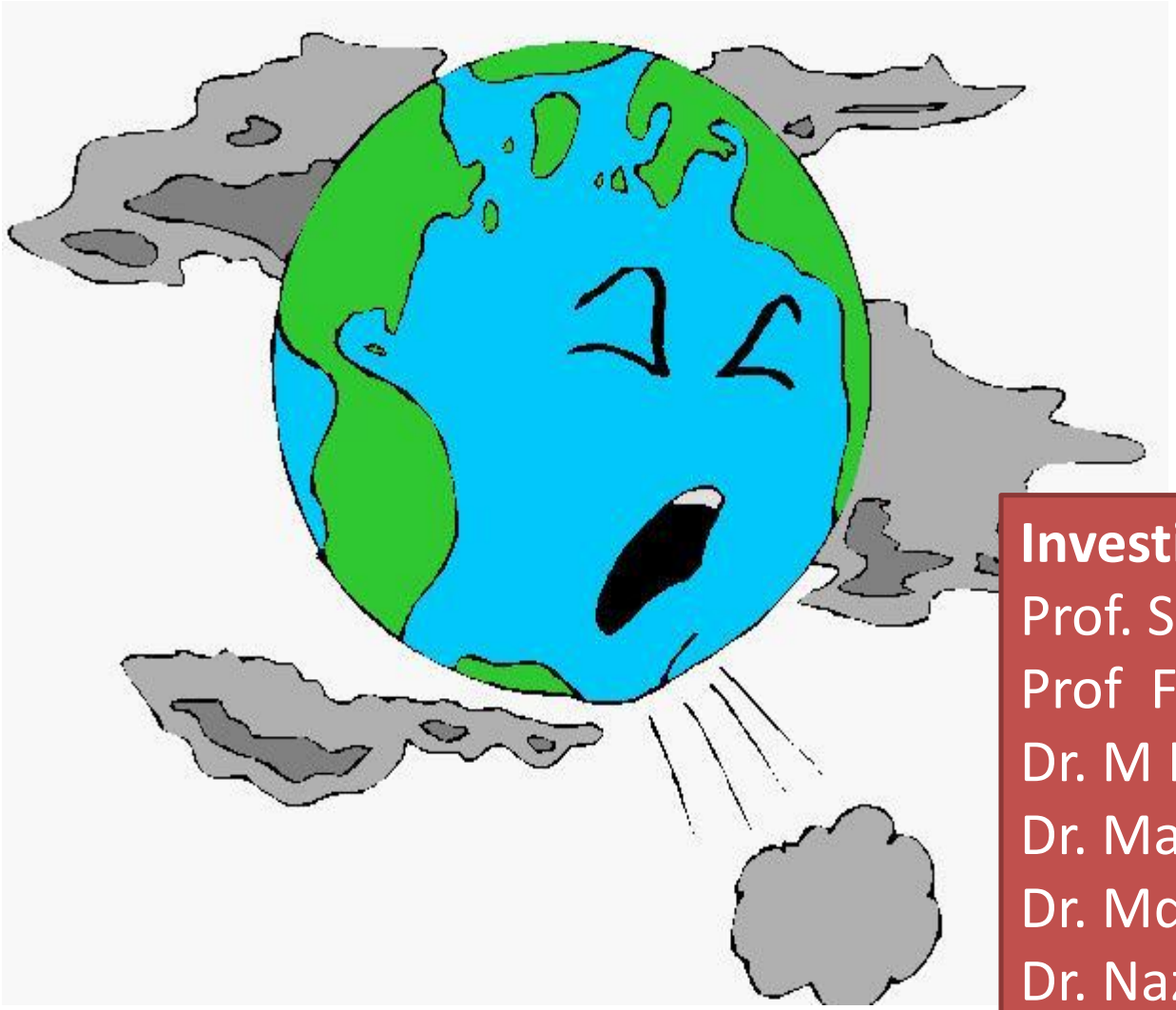
Assessment of impact of air pollution among school children in selected schools of Dhaka city



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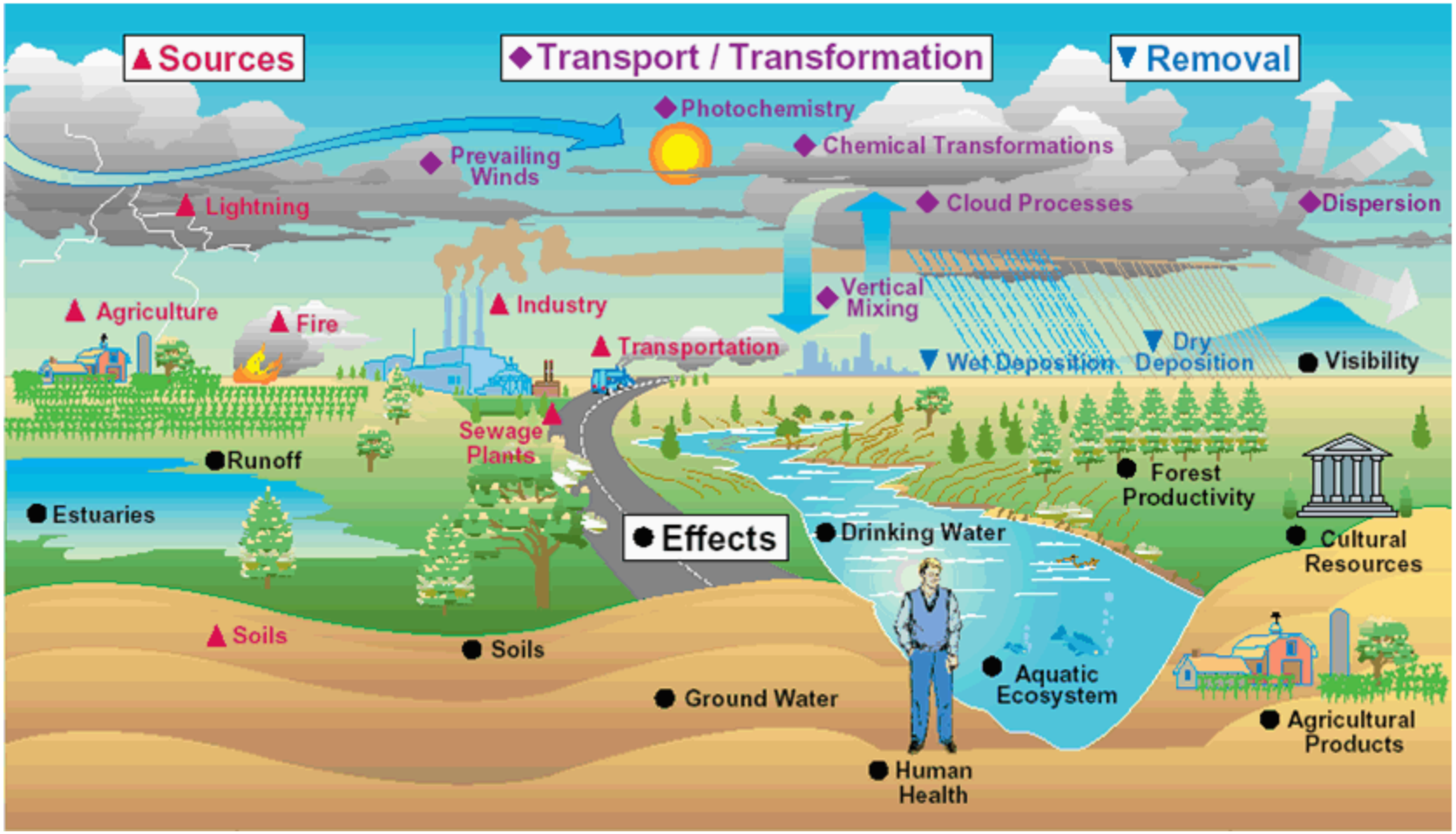
Background of the study

- Degradation of air due to anthropogenic activities is a major concern all over the world.
- Air pollution has become a key environmental issues in Asia-Pacific region as well with the growth of big cities.
- Air quality in Dhaka is a serious issue in view of the magnitude of its health and economic impacts.
- Huge population growth and infrastructure development affected the major components of the city environment.

Air quality of Dhaka

- The main air quality problem in Dhaka is the high level of particulate matter.
- Both PM10 and PM 2.5 levels are high, being much above the safety standards especially during the dry season.
- The increasing number of transportation vehicles and their improper management and operation are mainly responsible for degradation of the air quality.

Air pollution



Source internet

Air pollution

- Air quality is affected by both human and natural activities.
- Particulate matters (PM) are the major air contributor of air pollutant
- PM is a mixture of particles that can be solid, liquid or both, are suspended in the air and represent a complex mixture of organic and inorganic substances.
- Particles are categorized according to particle size (PM 10 & PM 2.5)
- Size is the important determinant of their effect on human health

Particulate matters

PM10

- Aerodynamic diameter smaller than 10 µm.
- Can reach the upper part of the airways and lung.

PM2.5

- Aerodynamic diameter smaller than 2.5 µm
- Can penetrate into the lung and may reach the alveolar region.

The major PM components are:

- Sulfate
- Nitrates
- Ammonia,
- Sodium chloride
- Carbon
- Mineral dust and Water

Evolution of Particulate Matters

Particles are directly emitted into the atmosphere through anthropogenic or natural processes.

Anthropogenic processes include

- Combustion of fossil fuel , diesel and petrol
- Solid-fuel like biomass, coal
- Combustion in households
- Industrial activities (building, road digging etc)
- Erosion of the soil, pavement by road traffic
- Human and Vehicular movement

Natural process include

- Volcano
- Earth quake
- Land slide

Sources of PM

Anthropogenic emissions of PM10

- Road traffic (10–25%),
- Stationary combustion (40–55%)
- Industrial processes (15–30%).

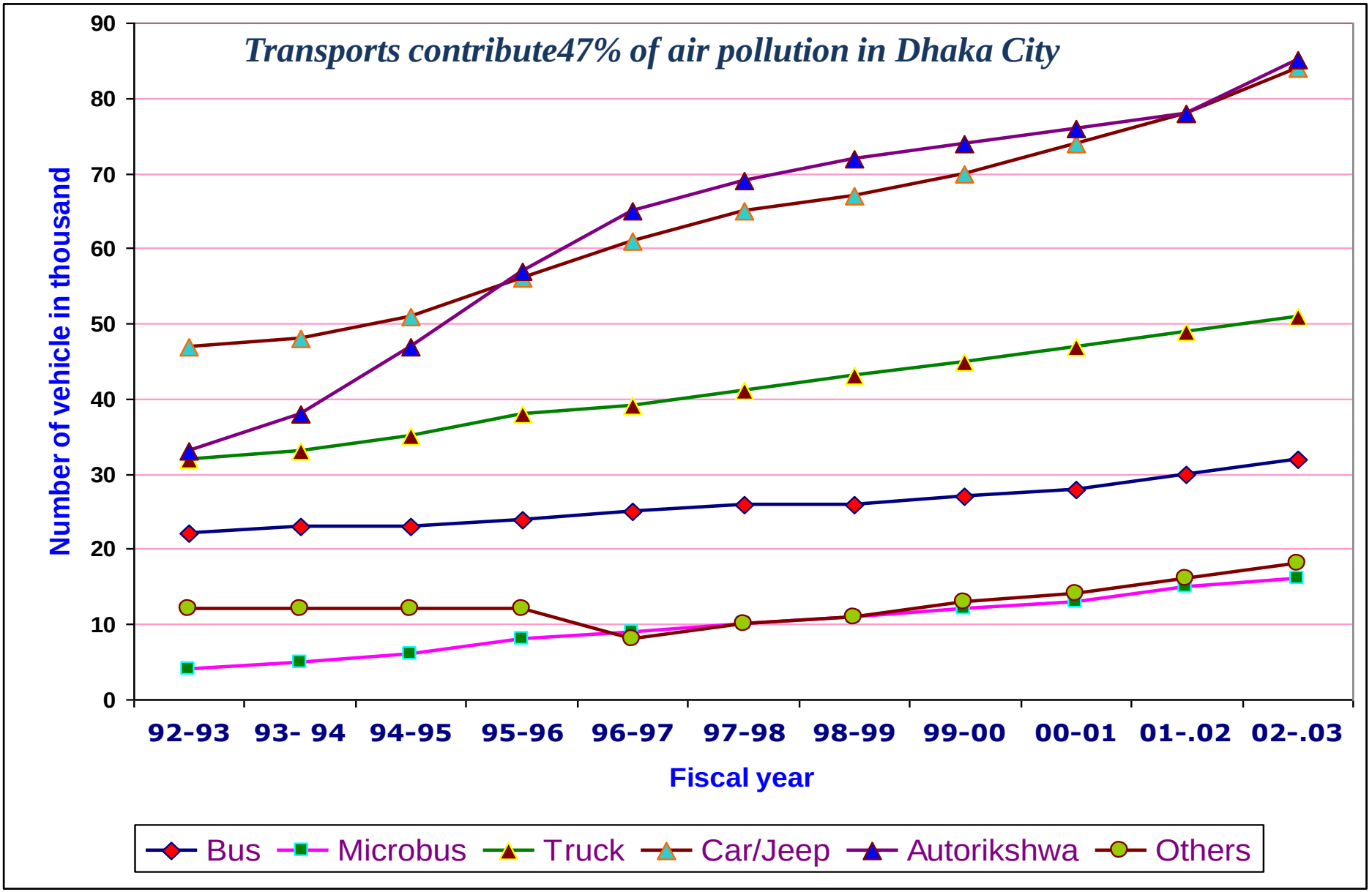
PM2.5 constitutes, on average, about 70% of the PM10 mass

(Dockery DW. 2001)

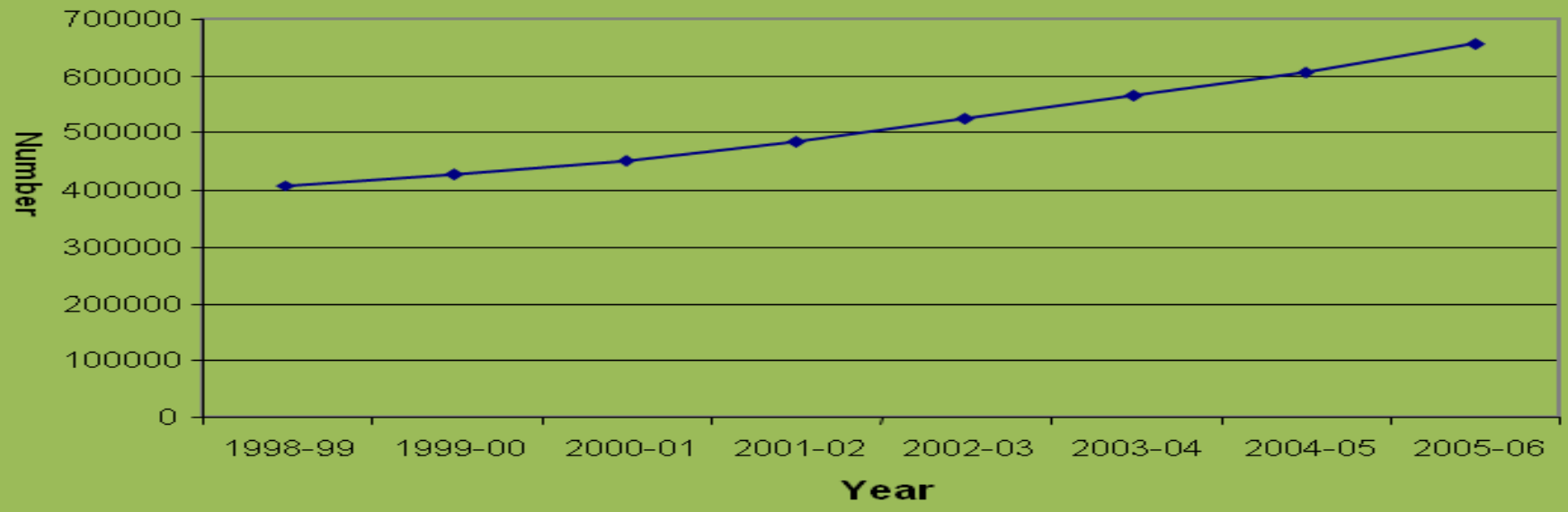
The seasonal variability of PM10 occurs due to the changes in PM2.5 concentration

Sources of Air pollution In Dhaka City

Motor Vehicles in Bangladesh



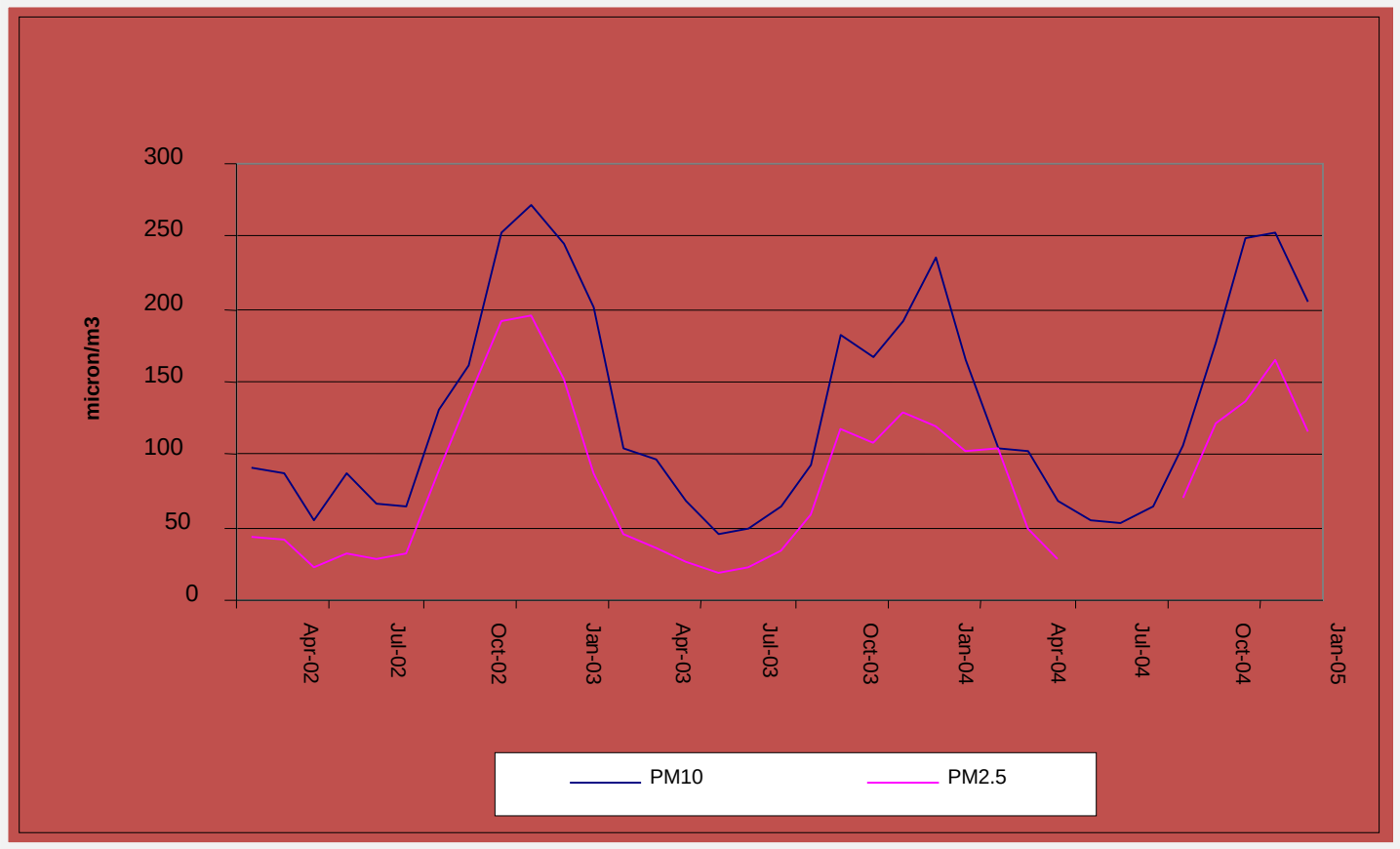
Increase of motor vehicles from '99-'06.



Increasing number of vehicles

Improper management operation

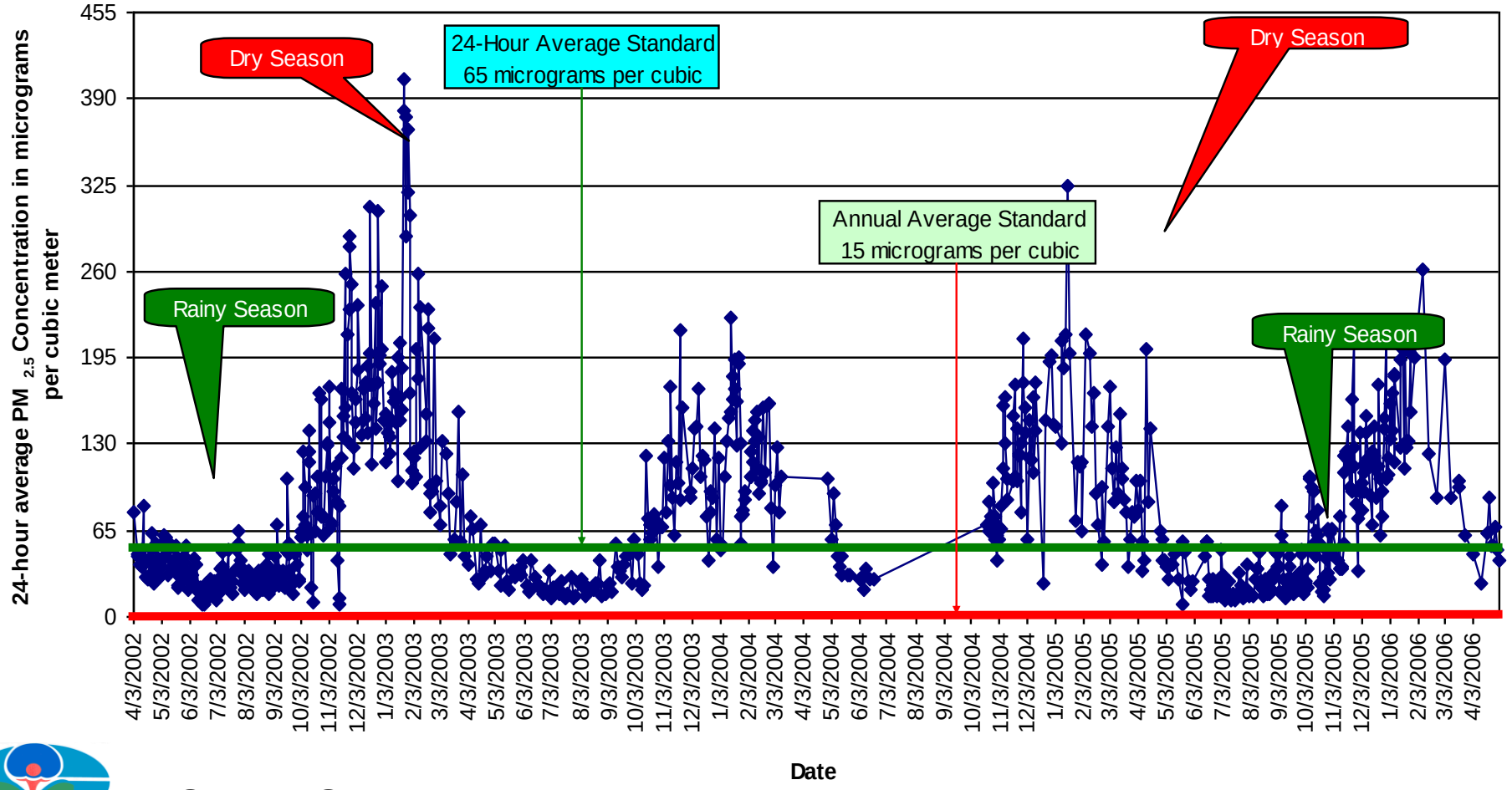
Average Particulates during April 2002 – February 2005



Seasonal Variation of Particulate Matter in Dhaka City

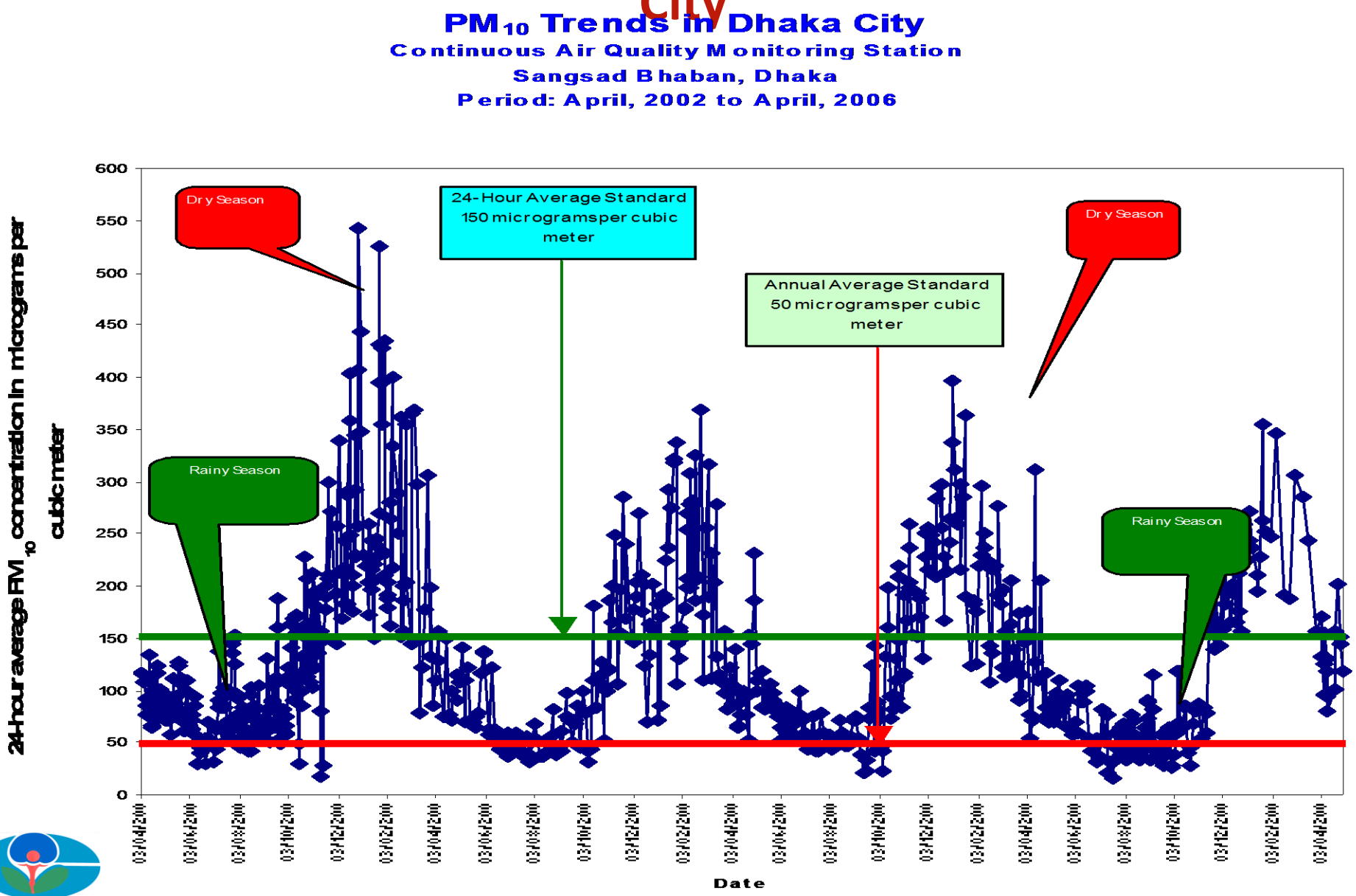
$PM_{2.5}$ Trends in Dhaka City

Continuous Air Quality Monitoring Station
Sangsad Bhaban, Dhaka
Period: April, 2002 to April, 2006



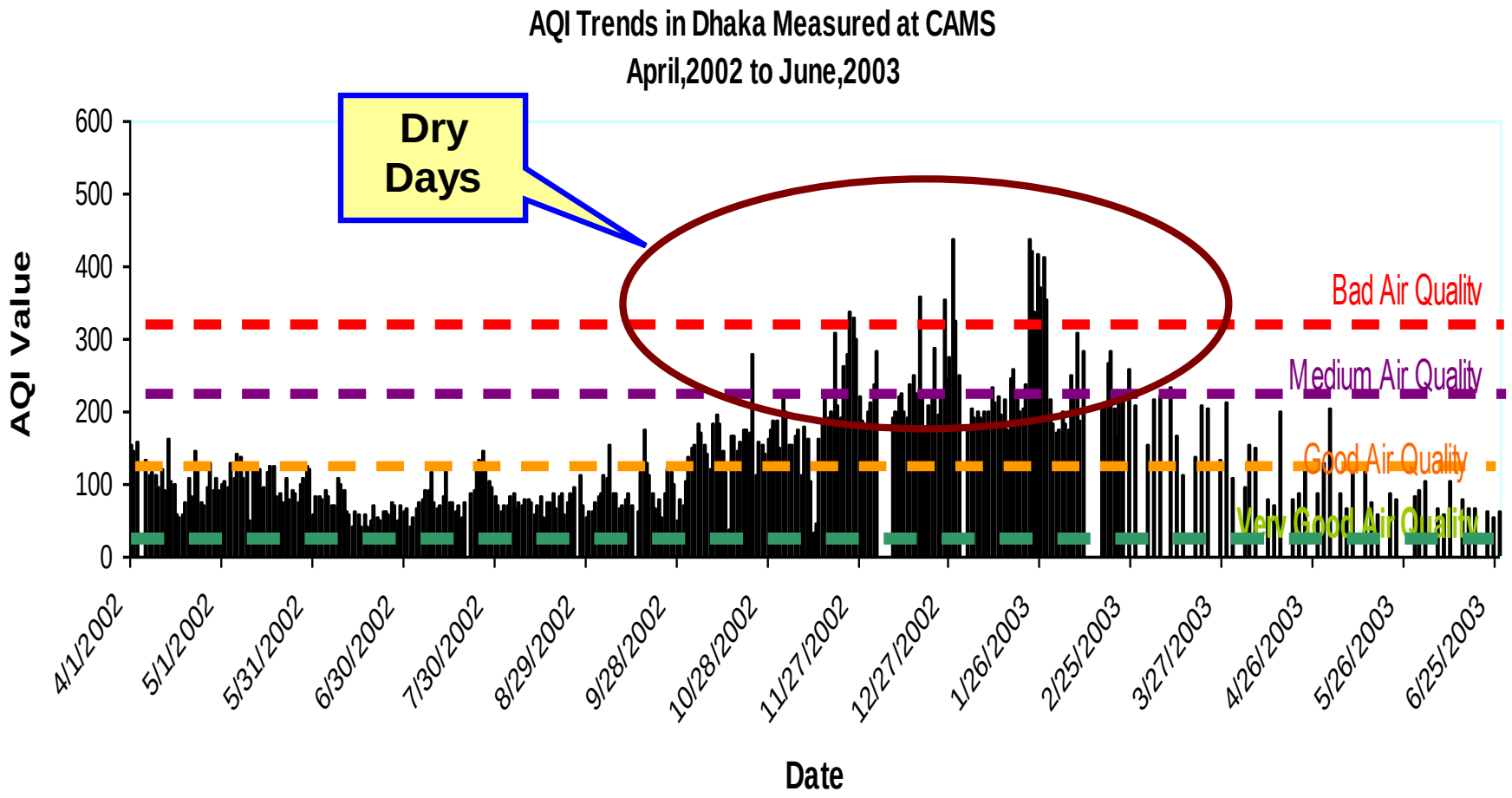
AQMP, DOE

Seasonal Variation of Particulate Matter in Dhaka City



AQMP, DOE

AQI Trends in Dhaka



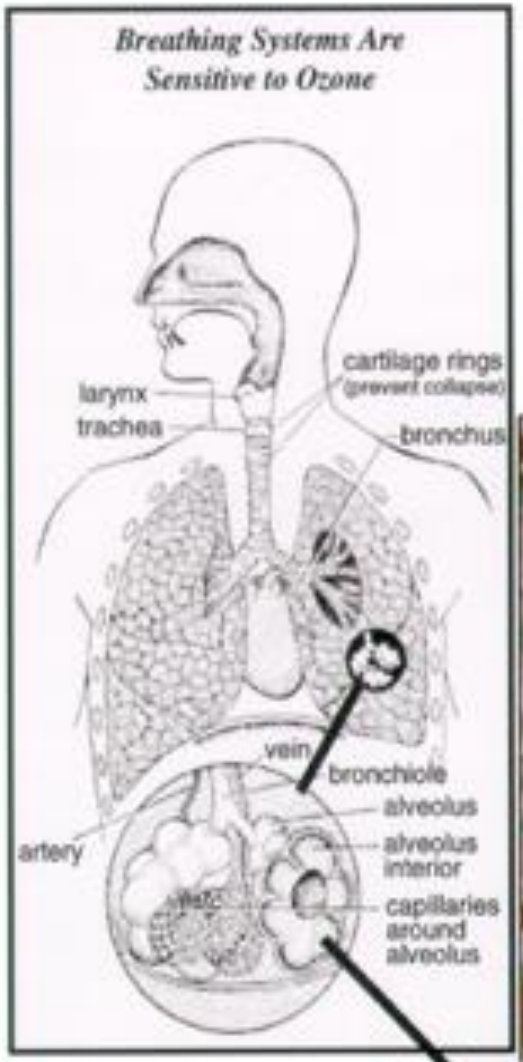
AQMP, DOE

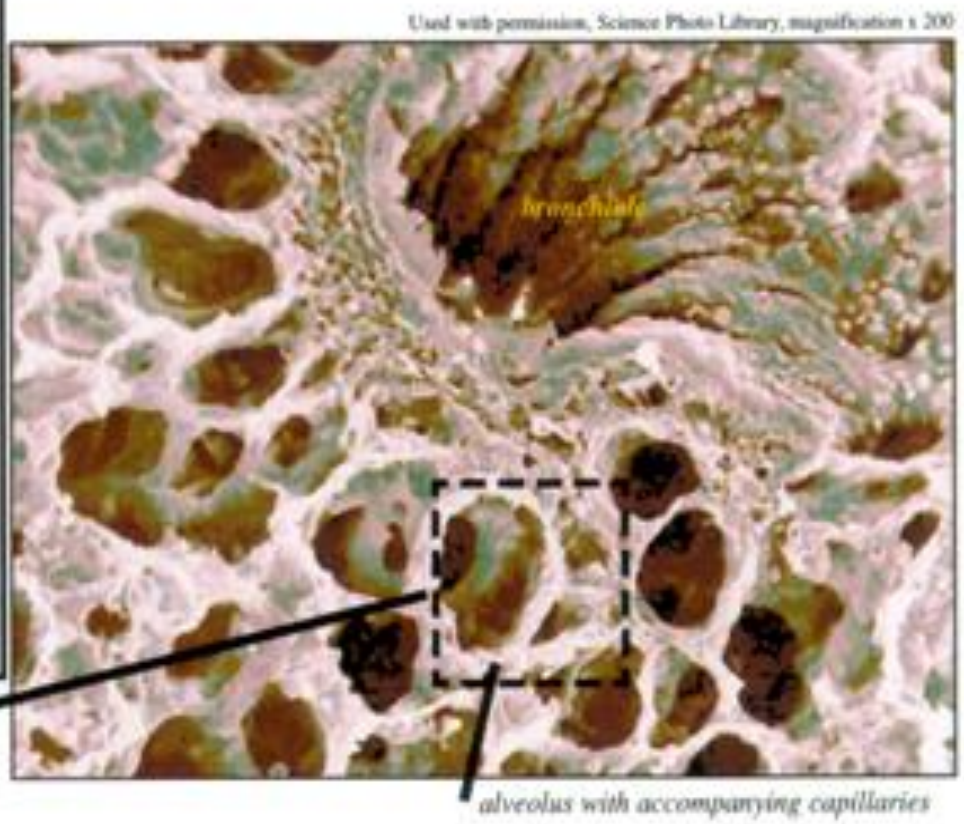
Air pollution & health

- High levels of outdoor air pollution have been associated with short-term increases in asthma morbidity and mortality
  - **(AAPCEH 1993; Ostro *et al.* 2001; Tolbert *et al.* 2000).**
- Specific exposures to outdoor plant allergens such as organic dusts from castor beans, soybeans, and grains dramatically illustrate this relationship.
  - **(Etzel 2003)**
- Ambient hazardous air pollutants, as well as industrial releases of aldehydes, metals, isocyanates, and others have been shown to cause and trigger asthma
  - **(Leikauf et al. 1995).**

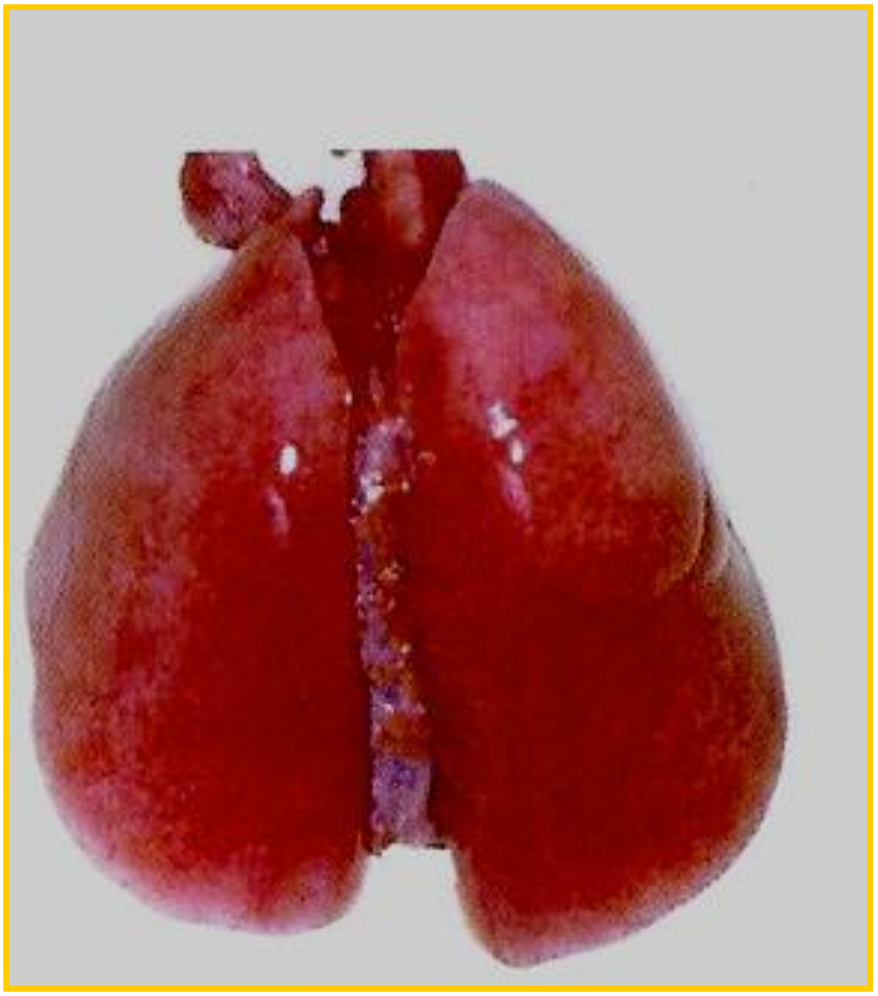
Exchange of gases occurs in air sacs (alveoli)

lungs contain some 700 million alveoli which have a total surface area comparable to that of a tennis court.





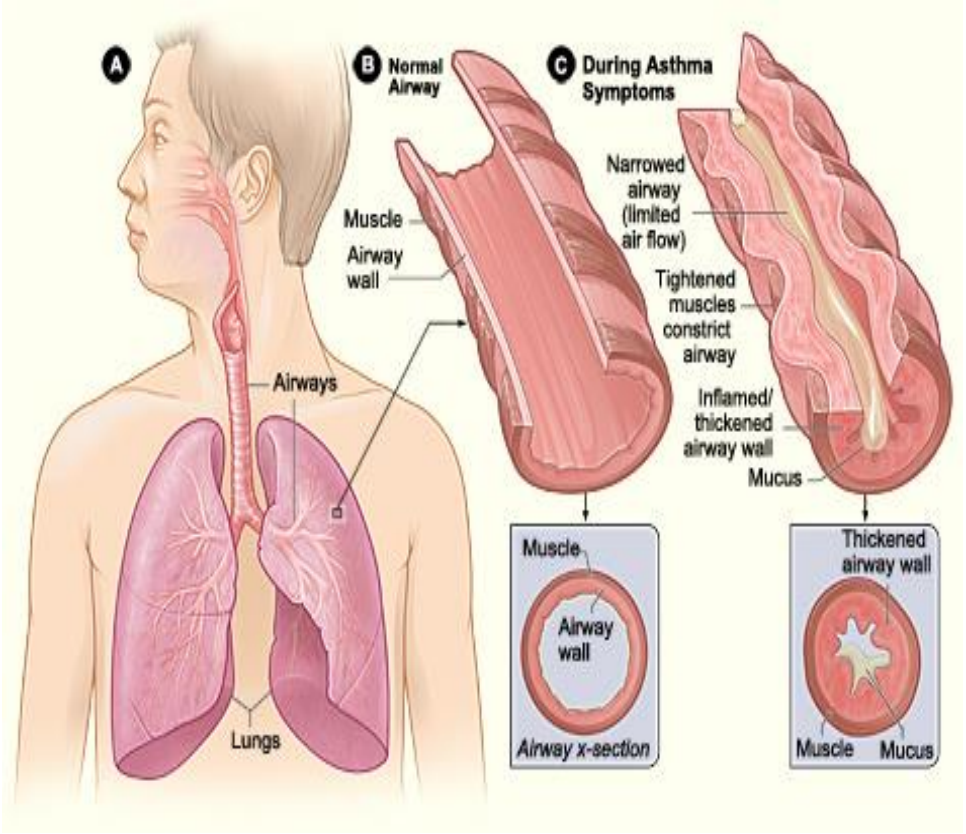
Health Impacts of Air Pollution



Health Impacts of Air Pollution

- Mortality
- Cardiopulmonary Hospitalizations
- Emergency department or outpatient visits
- Symptomatic exacerbations
- Changes in lung function
- Cardiopulmonary symptoms
- Upper respiratory illnesses
- Lower respiratory illnesses

Asthma



- Asthma is a common chronic disorder in childhood
- An asthma episode results in narrowed airways following:
  - Swelling of the lining
  - Tightening of the muscle
  - Increased secretion of mucus in the airway.
- Children with asthma may experience wheezing, coughing, chest tightness and trouble breathing, especially early in the morning or at night.

Child hood Asthma

- The 3rd leading cause of hospitalization among children under the age of 15.
- one of the leading causes of school absenteeism
- The annual direct health care cost poses huge economic burden
- Can be a life-threatening disease if not properly managed among children.

Other Effects of Air Pollution

- Immune System; Allergies
  - Allergic Asthma, Allergic Rhino-conjunctivitis
  - Extrinsic Allergic Alveolitis / Hypersensitivity
- Central Nervous System
  - Toxic Damage of Nerve Cells
  - Mental retardation
- Carcinogenic Effects
  - Lung Cancer, Leukemia
- Reproductive effects
  - Infant mortality, Low weight birth

Health Effects of Air pollution in Dhaka City

- Child hood Asthma and ARI has increased significantly in Dhaka city
- 500,000 premature death & a million in the whole country become ill every year due to air pollution. About 15,000 premature death of children occurs in Dhaka city only
  (World bank estimate)
- 577,152 of respiratory disorders in a year of Bangladesh
  (DGHS report 2003)

Health effect of PM

- Particulate emission is mainly responsible for increased death rate and respiratory problems for the urban population.
- PM2.5 particularly contributes in increasing deaths from cardiovascular and respiratory diseases and lung cancer.
- PM increases the risk of respiratory death in infants under 1 year, affects the rate of lung function development, aggravates asthma and causes other respiratory symptoms such as cough and bronchitis in children (Ostro B 2001)

Health effect of PM……

- Increased PM2.5 concentrations increase the risk of emergency hospital admissions for cardiovascular and respiratory causes
- PM10 affects respiratory morbidity, as indicated by hospital admissions for respiratory illness.
- (WHO 1999, American Thoracic Society, 1996)
- Toxicity of particles may vary with composition .

  (Ghio AJ 2002, Pandya RJ 2002)
- Particle pollution contributes to excess mortality and hospitalizations for cardiac and respiratory tract disease.

  (Schwartz J. 1994, Samet JM et al 2000)

Children are more Vulnerable

- In children, particulate pollution affects lung function and lung growth.

(Ostro 2001, Yu O 2000, Gauderman 2000)

- Children have higher exposure to many air pollutants compared with adults because of higher minute ventilation and higher levels of physical activity.

(WHO1999. COEH 2004)

- Notable respiratory effects in children and adults
  - Asthma exacerbations
  - Decreased lung function.

(Gauderman 2000, ATS 1996)

Rationale for the study

- There is no doubt that air pollution affecting human health in Bangladesh, especially in Dhaka City.
- Lack of formal studies showing the linkages between air pollution concentration and health impacts in most Asian countries as well as in Bangladesh.
- Current effort attempted to provide evidence on impact of air pollution among school children of Dhaka City .
- Under the Malé Declaration sub-activity 4.1.2 'Measuring health effects of air pollution through cohort, time-series or cross-sectional studies‘.
- Assessment of impact of air pollution among school children in selected schools of Dhaka City has been decided to undertaken

Stakeholders

The Study was initiated jointly by

- United Nations Environment Program (UNEP)
- RRCAP
- Stockholm Environment Institute (SEI) of Sweden,
- Department of Environment (DoE)
- Department of Occupational & Environmental Health (DOEH) of NIPSOM

Objective of the study

To explore whether air pollution in terms of the **concentrations of particulates** is related to **respiratory symptoms** and **lung function** (PEFR) in children in Dhaka City.

The findings of the study was expected to address uncertainties and strengthen inferences of **causality** and to develop a **dose-response** association.

Phases of the study

Current study consists of two components

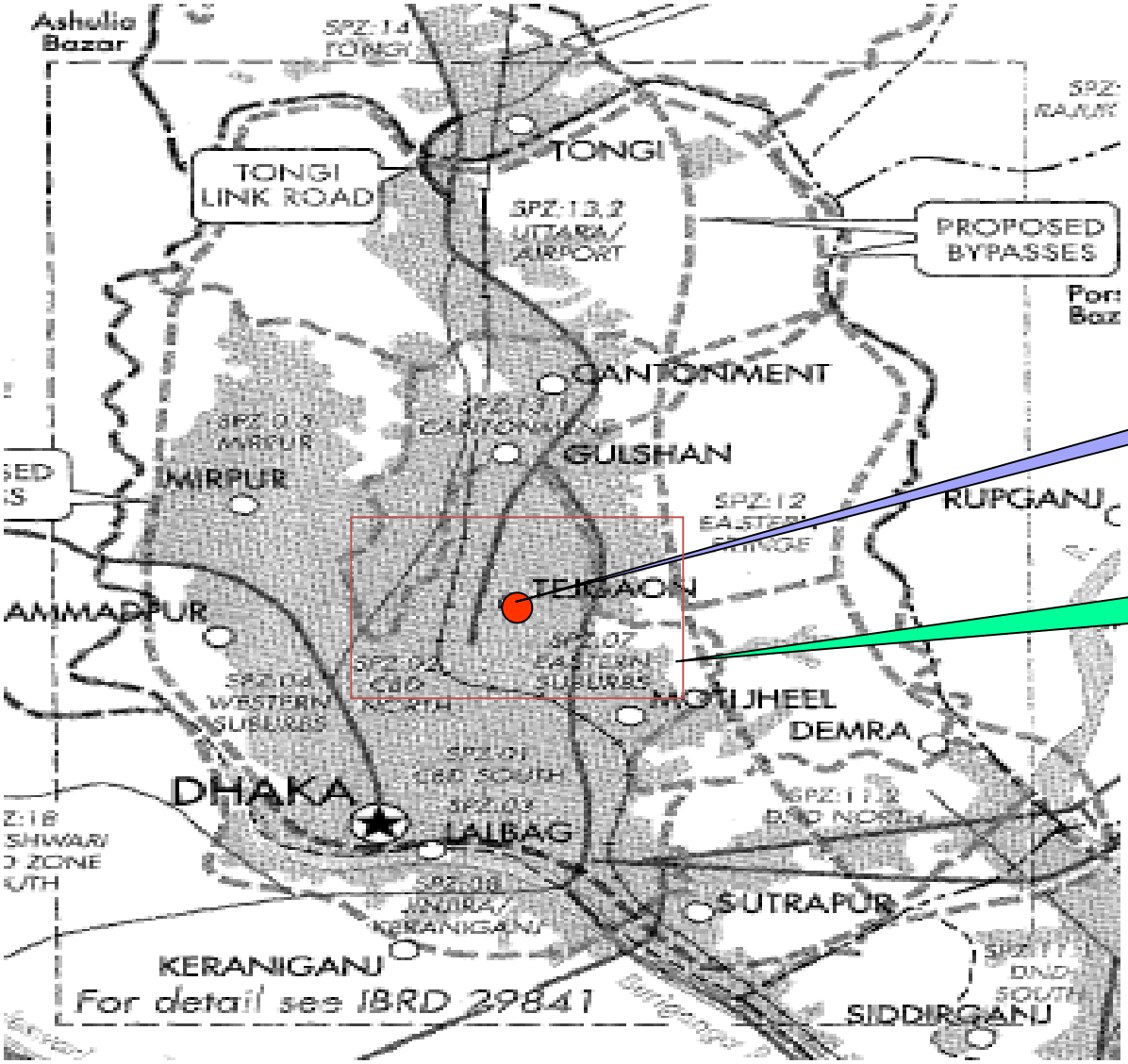
Phase I: Baseline Survey

Phase II: Health impact study

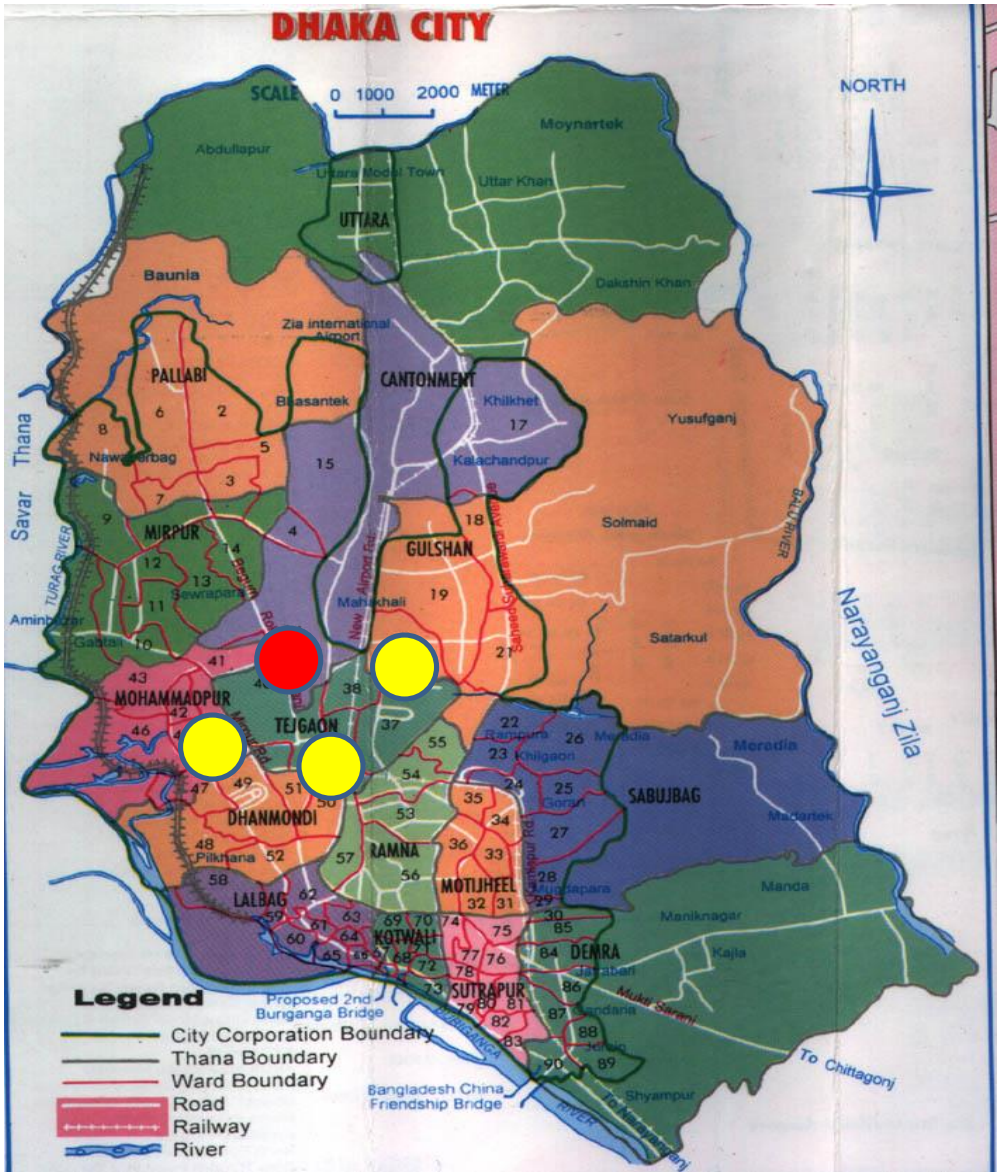
Methods

- Base survey was conducted in 3 schools of Dhaka City & within 1 Km of Air Quality Monitoring Station of DoE
  - Dhanmondi Boy's School (DBS),
  - Tejgaon Girl's School (TGS)
  - Civil Aviation School (CAS).

PM Sampling station & Health impact study area



Study place


DHAKA CITY
SCALE 0 1000 2000 METER
NORTH
Abdullapur
Uttara Model Town
Uttar Khan
Moynartek
UTTARA
Baunia
Dakshin Khan
Zia international Airport
PALLABI
CANTONMENT
Khilkhet
Yusufganj
Kalachandpur
Solmaid
MIRPUR
GULSHAN
Mahakhali
Satarkul
Savar Thana
Narayanganj Zila
MOHAMMADPUR
TEJGAON
Meradia
SABUJBAG
DHANMONDI
RAMNA
MOTIJHEEL
Manda
Maniknagar
LALBAG
KOTWALI
DEMRA
Kajla
SUTRAPUR
Proposed 2nd Buriganga Bridge
Bangladesh China Friendship Bridge
To Chittagonj
Legend
City Corporation Boundary
Thana Boundary
Ward Boundary
Road
Railway
River

Methods

- AQMP data of the place was considered as representative of the air quality state of the selected schools.
- All students of class V, VI, VII, VIII & IX of these schools were targeted as participants for the baseline survey.
- N= 1800 and age range was from 9-16 years

Data collection

Data collection instrument

Bengali version of ISAAC (International Study of Asthma and Allergies in Childhood) questionnaire

Health & Medical history check list

The Questionnaire consisted 3 parts:

Part-I : Introductory information.

Part II: Socioeconomic data

Part-III : Respiratory health related data.

Data collection Procedure

The questionnaire was delivered to all the students to fill in with the assistance of their parents.

Present health state and medical history were recorded in Check list by medical personnel

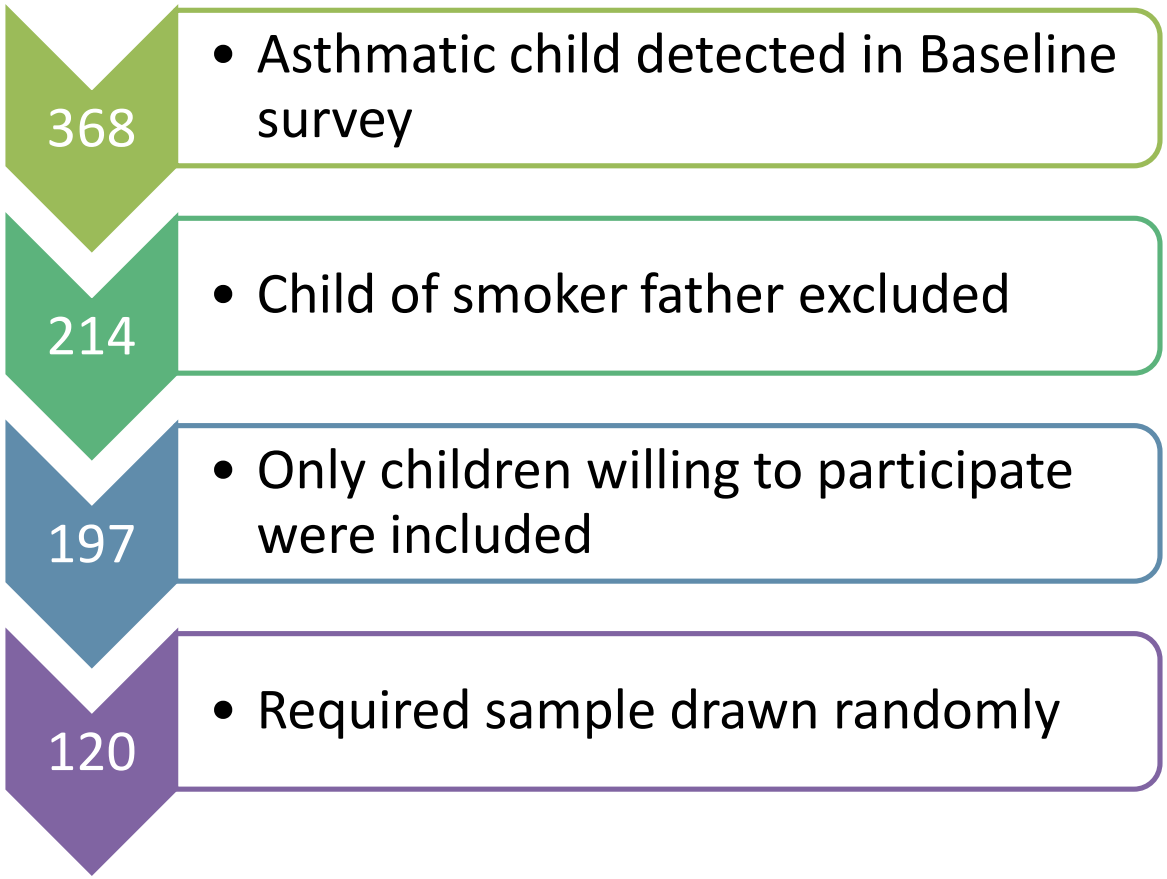
Anthropometric data collection

- Health check up by doctors using check list

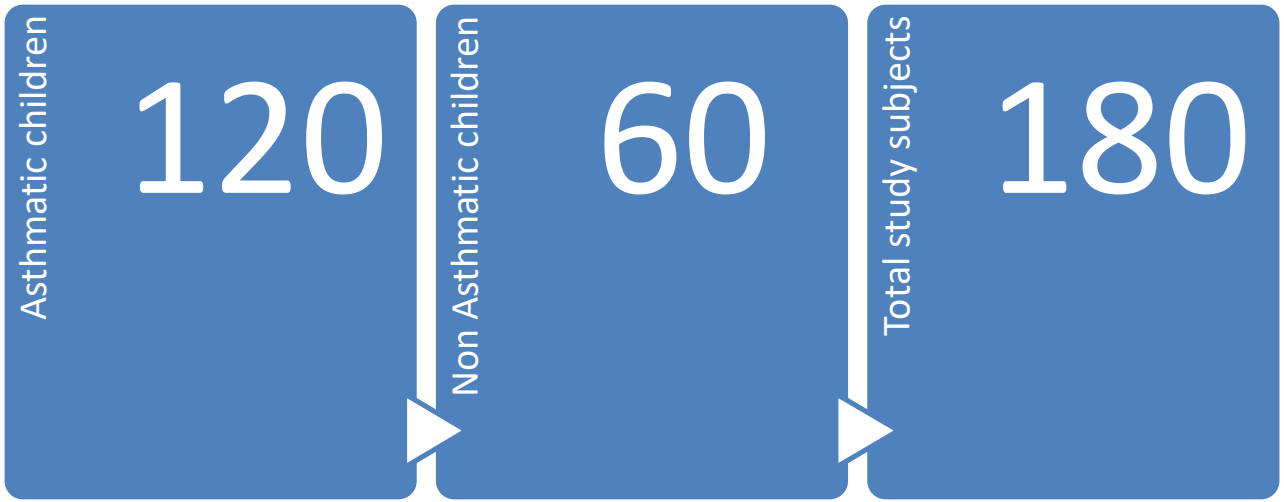
Response rate In Phase I

- Out of the 1800 targeted students
- 1618 students ultimately submitted the filled in questionnaire and were considered as participants of the study.
- The response rate was around 80%.
- To encourage responses and to achieve targeted 80% response rate for base line data, every respondent who returned the filled in questionnaire was given a token prize (e.g. Pencil box or Geometry Box or Pen set).

Recruitment of asthmatic children For Phase II



Sample size



Randomly	Up on consent	Final sample
• Selected from asthmatic children of phase one	• Selected from non asthmatic children of phase one	• Participated in Phase 2

Study period

•Data collection was planned during the peak dust periods of dry season.
•Typically in Bangladesh the dry period starts in November.
•During the period of November to February the dust level usually remains high com

Week	January				February				March				April				May				June				July			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1st																												
2nd																												
3rd																												
4th																												
5th																												
6th																												

Additional 1 week data were collected on November 07

Exposure assessment

Particulate material and weather condition were considered as exposure

Particulate data collected from the Air Quality Management Project (AQMP)

- PM10 and PM2.5 Level of relevant period was

Metrological data from the Department of Metrology

- Temperature : maximum, minimum and average
- Relative humidity: Maximum, minimum & average
- Wind speed

Exposure and outcome data were taken on same day for correlation

Outcome Measures

Lung function tests: Lung function tests evaluate how well lungs work.

- The tests determine how much air lungs can hold
- How quickly one can move air in and out of lungs
- How well lungs put O_2 into and remove CO_2 from blood.

Spirometry

- Forced vital capacity (FVC)
- Forced expiratory volume (FEV).
- Peak expiratory flow (PEF)
- Maximum voluntary ventilation (MVV)
- Total lung capacity (TLC)
- Functional residual capacity (FRC)
- Expiratory reserve volume (ERV)

Peak Expiratory Flow Rate (PEFR)

- PEFR measures maximum flow rate of expired air.
- That is how quickly one can exhale.
- This is a simple method of measuring airway obstruction

- The simplicity of the method is its main advantage.
- Peak flow measurement using a peak flow meter is particularly useful for individuals with asthma.

Outcome Measurement

- PEFR was measured twice per day
- Once in the morning shortly before the classes began Again when the classes for the day ended.
- Morning measurements were recorded before taking of any airway medication.
- Each measurement was replicated three times in the standing position, and the highest reading was recorded.

Statistical analysis

- A variety of statistical tests were used including:
  - chi-square tests to evaluate group data
  - t-test & ANOVA to test the difference between group means
  - Correlation analyses
  - Regression analyses
  - Repeated measures analyses

Results

Selected Socio demographic status of School Children

Class	Gender	No	Mean age (±SD)
Class V	Male	206	10.25 (±0.86)
	Female	212	10.40 (±0.89)
Class VI	Male	124	11.10 (±0.93)
	Female	223	11.26 (±0.82)
Class VII	Male	102	12.20 (±0.82)
	Female	165	12.28 (±0.78)
Class VIII	Male	98	13.11 (±0.90)
	Female	191	13.05 (±0.71)
Class IX	Male	109	13.80 (±0.89)
	Female	188	13.73 (±0.75)

Socio- demography

Age of the study participants ranged from 9 to 16 years.

The groups were found to be similar in terms of gender, age, academic level.

The two groups assumed to be homogenous with respect to the socio- demographic variables.

Respiratory Problems 1

Respiratory Problems	Response	No.	%
Wheezing sound in respiration	yes	268	19.6
	no	1101	80.4
Sound in respiration in last 1 year	yes	158	59.0
	no	110	41.0
No. of attacks of wheezing in past 1 year	1-3 times	126	79.7
	4-12 times	24	15.2
	>than 12 times	08	5.10
	no	999	73.6

Respiratory Problems 2

Respiratory Problems	**Response**	No.	**%**
Sleep disturbed for wheezing	> Once/wk	31	19.6
	Once/wk	64	40.5
	never	63	39.9
Severe wheezing	yes	67	42.4
	no	91	57.6
Child suffered from asthma	yes	235	16.5
	no	1190	83.5
Chest sounded wheezy during or after exercise	yes	114	8.20
	no	1282	91.8
Cold cough at night	yes	358	26.4
	no	999	73.6

Respiratory Problems not due to general cold/fever

Respiratory Problems not due to flu	Response	No.	%
Ever sneezing not due to general cold/fever	yes	567	40.6
	no	829	59.4
In last 1 year sneezing not due to general cold/fever	yes	486	85.7
	no	81	14.3
Eye itching with nose problem	yes	346	71.2
	no	140	28.8
Study and play disturbed in last year	most disturbed	9	1.90
	much disturbed	38	8.00
	little	269	56.4
	never	161	33.8
Allergy related fever	yes	172	12.5
	no	1208	87.5

Non Respiratory Allergic symptoms

Other Allergic symptoms	Response	No	%
Frequent rash in last 6 months	Yes	267	20.2
	No	1052	79.8
Rash at least once in last one year	Yes	241	90.3
	No	26	9.7
Rash in elbow, knee, heel, throat, eye, ear	Yes	170	68.3
	No	79	31.7
Rash automatically cured in last one year	Yes	153	62.2
	No	93	37.8
Night sleep disturbed for rash in last one year	> once/week	41	15.8
	once /week	66	25.4
	Never	153	58.8
Child suffered from eczema	Yes	136	9.7
	No	1259	90.3

Smoker in Households

Smoking status		N	%	Total
Any smoker among the house hold	Yes	574	39.8	1443 (89.2%)
	No	869	60.2	
Do they Smoke in the house	Yes	285	49.7	574 (39.8%)
	No	289	50.3	

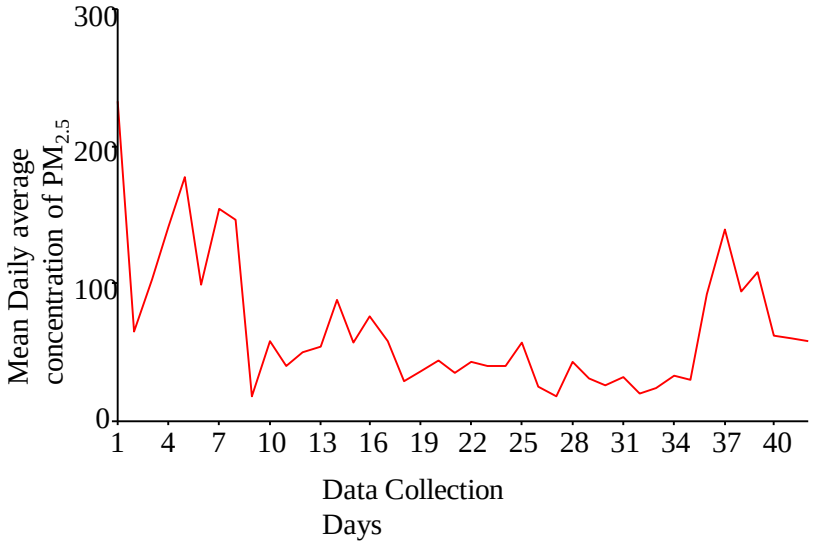
Asthma Status of Children

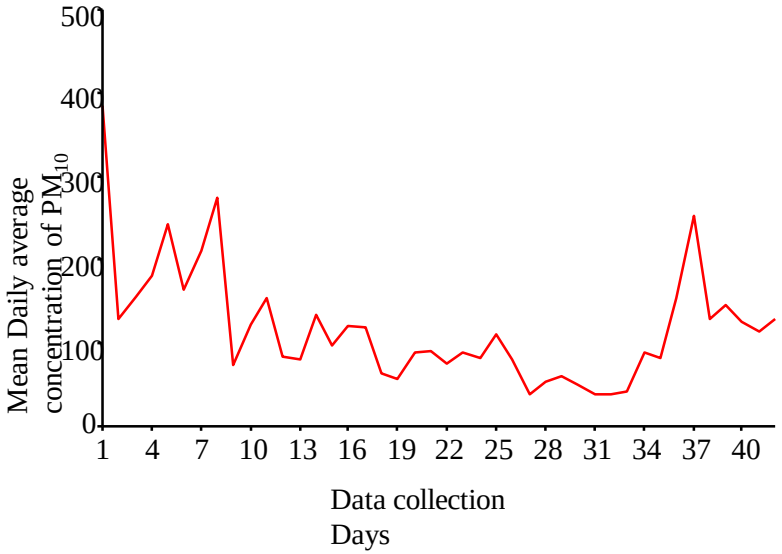
Asthma diagnosed by study physician	Child ever suffered from Asthma		Total
	Yes	No	
Yes	234 (63.6%)	134 (36.4%)	368 (25.8)
No	1 (0.1%)	1056 (99.9%)	1057 (74.2)
Total	235 (16.5%)	1190 (83.5%)	1425 (100.0)

Anthropometry

Variables of interest	Asthma status	Mean	SD	t-value	P value	95% CI
Height	No	149.17	10.548	-0.564	0.573	-4.1 – 2.3
	Yes	150.07	09.857			
Weight	NO	45.53	12.213	0.022	0.982	-3.6 -3.7
	Yes	45.49	11.586			

PM 10 and PM 2.5

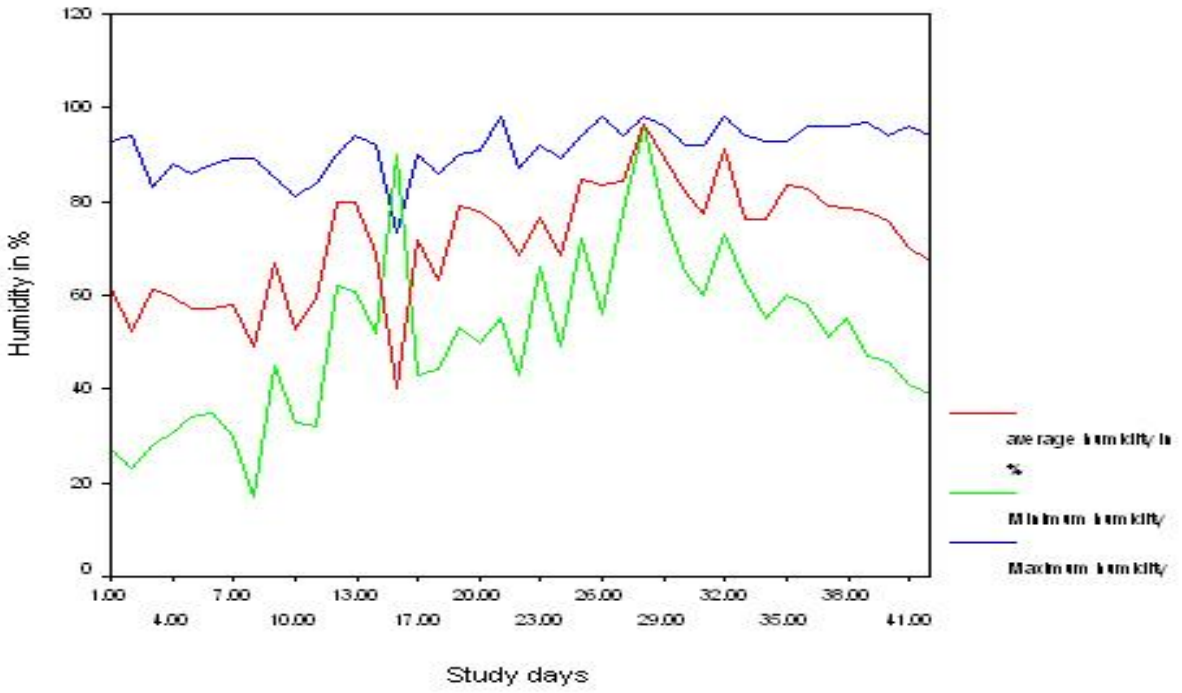




- **Mean PM 10 concentration 119 µg/m3 (38 to 385 µg/m3)**
- **Mean PM 2.5 concentration 67 µg/m³ (18 to 233 µg/m³)**

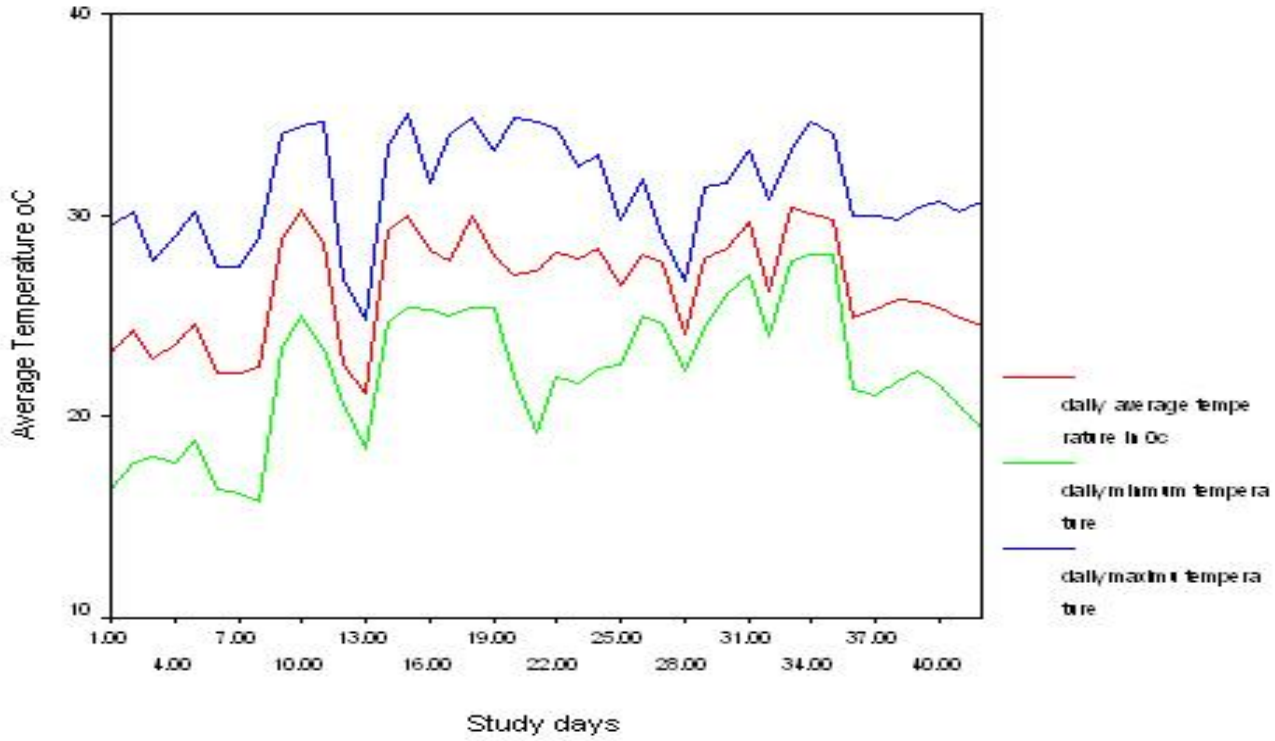
(Standard PM_{10} level of 150 µg/m & Standard PM2.5 of 65 µg/m3)

Humidity

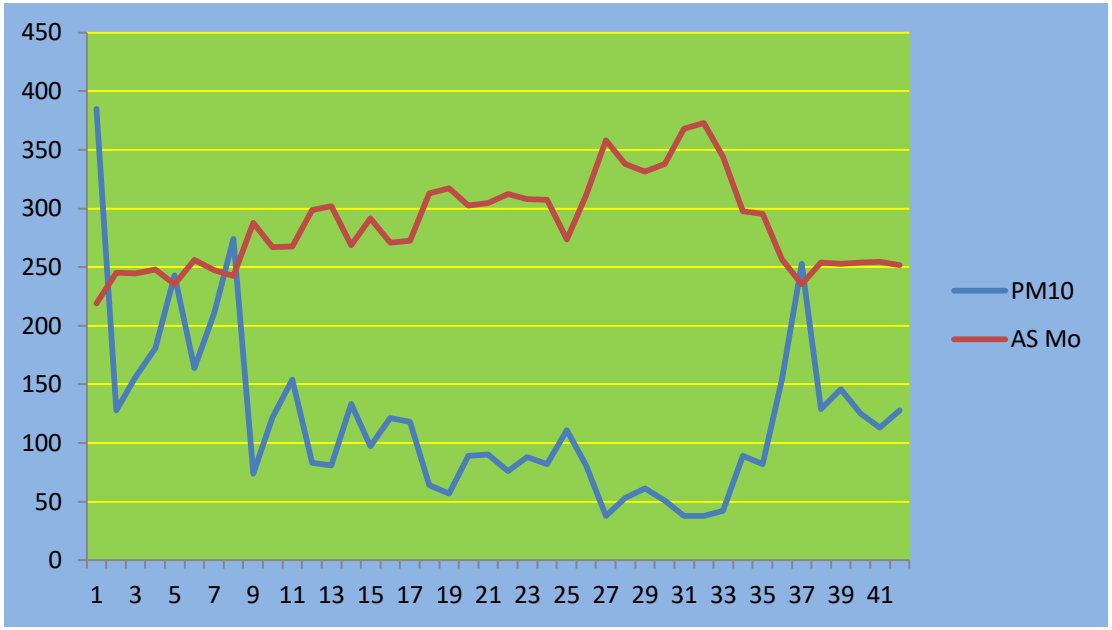


- Average Low Humidity was found in first 11 days of study period which was 48-59 %.
- After that the average humidity was increased and it was highest (98%) on 21th and 32nd day.

Temperature

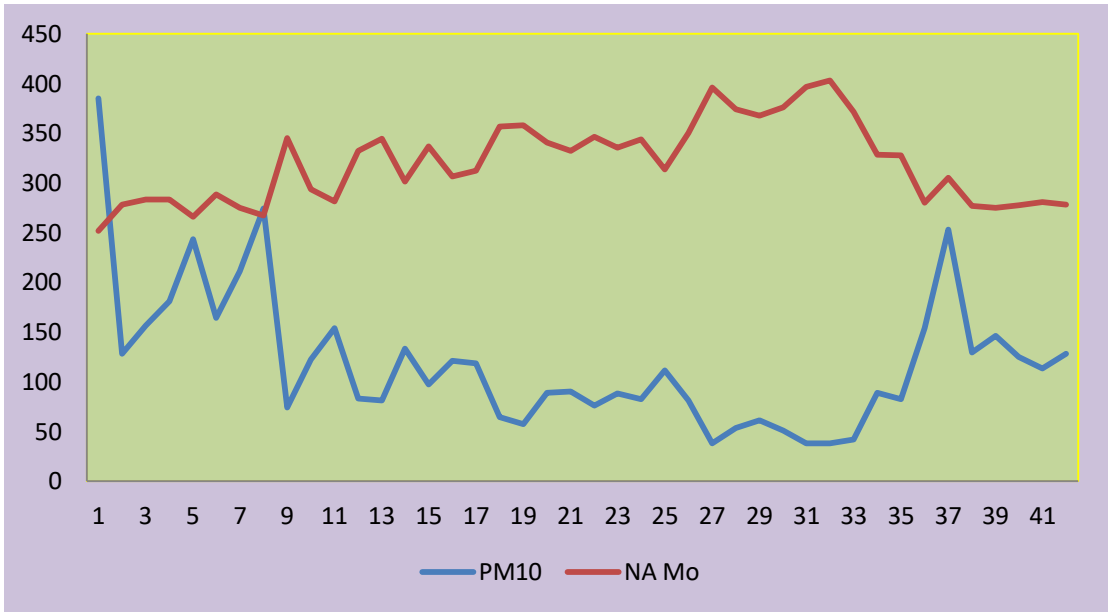


Average Low Temperature was observed during first 10 days which was 22-24^{0}C and the Lowest Temperature was 15.8^{0}C on 8th day.



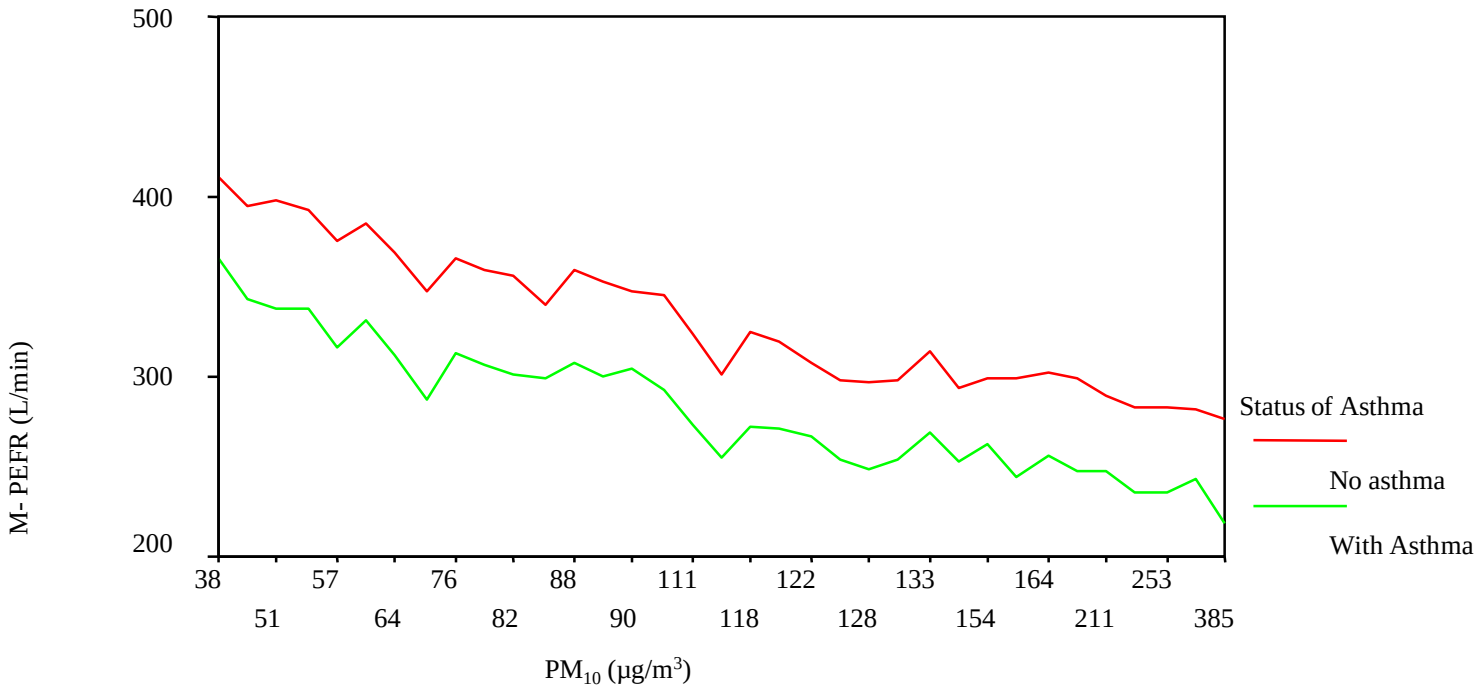
Asthma

PM 10
&
Morning PEFR



Non Asthma

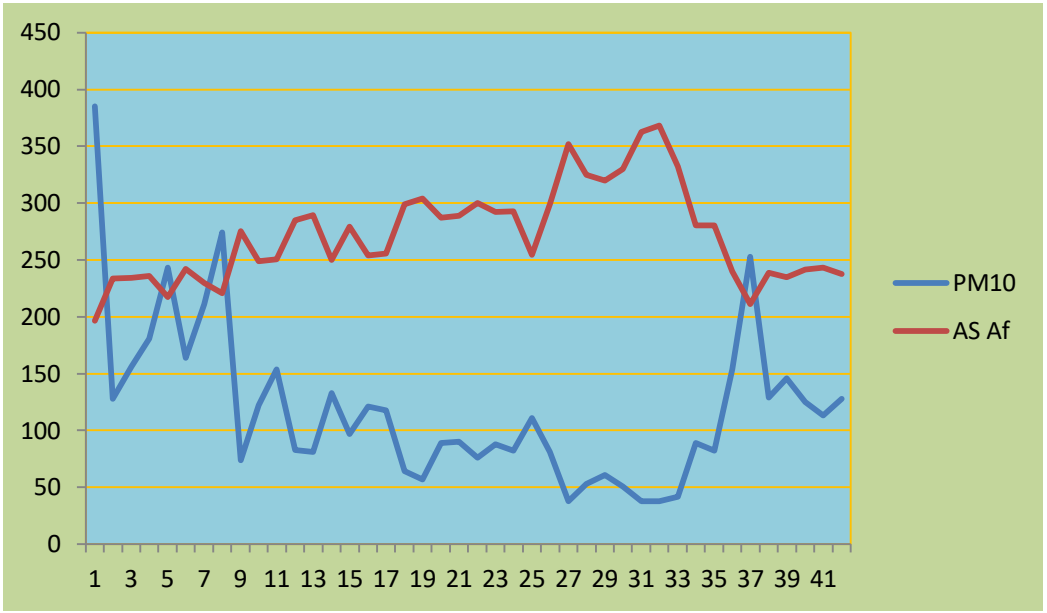
PM10 and Morning PEFR



PM_{10} accounted for 58.4% variance of Morning PEFR

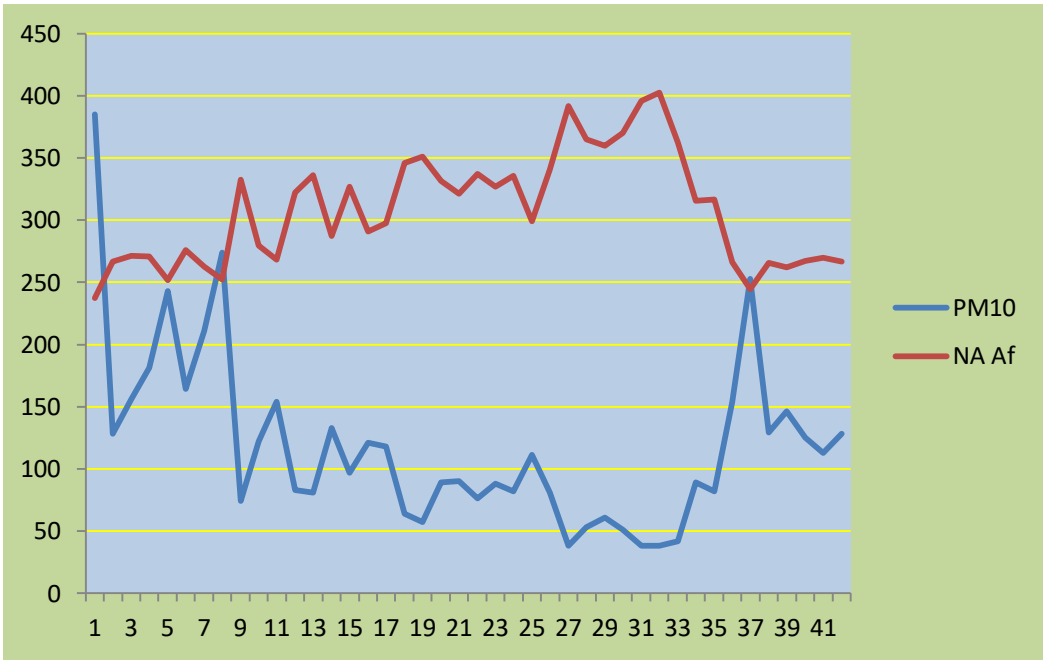
(F= 2624.20; P= <0.001)

Morning PEFR decreased by 37.60% in both asthmatic & non-asthmatic children from lowest to the highest PM_{10} Level.



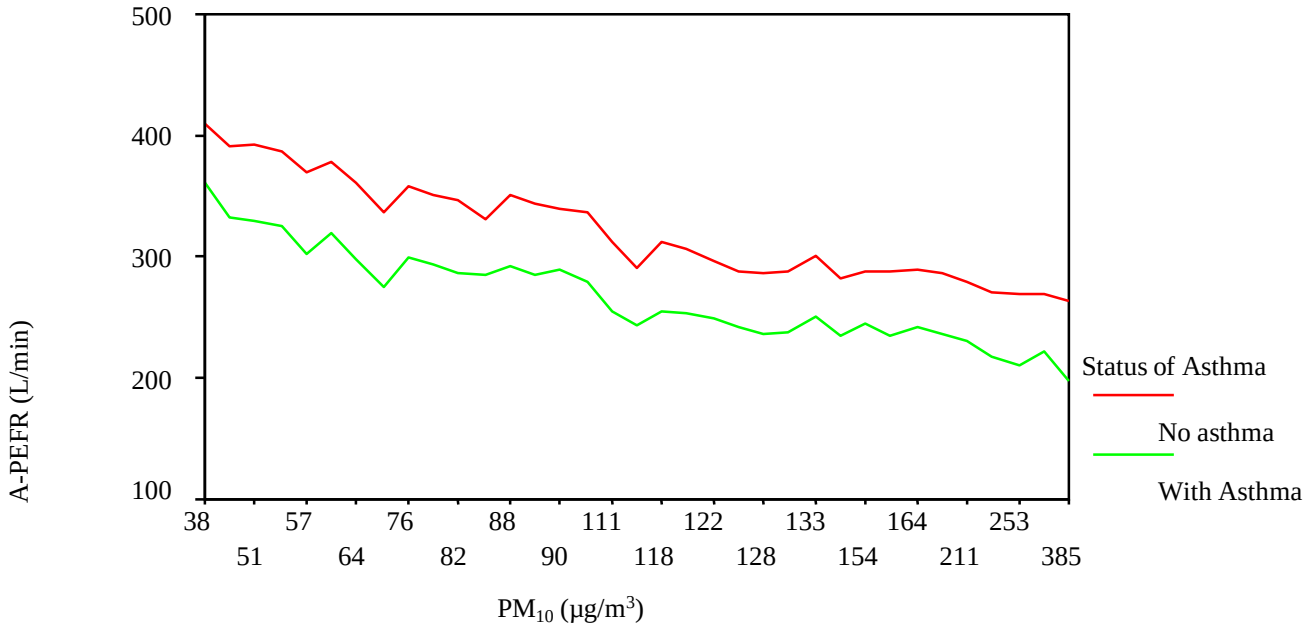
Asthma

PM 10 & Afternoon PEFR



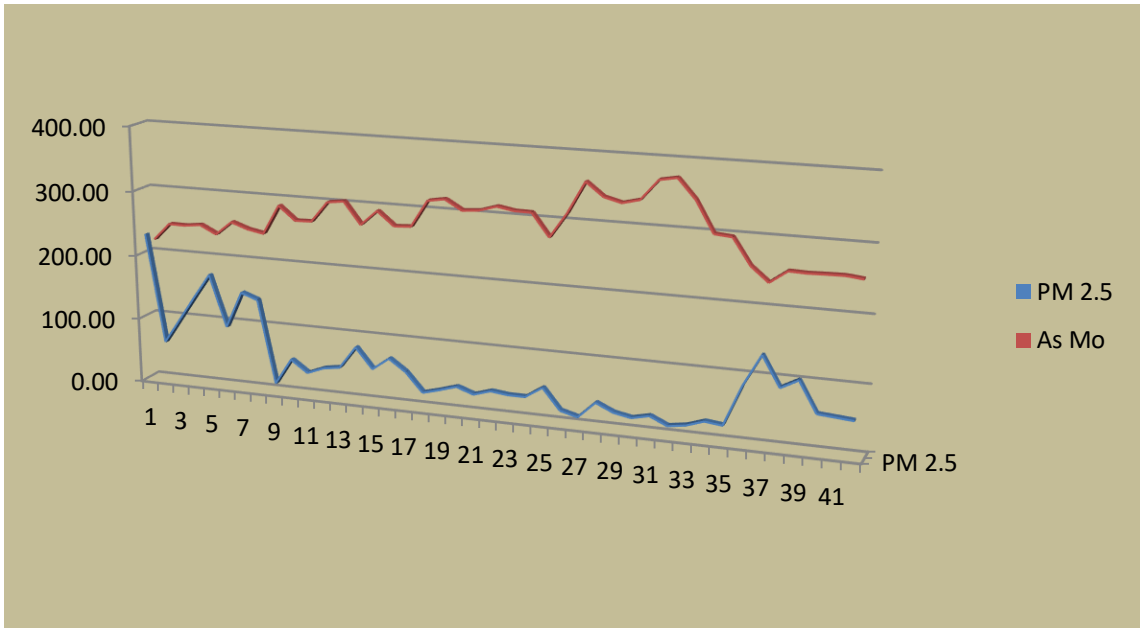
Non Asthma

PM 10 & Afternoon PEFR



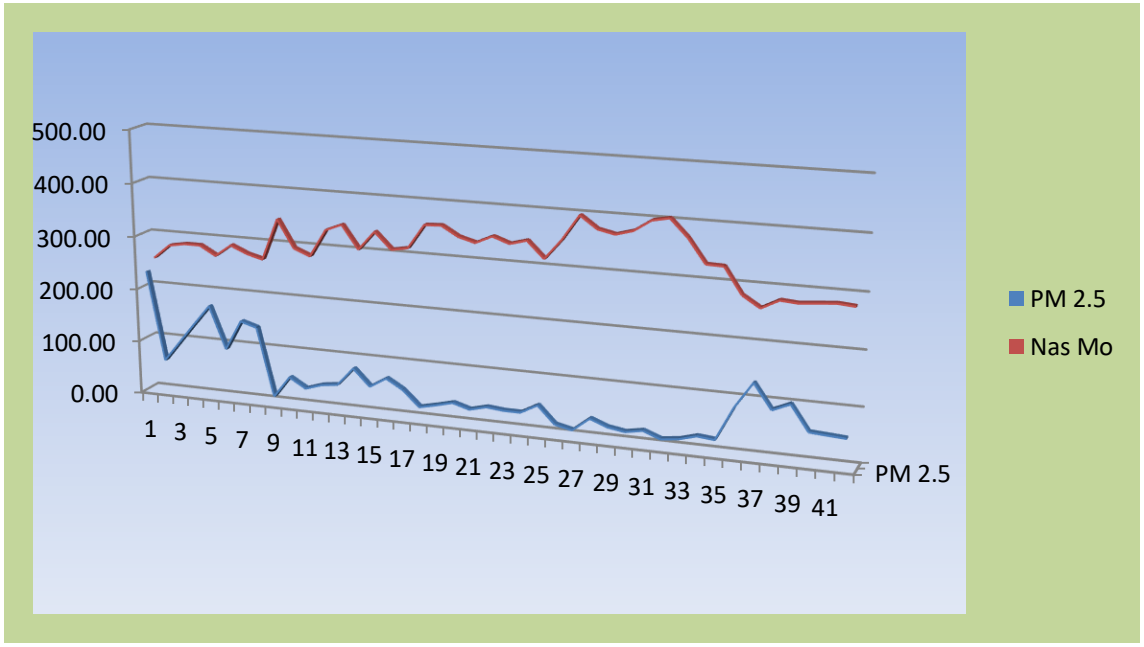
PM_{10} concentration accounted for 60.9% variance of the afternoon PEFR (F=2913.29; p= <0.001).

A 41.87% reduction of afternoon PEFR was observed due to change from the lowest to the highest level of PM_{10} concentration.



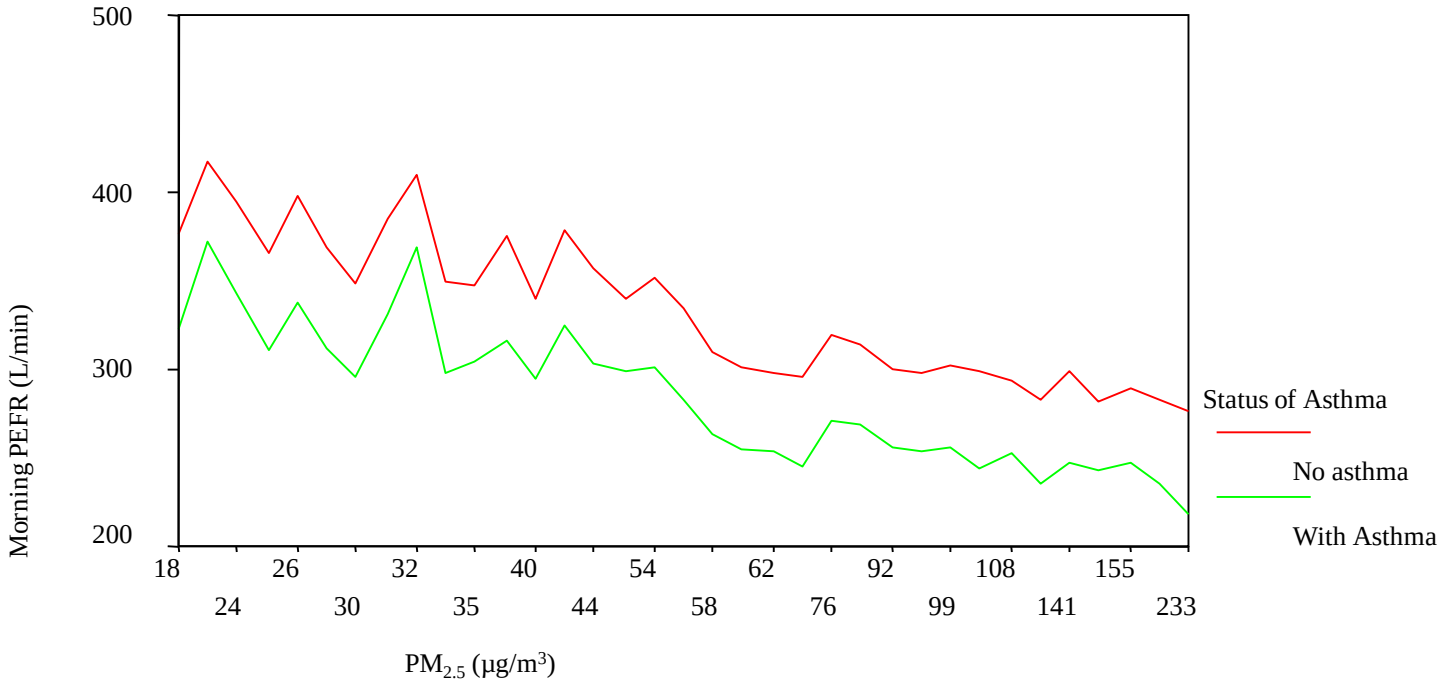
Asthma

PM 2.5 & Morning PEFR



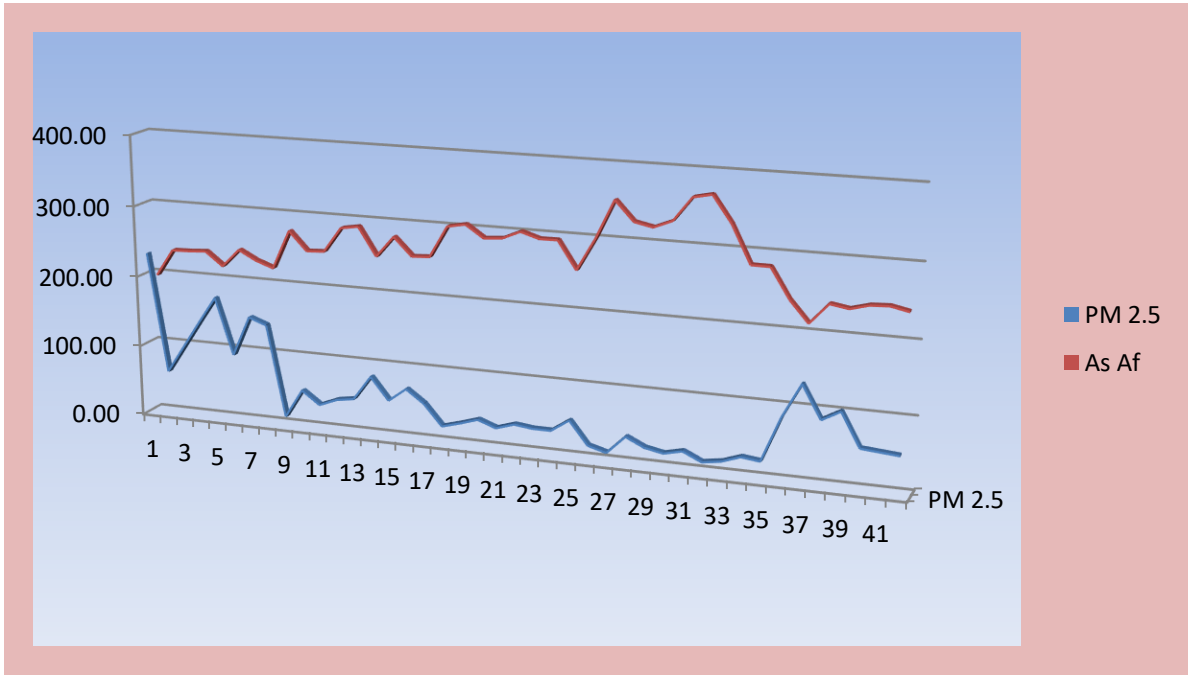
Non Asthma

PM 2.5 & Morning PEFR



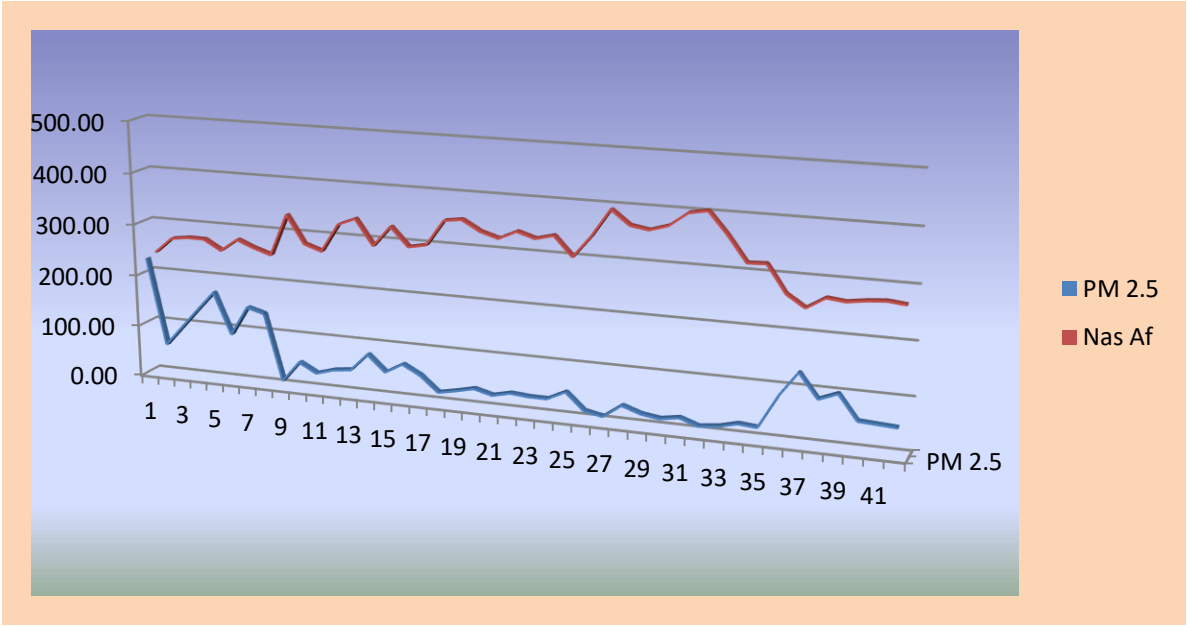
$PM_{2.5}$ concentration accounted for 48.7% of the variance in afternoon PEFR

Morning PEFR decrease by 30% with an increase of $PM_{2.5}$ concentration from lowest to highest.



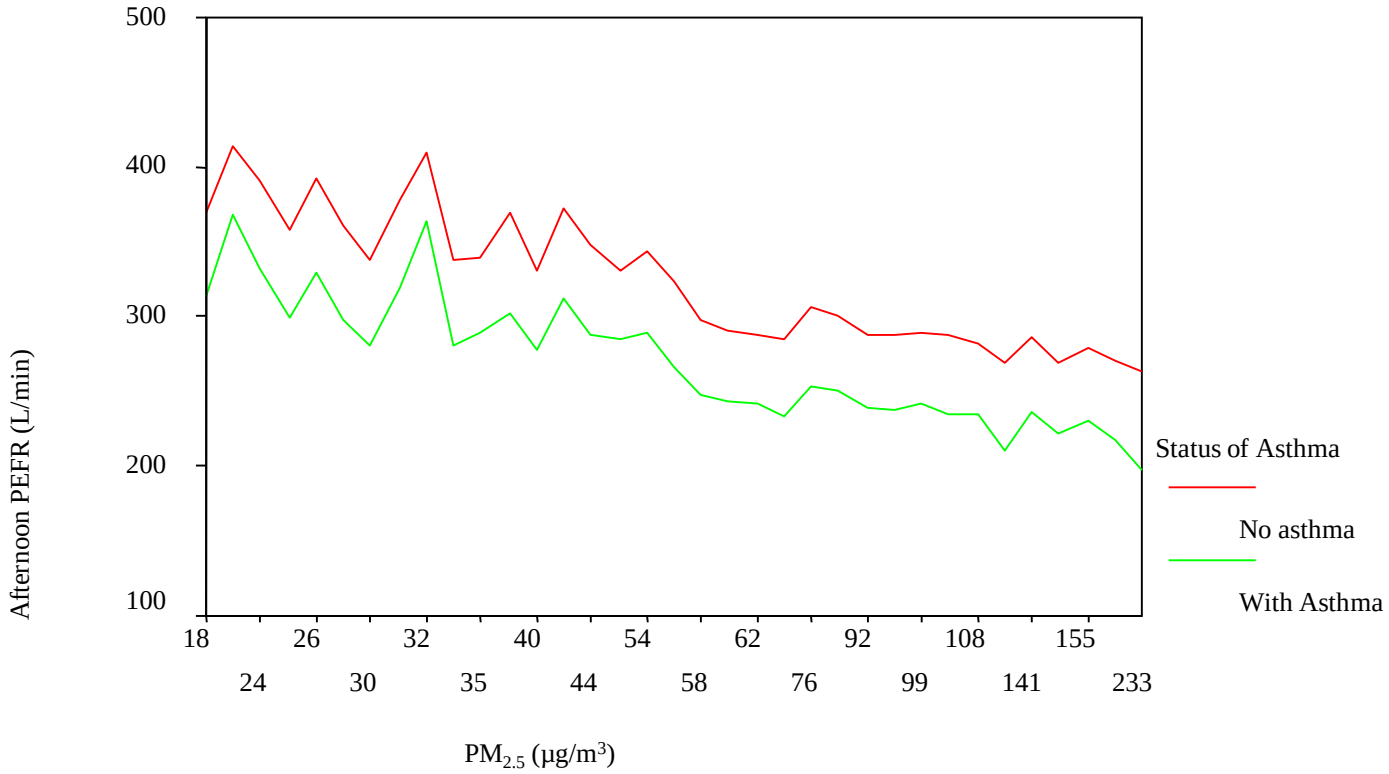
Asthma

PM 2.5 & Afternoon PEFR



Non Asthma

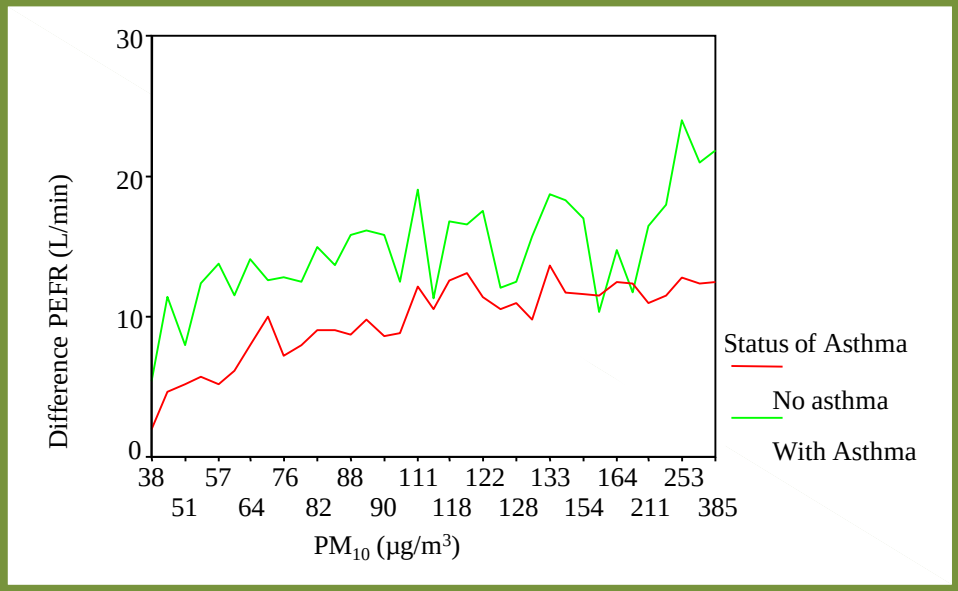
PM 2.5 & Afternoon PEFR

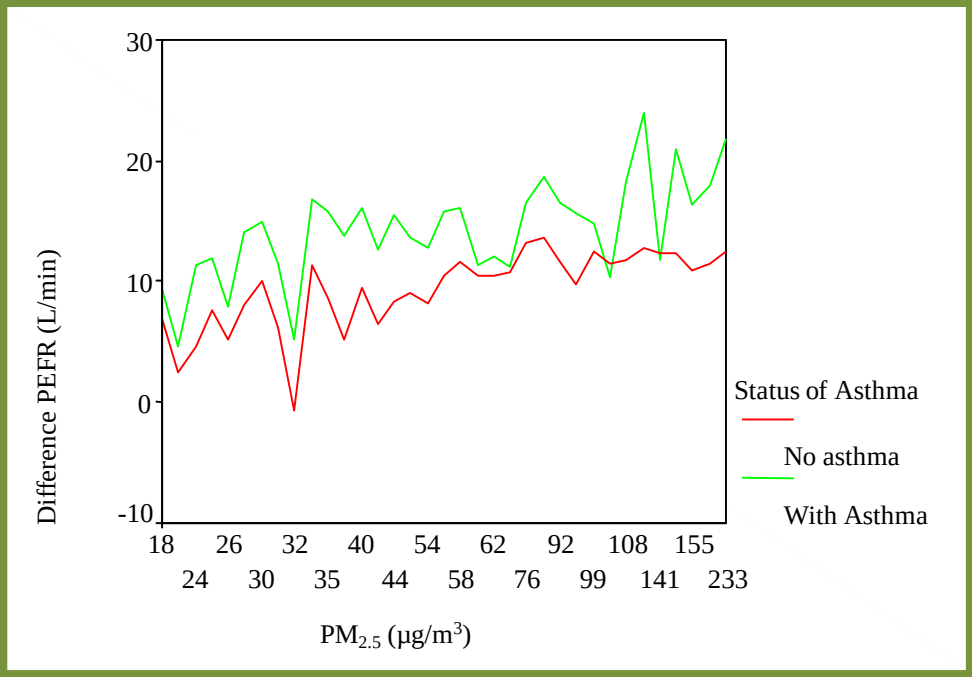


$PM_{2.5}$ concentration alone accounted for 50.50% variance of the afternoon PEFR **(F=1910.51; p= <0.001).**

A 33.85% reduction of afternoon PEFR was observed due to change from the lowest to the highest level of $PM_{2.5}$ concentration.

PEFR Change & PM10 and PM2.5

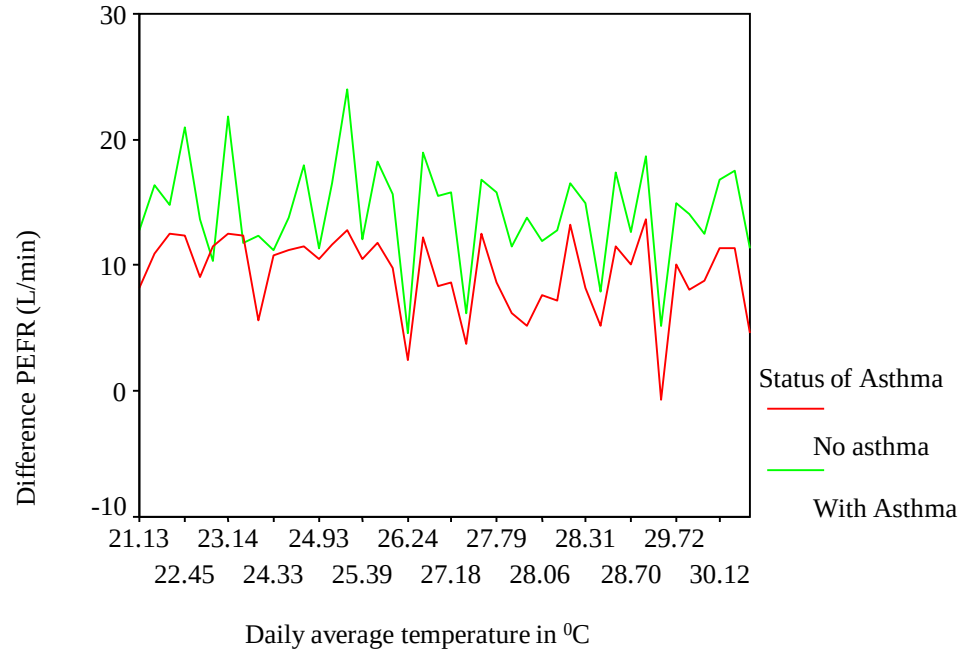


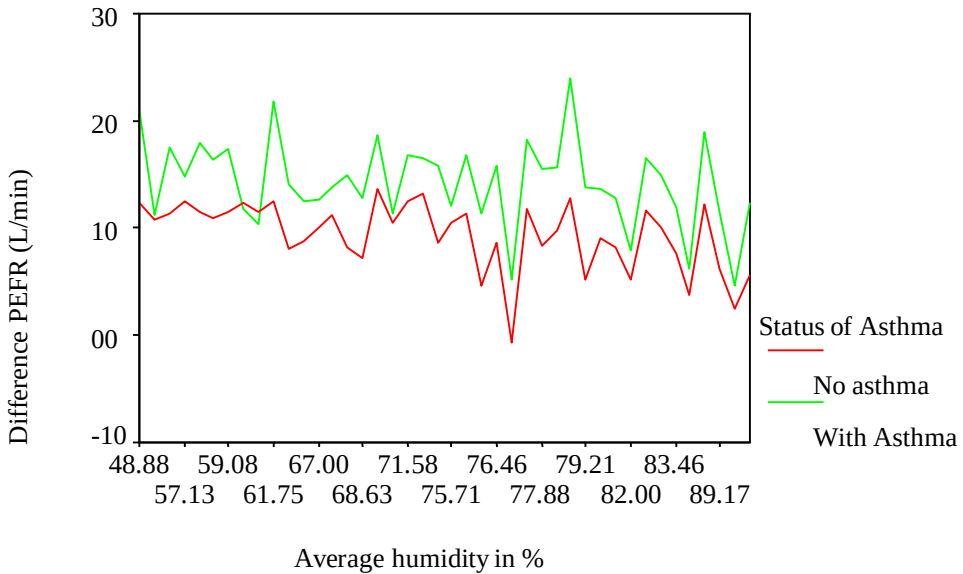


PEFR decreased by about 40% in both asthmatic and non-asthmatic children when PM_{10} increased from its lowest level of 38 µg/m³ to its highest daily mean of 385 µg/m³.

PEFR decreased by about 30% in both asthmatic and non-asthmatic children when $PM_{2.5}$ increased from its lowest level of 18 µg/m³ to its highest daily mean of 233 µg/m³.

PEFR difference & temperature & humidity





PEFR change in both the asthmatic & non-asthmatic children is related to rise in temperature and humidity.

PEFR increased by about 40% if average humidity rises from 60% to 90%.

Temperature and Humidity

The Temperature and Humidity were also independently affecting the Morning, Afternoon and Difference PEFR with statistical significance.

After removing the effect of temperature and humidity, the PM_{10} and $PM_{2.5}$ concentrations were alone significantly influencing the Morning, Afternoon and Difference PEFR.

After removing the effect of PM_{10} and $PM_{2.5}$ it was observed that humidity could also significantly influence the Morning and Afternoon PEFR with a positive direction but humidity could not affect the Difference PEFR.

Total Expenditure for respiratory problem

Respiratory Problems	Mean (±SD)-Taka	Min	Max	Significance
No asthma (35)	3478.86 (±4171.34)	200	19000	F=-21.6, P<0.001
With Asthma (73)	6918.68 (±3315.18)	1411	17200	
Total (108)	5803.43 (±3942.15)	200	19000	

Total annual expenditure for respiratory illnesses of asthmatic children (6918 Taka, about 100 USD) was twice the expenditure of non-asthmatic children (3478 Taka).

Limitations of the current study

- A limitation of this study that is shared by all other such studies is that the ambient pollution concentrations may not adequately reflect exposures of individual subjects.
- Since most of a child's time during a school year is spent indoors, and since indoor pollutant concentrations, and particulates, can be markedly different from those outdoors, the outdoor concentrations measured in this study may not have been valid estimates of each subject's exposure.
- Another weakness of this study is that PEFR is primarily a measure of large airways function. Thus, to the degree to which the anticipated effect is due to small airways abnormalities, PEFR may not be a sensitive measure of pulmonary function decrement due to air pollution.

Limitations of the current study

- Despite these limitations the findings of the current study is indicative that air pollution especially the particulates (both PM_{10} and $PM_{2.5}$) are adversely affecting the respiratory health of the children in Dhaka, Bangladesh, and those having adverse lung conditions like asthma are being more affected than healthy children

- The data was planned to collect in the peak dry season however some of the data collected days were not dry days. Additional 7 days of data were collected to counter the limitation. However collection of data on non dry days might hamper the generality of the study findings.

Conclusion

The pollutants load, both PM_{10} and $PM_{2.5}$, in the air and the humidity level of Dhaka city is quite high.

PMs were found to be associated with adverse respiratory health in both asthmatic and non-asthmatic children

Among the them PM_{10} is more significantly associated with worsening of asthma.

These factors particularly PM_{10} concentrations are also detrimentally affecting the respiratory health of the non-asthmatic children of Dhaka city .

Cost for the management of respiratory problems have adverse economical implication at the family and in turn on the national economy.

Recommendations

Air pollution should be paid due attention as an important cause of morbidity and mortality and should be regarded as an economic burden to the nation.

Major causes and sources of air pollution especially the particulate matter should be addressed with control measures.

School health program with especial emphasis on respiratory health problems should be strengthened.

Further study should be conducted to identify the specific pollutants which are mostly contributing towards adverse effects on respiratory health.

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Question & Answer