	10 feb 2011, 11:20	10 feb 2011, 11:30	
Cars/hr	582	420	1002
Taxi/hr	18	24	42
Bus/hr	6	0	6
Truck/hr	30	30	60
MC/hr	54	66	120
Tuktuk/hr	114	90	204
Total veh/dir/hr	**804**	**630**	
Total veh/hr	**1434**		1434
PM	Yes	Yes	
Comments			
%Cars/hr	72 %	67 %	70 %
%Taxi/hr	2 %	4 %	3 %
%Bus/hr	1 %	0 %	0 %
%Truck/hr	4 %	5 %	4 %
%MC/hr	7 %	10 %	8 %
%Tuktuk/hr	14 %	14 %	14 %

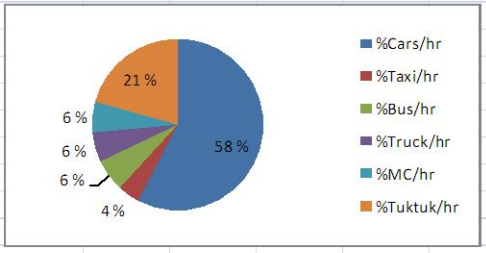




SITE 10

Site#	10	10	10
Description	Airport Rd Banani	Airport Rd Banani	
Road	Airport Rd (Southbound)	Airport Rd (Northbound)	
Lat	23°48'34.74"N	23°48'34.74"N	
Long	90°24'13.38"E	90°24'13.38"E	
Road type	primary	primary	
Traffic flow	medium	medium	
Observer	SR/GS/Salim/Ashraf	SR/GS/Salim/Ashraf	
Date/time	10 feb 2011, 12:00	10 feb 2011, 12:10	
Cars/hr	2640	1680	4320
Taxi/hr	150	160	310
Bus/hr	290	170	460
Truck/hr	230	190	420
MC/hr	270	160	430
Tuktuk/hr	980	570	1550
Total veh/dir/hr	**4560**	**2930**	
Total veh/hr	**7490**		7490
PM	Yes	Yes	
Comments	slight effects of train crossing	slight effects of train crossing	
%Cars/hr	58 %	57 %	58 %
%Taxi/hr	3 %	5 %	4 %
%Bus/hr	6 %	6 %	6 %
%Truck/hr	5 %	6 %	6 %
%MC/hr	6 %	5 %	6 %
%Tuktuk/hr	21 %	19 %	21 %





Appendix G

Passive Sampling Database

Passive Sampling (SO_2, NO_2, O_3)

Site#	Description	Placement	Height	Classification	Observer	Lat	Long	Set date	Set time	Retr date	Retr time	SO2 ug/m3	NO2 ug/m3	O3 ug/m3	PM Site	Traffic Site
1a	Westin hotel 23rd	Balcony N.	100m	U/T/C	SR/BS	23.79346484	90.41457298	01.feb	22:35	13.feb	20:00	94.0	75.5	62	11A	No
1b	Westin hotel 2nd	Balcony S.	15m	U/T/C	SR	23.79315311	90.41486754	07.feb	14:45	14.feb	18:45	199.3	-		11B	No
2	BSMMU	Guard house	3m	U/T/C	SR/AJ	23.73874679	90.39575174	01.feb	13:00	13.feb	10:15	59.4	88.7	21	No	No
3	Postogola	Front door	3m	U/T/C	SR/AJ	23.69178668	90.43255251	01.feb	14:25	13.feb	10:55	77.6	72.0	18	No	No
4	Smiling Sun Clinic	Up stairs	6m	U/T/C	SR/AJ	23.71050833	90.42373889	01.feb	15:00	13.feb	10:40	77.9	114.8		No	No
5	Health Aid Clinic	Front door	3m	U/T/C	SR/AJ	23.72124722	90.38781944	02.feb	11:00	13.feb	12:45	96.8	77.5	36	No	No
6	Power St. Haziabag	Inside gate	4m	S/I/I	SR/AJ	23.72367551	90.37233879	02.feb	11:45	13.feb	14:45	131.0	66.9	43	No	No
7	Machine Workshop	Above gate	6m	U/I/I	SR/AJ	23.71223305	90.38977799	02.feb	12:05	13.feb	14:30	186.0	76.7		No	No
8	Pink Palace	Left front	5m	U/B/NRC	SR/AJ	23.70848889	90.40588333	02.feb	13:10	13.feb	13:55	162.4	70.1	43	No	No
9	Guliztan Monkies	Left up	4m	U/T/C	SR/AJ	23.72650000	90.41056667	02.feb	14:45	13.feb	12:05	59.5	78.5	32	No	No
10	Rainbow Heart	Back camera	3m	U/T/C	SR/AJ	23.75330464	90.37685095	02.feb	15:15	13.feb	15:25	101.7	83.3	27	No	No
11	Pearls Fair	Above door	3m	U/T/C	SR/BS	23.79394167	90.41516111	03.feb	11:20	14.feb	18:20	83.2	126.7		13	No
12	Norwegian Embassy	Lund balcony	7m	U/B/R	SR/BS	23.79031111	90.41718333	03.feb	14:15	15.feb	13:14	73.7	114.1		1C	1A
13	Ashraf - S. Banasree	Balcony	10m	R/B/R	AM	23.75967500	90.43654167	01.feb	19:59	14.feb	07:22	38.0	64.2		No	No
14	DoE	At fence	4m	U/B/C	BS/MR	23.77691111	90.37218056	01.feb	11:38	13.feb	17:26	60.0	67.8	48	12	No
15	Balaka build Airport	Behind recept	2m	S/B	BS/MR	23.84738333	90.41019722	01.feb	12:45	13.feb	11:32	65.0	78.6	36	No	No
16	Tongi Bazaar	Balcony 2 fl	5m	U/T/C	BS/MR	23.88508611	90.40046944	01.feb	13:35	13.feb	11:54	149.9	152.8	22	No	No
17	Sector14,Road 17	Balcony 3 fl	14m	S/B/R	BS/MR	23.86788333	90.38391389	01.feb	14:38	13.feb	12:19	80.4	73.5	42	No	No
18	Kochukhet(M3)	Balcony gf	3m	U/T	BS/MR	23.79333333	90.39780000	01.feb	16:20	13.feb	13:12	62.3	161.3		No	No
19	Vashantek (M4)	Balcony 2 fl	12m	S/B/R	BS/MR	23.81249139	90.39361105	01.feb	16:46	13.feb	12:58	48.3	71.2		No	No
20	Parliament site	roof	6m	U/B/C	BS/MR	23.76260435	90.38363620	02.feb	10:15	15.feb	08:45	81.8	105.9	47	16	6
21	BARC, Farmgate	Roof 2fl	10m	U/T/C	BS/MR	23.75979082	90.38940981	02.feb	10:40	15.feb	07:35	93.3	112.5	43	3	3
22	Newspaper, Mas 10	Roof 2fl	3m	U/B	BS/MR	23.71032903	90.44672491	02.feb	12:10	13.feb	17:10	112.7	85.2	50	No	No
23	Karzon Hall, Mas12	University	8m	U/B	BS/MR	23.72719444	90.40165556	02.feb	13:10	14.feb	13:55	59.0	67.7	44	No	No
24	Katashur Mohamad	Private house	12m	S/B/R	BS/MR	23.75549047	90.35973841	02.feb	14:30	14.feb	09:35	103.5	58.1	35	No	No
25	Gobtoli Landing	On post	2m	S/I/I	BS/MR	23.77788300	90.33805100	02.feb	15:30	13.feb	16:30	131.9	66.0		No	No

Passive Sampling (SO_2, NO_2, O_3) (page 2)

Site#	Description	Placement	Height	Classification	Observer	Lat	Long	Set date	Set time	Retr date	Retr time	SO2 ug/m3	NO2 ug/m3	O3 ug/m3	PM Site	Traffic Site
26	Central Dh marked	On roof	8m	S/I/I	BS/MR	23.77826696	90.33811344	02.feb	15:35	13.feb	16:36	104.3	-		14	No
27	S-18(Shamim_Sis)	2nd floor	8m	U/R	GS	23.76066944	90.36603611	01.feb	16:44	14.feb	13:55	93.6	78.8		No	No
28	S-16(Shamim)	2nd floor	6m	U/R	GS	23.76646944	90.35770833	01.feb	17:06	14.feb	13:30	93.3	67.2		No	No
29	S-04(Tech)	2nd floor	8m	U/R	GS	23.73212500	90.42916667	01.feb	20:15	14.feb	20:56	52.1	82.0		No	No
30	S-07(Faruq)	2nd floor	8m	U/R	GS	23.74701389	90.38644722	01.feb	17:44	13.feb	20:11	71.4	73.9		No	No
31	S-06(paps)	1st floor	9m	U/R	GS	23.74854444	90.36823056	01.feb	20:18	13.feb	21:58	94.6	67.6		No	No
32	S-01(Mine)	1st floor	6m	U/R	GS	23.78343889	90.42507500	01.feb	22:00	13.feb	23:20	86.5	89.0		No	No
33	S-25(AECD)	1st floor	5m	U/R	GS	23.73092222	90.39647778	02.feb	13:17	14.feb	16:40	48.3	61.9	31	No	No
34	S-26(S.Bank)	1st floor	5m	U/T	GS	23.75675833	90.37478333	02.feb	14:23	14.feb	14:03	87.1	141.3		No	No
35	S-23(IUCN)	2nd floor	8m	U/R	GS	23.77779444	90.41864722	02.feb	17:35	14.feb	10:25	58.2	79.9	32	No	No
36	S-08(Bilkis)	1st floor	6m	U/R	GS	23.78170556	90.40118333	02.feb	18:17	13.feb	17:50	54.9	96.8	25	No	No
37	S-02(Uncle)	1st floor	5m	U/R	GS	23.77640000	90.42387222	02.feb	20:45	14.feb	09:10	53.6	66.4		No	No
38	S-03(Bro)	2nd floor	8m	U/R	GS	23.78075278	90.42803611	02.feb	21:35	15.feb	08:10	68.7	71.0		No	No
39	S-27(Sumon)	1st floor	6m	U/R	GS	23.74533056	90.36950833	02.feb	23:47	14.feb	13:15	84.3	69.2		No	No
40	S-20 (Jahur_Frn)	2nd floor	8m	U/T	GS	23.72833611	90.38452222	05.feb	12:57	14.feb	06:58	74.3	66.8		No	No
41	S-28 (Dr.Nasir)	2nd floor	8m	U/R	GS	23.74187778	90.37951111	06.feb	23:30	13.feb	22:45	48.6	59.1		No	No
42	S_10(SKB)	1st floor	5m	U	SKB	23.73146944	90.38556111	01.feb	21:25	14.feb	07:25	63.1	74.0		No	No
43	S_11(SKB)	3rd floor	11m	U	SKB	23.73666111	90.38731667	02.feb	20:35	13.feb	09:15	82.4	72.0		No	No
44	S_13(SKB)	2nd floor	9m	U	SKB	23.75050278	90.36615556	02.feb	20:45	12.feb	17:25	129.7	69.6		No	No
45	S_12(SKB)	1st floor	5m	U	SKB	23.71842222	90.41177222	03.feb	18:30	13.feb	20:35	85.0	68.7		No	No
46	Masuds house			S/B/R	MR	23.78104156	90.36780857	01.feb	21:36	13.feb	15:15	96.9	70.8		No	No
47	Shapan Shirdo med				MR	23.73333333	90.36194444	02.feb	19:00	14.feb	19:02	81.7	35.6		No	No
48	Liton's house				Mr	23.80333333	90.37277778	02.feb	20:50	13.feb	18:45	58.4	159.3		No	No

Active Sampling (PM_{10}, $PM_{2.5}$)

Site#	Description	Road	Classification	Lat	Long	Observer	Date	Time	PM2.5 ug/m3 avg (10s)	PM10 ug/m3 avg (10s)	ratio PM2.5	Ratio PM10	Traffic Site	Passive Site
1a	At Norwegian Embassy	Road 111	U/B/R	23°47'24.59"N	90°25'1.86"E	SR/BS	03.02.2011	16:41:06	328	491	67 %	33 %	1A	No
1b	West from Norwegian Embassy	Gulshan Ave	U/T/R	23°47'23.48"N	90°24'58.93"E	SR/BS	03.02.2011	17:18:05	409	564	73 %	27 %	1B	No
1c	At Norwegian Embassy Balcony	Road 111	U/B/R	23°47'23.48"N	90°24'58.93"E	SR/BS	15.02.2011	24HOUR	381	413	92 %	8 %	No	12
2	Ishkabad	Mirpur road	R/T/A-I	23°47'23.35"N	90°19'20.49"E	SR/BS	04.02.2011	11:55:52	487	806	60 %	40 %	2	No
3	Farmgate CAMS station	Airport Road	U/T/C	23°45'34.95"N	90°23'21.89"E	SR/BS	04.02.2011	13:01:30	329	359	92 %	8 %	3	21
4	Aftabnagar	TV tower road	S/B/R	23°45'51.49"N	90°25'48.67"E	SR/BS	05.02.2011	13:35:14	236	288	82 %	18 %	4	No
5	Paltan	DIT Extension Rd	U/T/R	23°44'22.18"N	90°25'11.20"E	SR/BS	05.02.2011	14:26:03	272	409	67 %	33 %	5	No
6	Parliament Primary Rd	Rokeya Sarani Rd	U/T/R	23°45'44.90"N	90°23'0.16"E	SR/Mizan/Khairul	09.02.2011	10:44:13	427	448	95 %	5 %	6	No
7	Sankar	Satmasjid Rd	U/T/R	23°44'54.85"N	90°22'11.76"E	SR/Mizan/Khairul	09.02.2011	12:38:26	233	275	85 %	15 %	7	No
8a	Tejgaion	Tejgaion Rd	U/T/I	23°45'34.12"N	90°23'58.34"E	SR/Mizan/Khairul	09.02.2011	15:57:17	442	501	88 %	12 %	8A	No
8b	off Tejgaion	Tejgaion Rd	U/T/I	23°45'34.42"N	90°24'1.53"E	SR/Mizan/Khairul	09.02.2011	16:33:23	295	372	79 %	21 %	8B	No
9a	Airport Rd North	Airport Rd	U/T/R	23°51'32.91"N	90°24'3.76"E	SR/GS/Salim/Ashraf	10.02.2011	10:35:41	216	258	84 %	16 %	9A	No
9b	off of Airport Rd North	Jashimuddin	U/T/R	23°51'39.37"N	90°23'49.15"E	SR/GS/Salim/Ashraf	10.02.2011	11:12:07	224	272	82 %	18 %	9B	No
10	Airport Rd Banani	Airport Rd	S/T/R	23°48'34.74"N	90°24'13.38"E	SR/GS/Salim/Ashraf	10.02.2011	11:56:55	236	265	89 %	11 %	10	No
11a	Westin Hotel 2nd floor	Gulshan Ave	U/T/C	23°47'35.61" N	90°24'52.60" E	SR	n=15	~20:00:00	629	705	89 %	11 %	No	1A
11b	Westin Hotel 23rd floor	Gulshan Ave	U/T/C	23°47'35.61" N	90°24'52.60" E	SR	n=4	~20:00:00	350	384	91 %	9 %	No	1B
12	DoE Office	N/A	U/B/C	23°46'36.88" N	90°22'19.85" E	SR	01.02.2011	09:46:54	705	715	99 %	1 %	No	14
13	DCC Market Gulshan-2	Gulshan Ave	U/T/C	23°47'37.96"N	90°24'55.47"E	SR/BS	03.02.2011	18:01:03	509	624	82 %	18 %	No	11
14	Amin Bazaar	N/A	S/I/I	23°46'41.32"N	90°20'17.88"E	SR/BS	04.02.2011	11:03:25	332	410	81 %	19 %	No	26
15	Lalberg Fort	N/A	S/B/R	23°43'9.32"N	90°23'16.54"E	SR/BS	04.02.2011	14:12:08	249	263	95 %	5 %	No	No
16	Parliament CAMS station	N/A	U/B/C	23°45'45.13"N	90°22'55.55"E	SR/Mizan/Khairul	09.02.2011	11:40:00	425	450	94 %	6 %	No	20
17a	Bangla Market - inside	N/A	U/C	23°43'25.21"N	90°24'21.26"E	SR/SH	12.02.2011	12:07:36	401	799	50 %	50 %	No	No
17b	Bangla Market - ouside	N/A	U/C	23°43'23.83"N	90°24'21.26"E	SR/SH	12.02.2011	12:46:01	497	1054	47 %	53 %	No	No
18	Old Town	N/A	U/C	23°42'56.18"N	90°23'45.22"E	SR/SH	12.02.2011	13:55:23	1131	2039	55 %	45 %	No	No

Traffic Sampling (Vehicle flows, vehicle distributions)

Site#	Description	Road	Lat	Long	Road type	Traffic flow	Observer	Date/time	Cars/hr	Taxi/hr	Bus/hr	Truck/hr	MC/hr	Tuktuk/hr	Total veh/dir/hr	Total veh/hr	PM Site	Comments
1a	At Norwegian Embassy	Road 111 (both directions)	23°47'24.59"N	90°25'1.86"E	diffuse	very light	BS	3 Feb2011: 16:36	116	0	2	0	18	8	**n/a**	**144**	**1a**	
1b	West from Norwegian Embassy	Gulshan Road (Northbound)	23°47'23.48"N	90°24'58.93"E	primary	very heavy	BS	3 Feb 2011; 17:20	964	4	14	12	32	80	**1106**	**2706**	**1b**	during rush hour northbound
1b	West from Norwegian Embassy	Gulshan Road (Southbound)	23°47'23.48"N	90°24'58.93"E	primary	light	SR	3 Feb 2011; 17:20	1176	24	24	54	66	256	**1600**		**1b**	during rush hour northbound
2	Ishkabad	Mirpur road (both directions)	23°47'23.35"N	90°19'20.49"E	primary	medium	BS	4 Feb 2011; 12:15	720	1	480	444	0	0	**n/a**	**1645**	**2**	weekend, near bus stop to countryside
3	Farmgate CAMS station	Airport Road (Northbound)	23°45'34.95"N	90°23'21.89"E	primary	light	BS	4 feb 2011, 13:00	1584	54	330	0	180	1002	**3150**	**5160**	**3**	weekend
3	Farmgate CAMS station	Airport Road (Southbound)	23°45'34.95"N	90°23'21.89"E	primary	medium	SR	4 feb 2011, 13:10	1014	78	150	54	156	912	**2364**		**3**	weekend
3	Farmgate CAMS station	Airport Road (Southbound)	23°45'34.95"N	90°23'21.89"E	primary	medium	BS	4 feb 2011, 13:15	828	12	36	48	72	660	**1656**		**3**	weekend
4	Aftabnagar	TV tower road (both directions)	23°45'51.49"N	90°25'48.67"E	diffuse	light	BS	5 Feb 2011, 13:45	561	24	42	6	108	183	**924**	**834**	**4**	weekend
4	Aftabnagar	TV tower road (both directions)	23°45'51.49"N	90°25'48.67"E	diffuse	light	SR	05 feb 2011, 13:30	426	30	36	24	90	138	**744**		**4**	weekend
5	Paltan	DIT Extension Rd (Southbound)	23°44'22.18"N	90°25'11.20"E	primary	medium	BS	5 Feb 2011, 1440	462	12	18	3	75	66	**636**	**1482**	**5**	weekend
5	Paltan	DIT Extension Rd (Southbound)	23°44'22.18"N	90°25'11.20"E	primary	medium	SR	05 feb 2011, 14:45	390	12	36	6	66	138	**648**		**5**	weekend
5	Paltan	DIT Extension Rd (Northbound)	23°44'22.18"N	90°25'11.20"E	primary	medium	BS	5 Feb 2011, 1440	666	6	18	0	75	75	**840**		**5**	weekend
6	Parliament Primary Rd	Rokeya Sarani Rd (Northbound)	23°45'44.90"N	90°23'0.16"E	primary	medium	SR/Mizan/Khairul	09 feb 2011, 11:00	568	28	164	0	68	320	**1148**	**2756**	**6**	after rush-hour
6	Parliament Primary Rd	Rokeya Sarani Rd (southbound)	23°45'44.90"N	90°23'0.16"E	primary	medium	SR/Mizan/Khairul	09 feb 2011, 11:20	768	42	114	12	390	282	**1608**		**6**	after rush-hour
7	Sankar	Satmasjid Rd (Southbound)	23°44'54.85"N	90°22'11.76"E	primary	medium	SR/Mizan/Khairul	09 feb 2011, 12:40	954	18	42	0	30	108	**1152**	**2468**	**7**	
7	Sankar	Satmasjid Rd (Northbound)	23°44'54.85"N	90°22'11.76"E	primary	medium	SR/Mizan/Khairul	09 feb 2011, 13:40	906	24	56	6	156	168	**1316**		**7**	
8a	Tejgaion	Tejgaion Rd (Southbound)	23°45'34.12"N	90°23'58.34"E	primary	medium	SR/GS/Mizan/Khairul	09 feb 2011, 16:05	1446	72	84	48	270	906	**2826**	**5694**	**8a**	Just before rush-hour
8a	Tejgaion	Tejgaion Rd (Northbound)	23°45'34.12"N	90°23'58.34"E	primary	medium	SR/Mizan/Khairul	09 feb 2011, 16:15	1212	96	108	54	324	1074	**2868**		**8a**	Just before rush-hour
8b	off Tejgaion	Tejgaion Rd (both directions)	23°45'34.42"N	90°24'1.53"E	diffuse (industrial)	light	SR/Mizan/Khairul	09 feb 2011, 16:45	42	2	4	0	10	36	**n/a**	**94**	**8b**	Most veh came last 10% of sample
9a	Airport Rd North	Airport Rd (Northbound)	23°51'32.91"N	90°24'3.76"E	primary	light	SR/GS/Salim/Ashraf	10 feb 2011, 10:45	2232	120	408	162	216	576	**3714**	**6702**	**9a**	after rush-hour
9a	Airport Rd North	Airport Rd (Southbound)	23°51'32.91"N	90°24'3.76"E	primary	light	SR/GS/Salim/Ashraf	10 feb 2011, 10:55	1722	96	300	138	210	522	**2988**		**9a**	after rush-hour
9b	off of Airport Rd North	Jashimuddin (Westbound)	23°51'39.37"N	90°23'49.15"E	secondary	very light	SR/GS/Salim/Ashraf	10 feb 2011, 11:20	582	18	6	30	54	114	**804**	**1434**	**9b**	
9b	off of Airport Rd North	Jashimuddin (Eastbound)	23°51'39.37"N	90°23'49.15"E	secondary	very light	SR/GS/Salim/Ashraf	10 feb 2011, 11:30	420	24	0	30	66	90	**630**		**9b**	
10	Airport Rd Banani	Airport Rd (Southbound)	23°48'34.74"N	90°24'13.38"E	primary	medium	SR/GS/Salim/Ashraf	10 feb 2011, 12:00	2640	150	290	230	270	980	**4560**	**7490**	**10**	slight effects of train crossing
10	Airport Rd Banani	Airport Rd (Northbound)	23°48'34.74"N	90°24'13.38"E	primary	medium	SR/GS/Salim/Ashraf	10 feb 2011, 12:10	1680	160	170	190	160	570	**2930**		**10**	slight effects of train crossing

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REPORT PREPARED FOR

BAPMAN Project

ABSTRACT
An ambient air pollution screening study was performed in Dhaka from 31 January – 15 February 2011. The main objective of the study was to gain an overview of the background concentrations and the spatial distribution of the air pollution in the Dhaka city area. Thorough ambient air quality data has not been collected in the city for some years. Results show relatively high concentrations for SO_2, NO_2, and O_3, with PM concentrations alarmingly high. PM concentrations could be attributed to local sources (predominantly brick Kilns and traffic), as well as regional influences (haze clouds) during the winter season which were compared to satellite AOD data.

NORWEGIAN TITLE

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