The Economic Valuation of the Health Impact by Air Pollution in Dhaka, Bangladesh

❖ Md. Murshid Aktar & Koji Shimada, Ritsumeikan Univ.

- Date : March 11, 2005
  - Session VII
  - Time : 09:40 – 10:00
- Ohyama Memorial Hall

    National Institute for Environmental Studies

    Tsukuba, Japan

About Dhaka City

- **Population : 9,912,908 (2001 Population Census, BBS)**

- **Area:1464 sq. km (The Dhaka Statistical Metropolitan Area (DSMA)**

- **Annual Average Rain Fall: 2060mm (approximately)**

- **Average Temperature: 20° C(Winter dec-feb) 28° C (Summer)**

- **Life Expectancy: 62years**

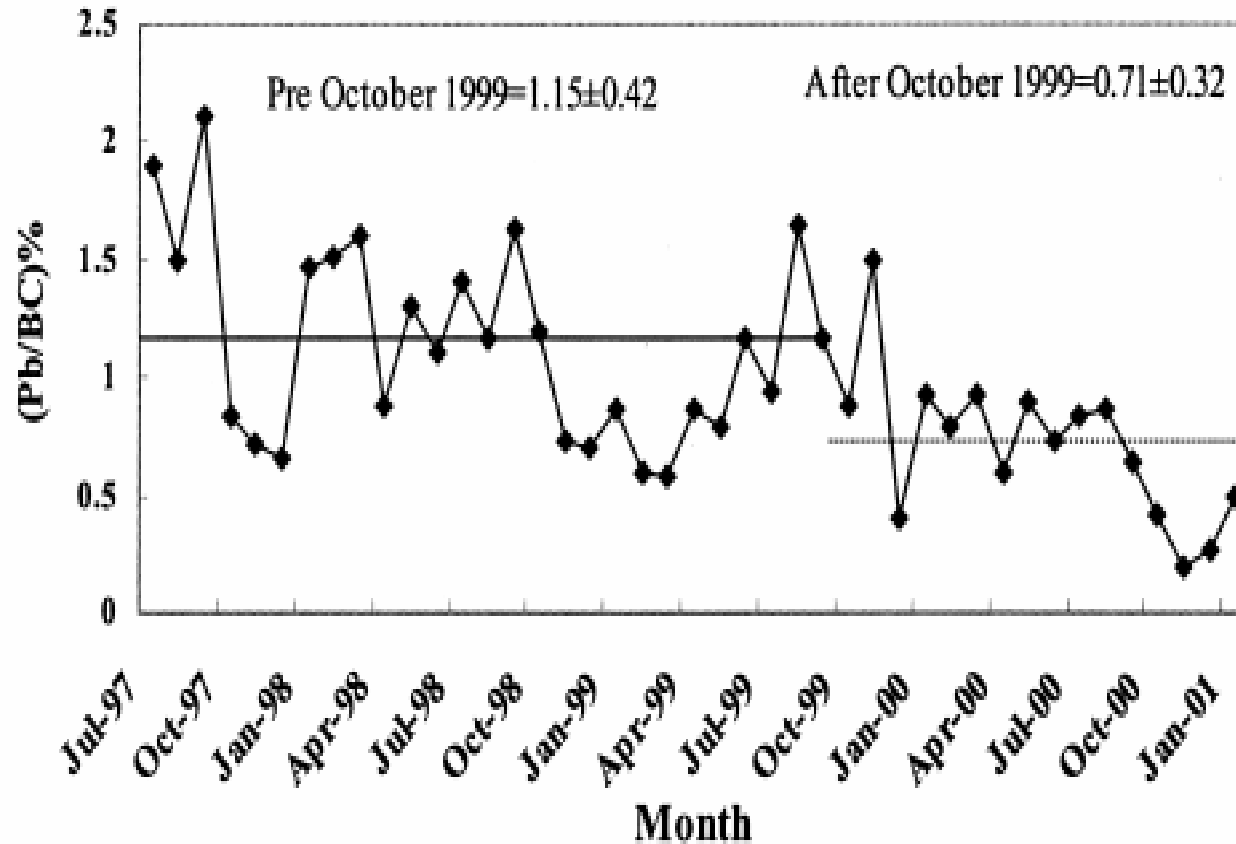# Major Policy: Introduction of Lead Free Gasoline from July 1, 1999.
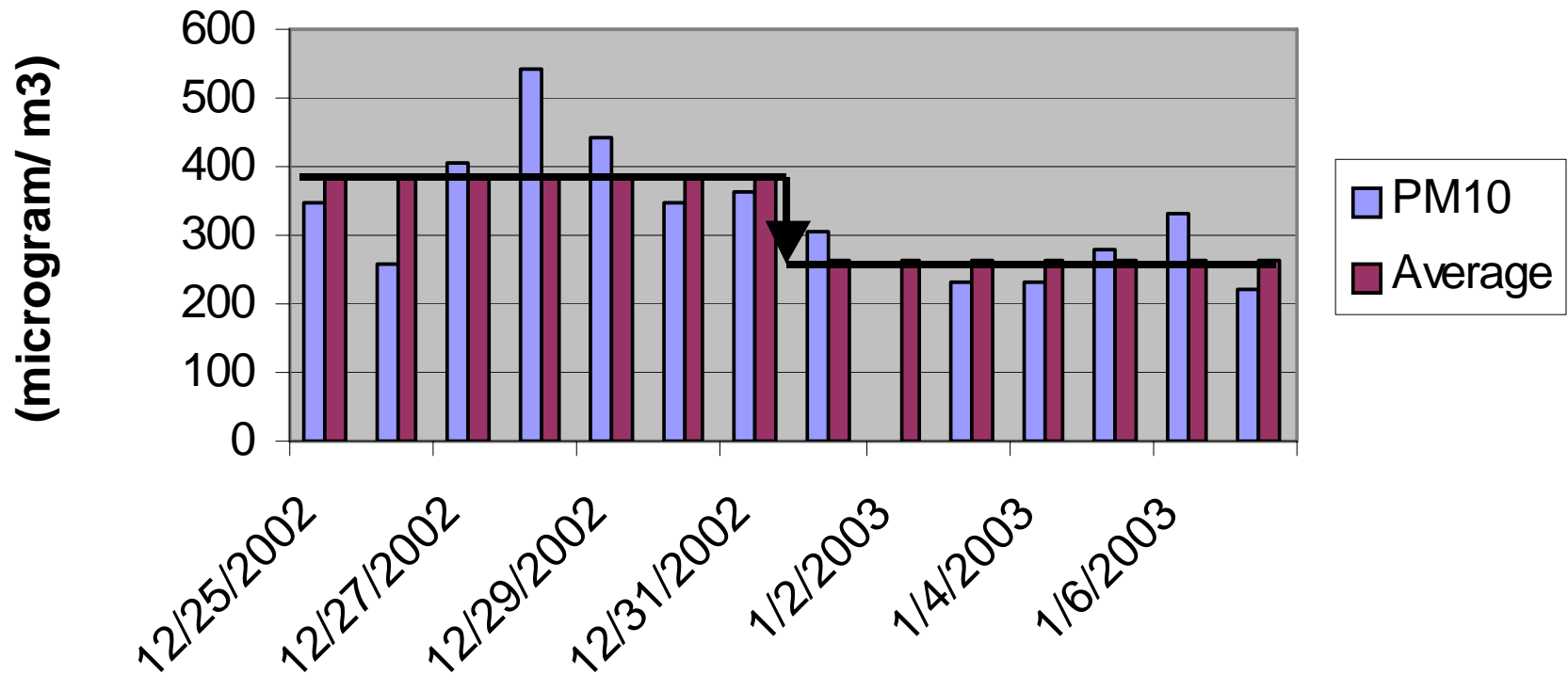

Figure 4. Average monthly Pb/BC% ratios vs. time for July 1997–January 2001.

- **Lead in Ambient Air of Dhaka decreased Approximately two-thirds**

Major Policy: Jan 1, 2003 Phase Out of All Existing Two-Stroke Engine Three-Wheelers from Dhaka
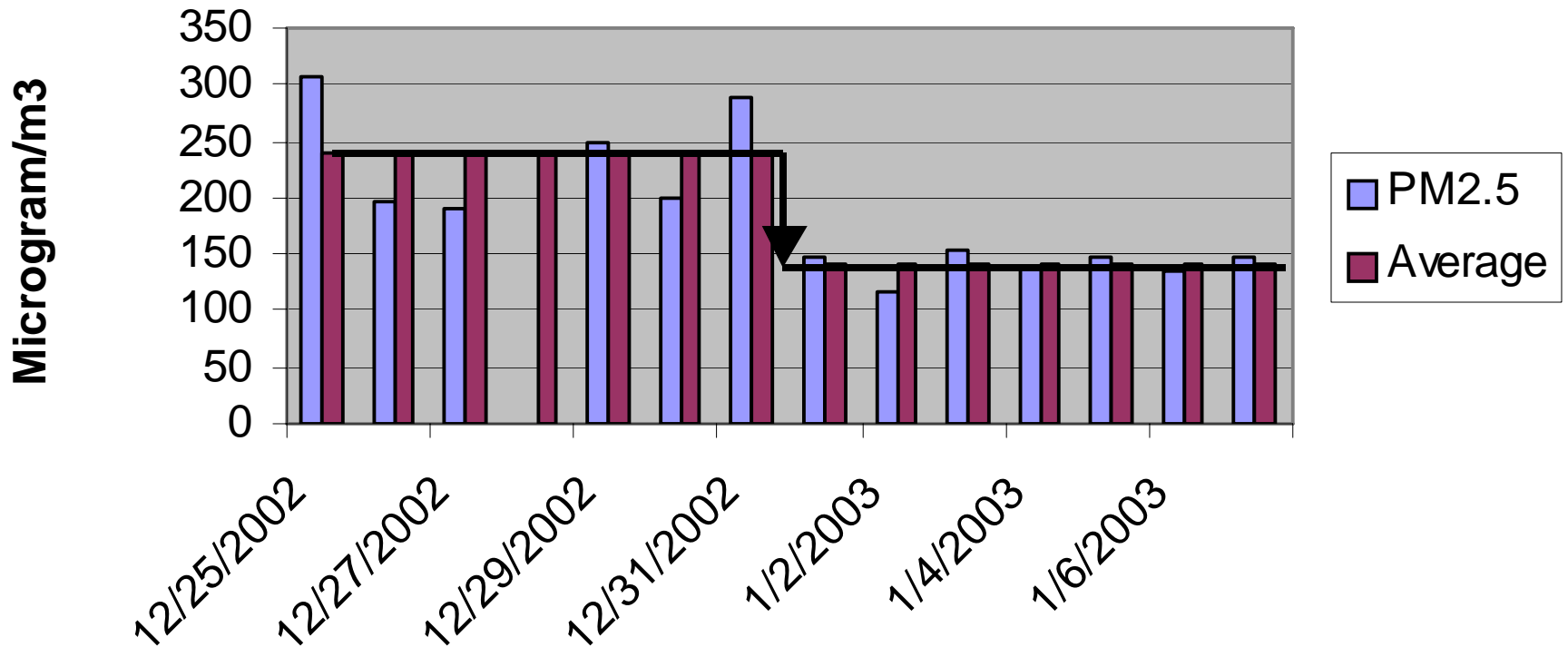

Levels of PM10 before and after removal of Baby Taxis (Phase-II)

- **PM10 concentrations in Dhaka Declines by 31%**

Major Policy: Jan 1, 2003 Phase Out of All Existing Two-Stroke Engine Three-Wheelers from Dhaka

Levels of PM2.5 before and after removal of Baby Taxis (phase-II)

- **PM2.5 concentrations in Dhaka Declines by 41%**

Estimating Health Impact of Air Pollution in Dhaka City

- Establishing Concentration Response Function (CRF).
- Pollution condition in Dhaka city
- Estimation of Health Impact

Concentration Response Function (CRF)

$$\Delta H_t = c_{te} * \Delta P_e * POP$$

$$Where, \Delta = \text{change in}$$

$$H_t = Health \text{ effects of type } t$$

$$c_{te} = \text{Coefficient of the CRF of health effect } t$$
$$\text{and pollutant } e \text{ per year}$$

$$P_e = \text{Ambient concentration of the pollutant } e.$$

$$POP = \text{Population exposed to the pollutant}$$

Estimated Percentage Change in Mortality Associated with a 10 ug/m³ Change in PM10
(based on Meta Analytical Reviews)

Meta Analytical Reviews	Number of study Included	Year	Coefficient	CI 95%
Metropolitan Mexico City Study	39	2000	1.01	0.83, 1.19
Study for Six Cities (Developing Country)	9	2000	0.84	NA
Study for Eight Major Italian Cities		2002	1.026	1.009, 1.043
Jakarta Study	6	1994	0.96	1.30, 0.62*
California Study	67	2001	1.05	0.5-1.6 (range)

Estimated Percentage Change in Mortality Associated with a 10 ug/m3 Change in PM10 - Developing Countries Experiences

Study	Year	Mean PM10	Age Group	Coefficient of CRF
Mexico city Study	2000	45	all	1.83
Bangkok City Study	1999	65	All	1.70
Sao Paulo Study	1995	82	65>	1.31
Santiago Study	1996	115	All	1.13
Delhi Study	1997	377(TSP)	all	0.4
Beijing (Residential Area) Study	1994	350(TSP)	All	0.7

Coefficient of the CRF of the Quantifiable Health Effects
(Associated with a 1ug/m3 change in PM10)

Health Impact	Coefficient
Mortality	0.096
Respiratory Hospital Admission (RHA)	0.000012
Emergency Room Visit (ERV)	0.0002354
Restricted Activity Days (RAD)	0.0575
(children) Lower Respiratory Illness (LRI)	0.00169
Asthma Attacks	0.0326
Respiratory Symptom Days (RSD)	0.183
Chronic Bronchitis (CB)	0.0000612

Dhaka City
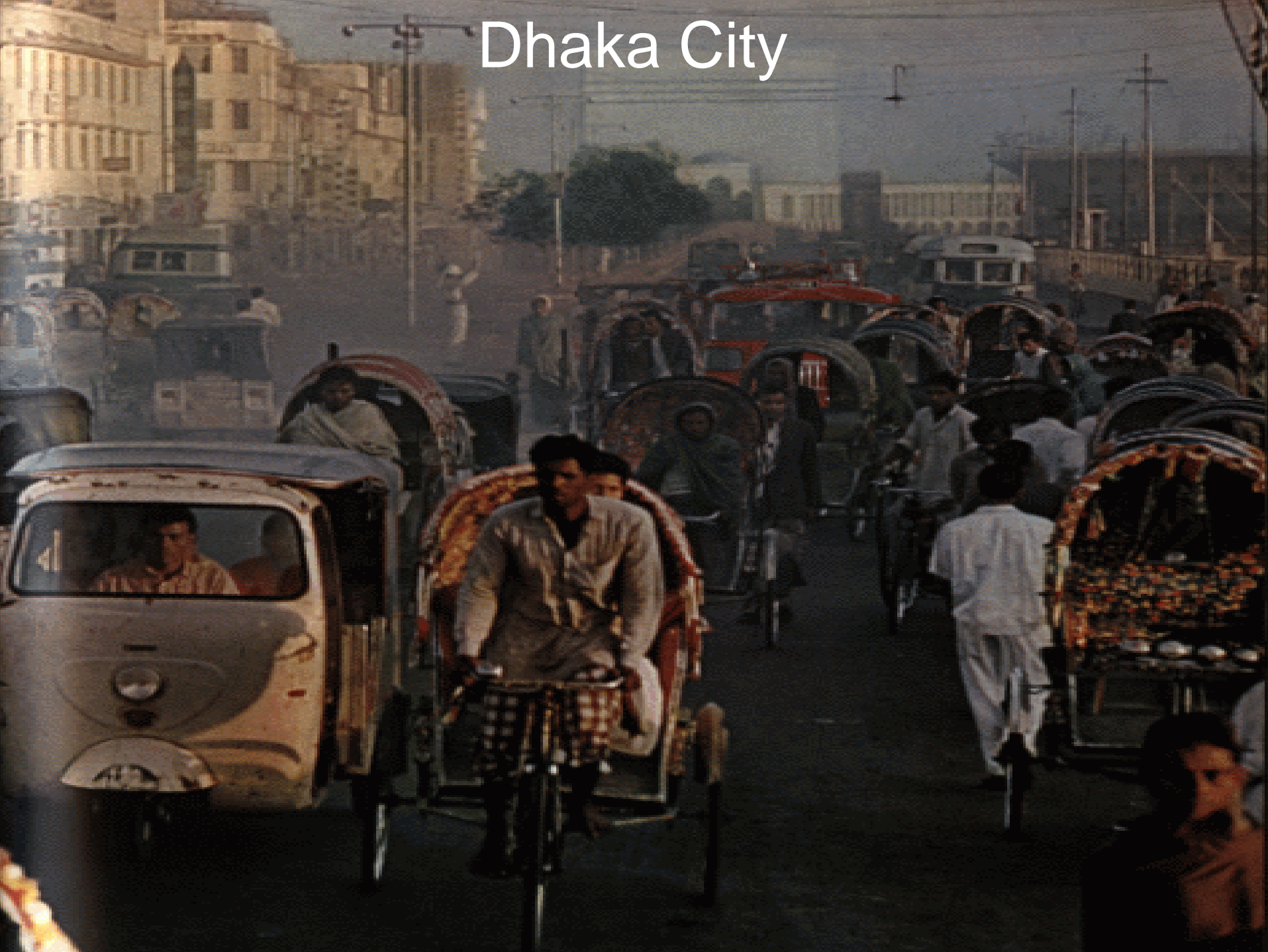
Black smocks emitted from the vehicles does not bother road side food venders

PROPOSED NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS) FOR BANGLADESH

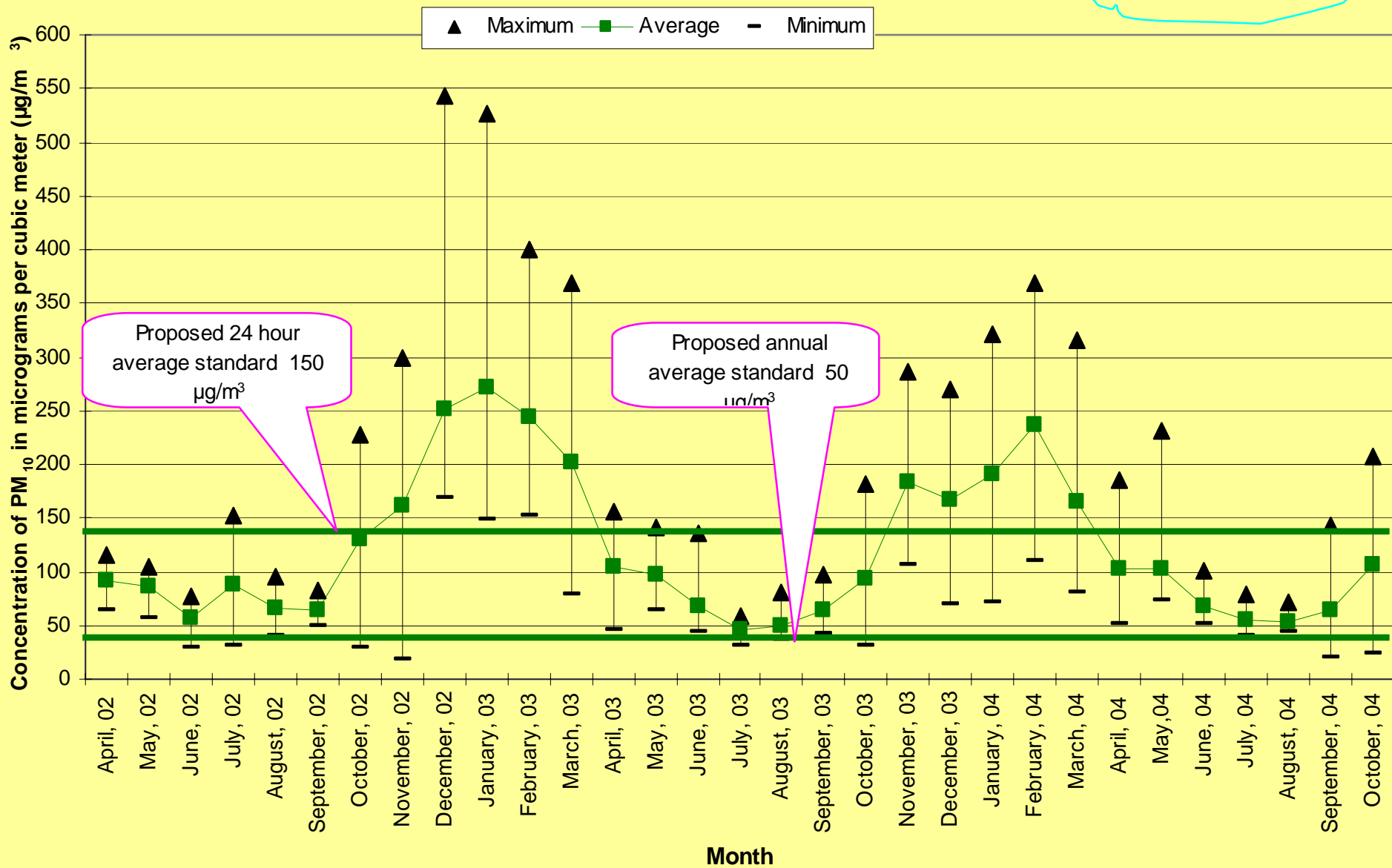Source   Air Quality Management Project (AQMP)

Pollutant	Proposed Bangladesh Standard	Averaging Time
PM_{10}	150 µg/m³	24-Hours
	50 µg/m³	Annual
$PM_{2.5}$	65 µg/m³	24-Hours
	15 µg/m³	Annual
SO_2	365 µg/m³ (140 ppb)	24-Hours
	80 µg/m³ (30 ppb)	Annual
NO_2	100µg/m³ (53 ppb)	Annual

- Six Pollutant (PM_{10}, $PM_{2.5}$, CO, SO_2, NO_2 and O_3) are measured under the supervision of MOE and Financed by WB with Air Quality Management Project (AQMP)

24 Hours Average PM$_{10}$ at CAMS, Sangsad bhaban

Monthly Maximum, Average and Minimum PM$_{10}$

Average of 31 months = 120µg/m3

Maximum ▲   Average ■   Minimum ―

Concentration of PM$_{10}$ in micrograms per cubic meter (µg/m^3)

Proposed 24 hour average standard 150 µg/m^3

Proposed annual average standard 50 µg/m^3

Month

April, 02 | May, 02 | June, 02 | July, 02 | August, 02 | September, 02 | October, 02 | November, 02 | December, 02 | January, 03 | February, 03 | March, 03 | April, 03 | May, 03 | June, 03 | July, 03 | August, 03 | September, 03 | October, 03 | November, 03 | December, 03 | January, 04 | February, 04 | March, 04 | April, 04 | May, 04 | June, 04 | July, 04 | August, 04 | September, 04 | October, 04
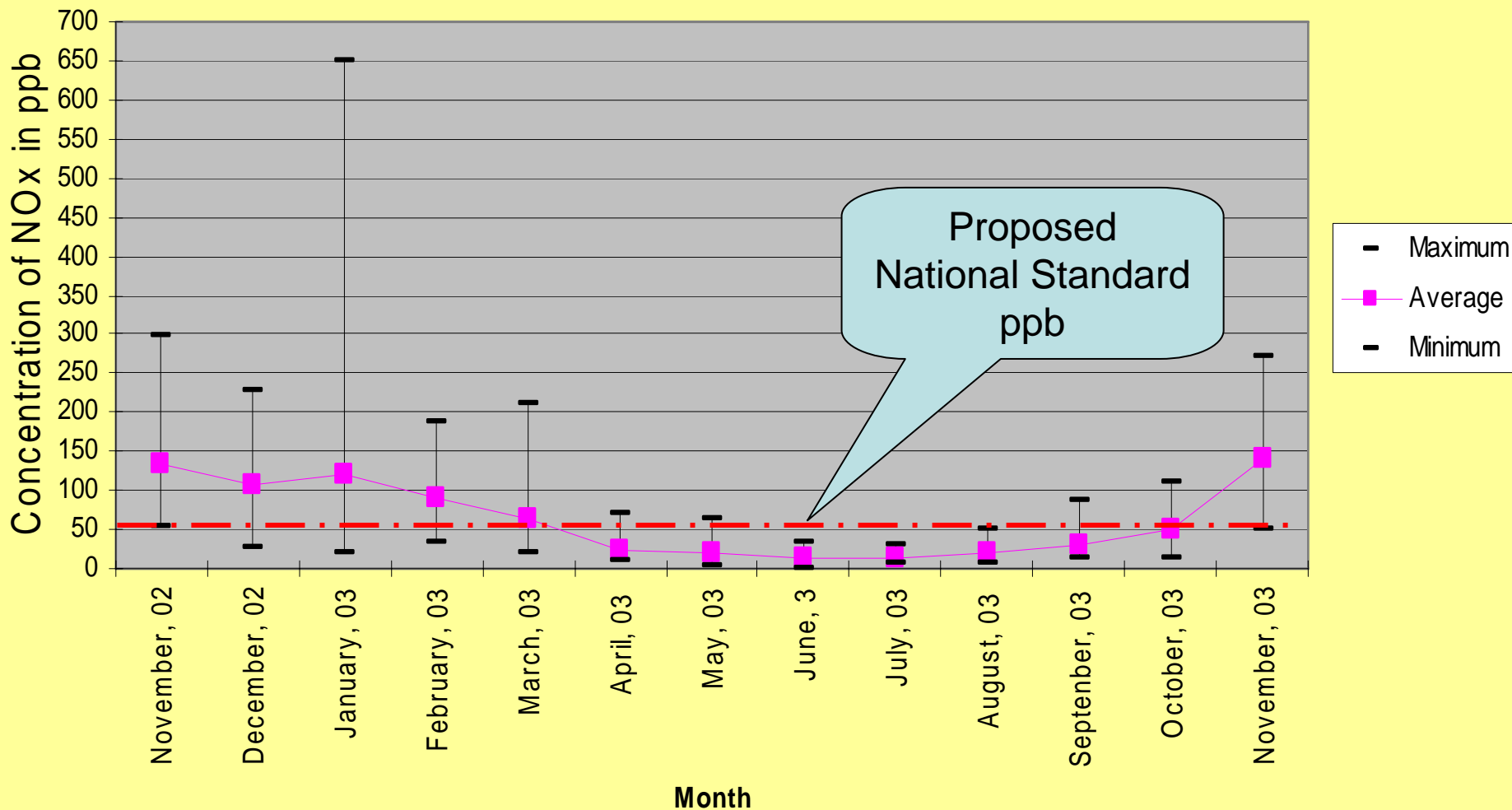
**Fig. 2 Sulfur Dioxide at CAMS, Sangsad Bhaban
Monthly Average, Maximum and Minimum Concentration
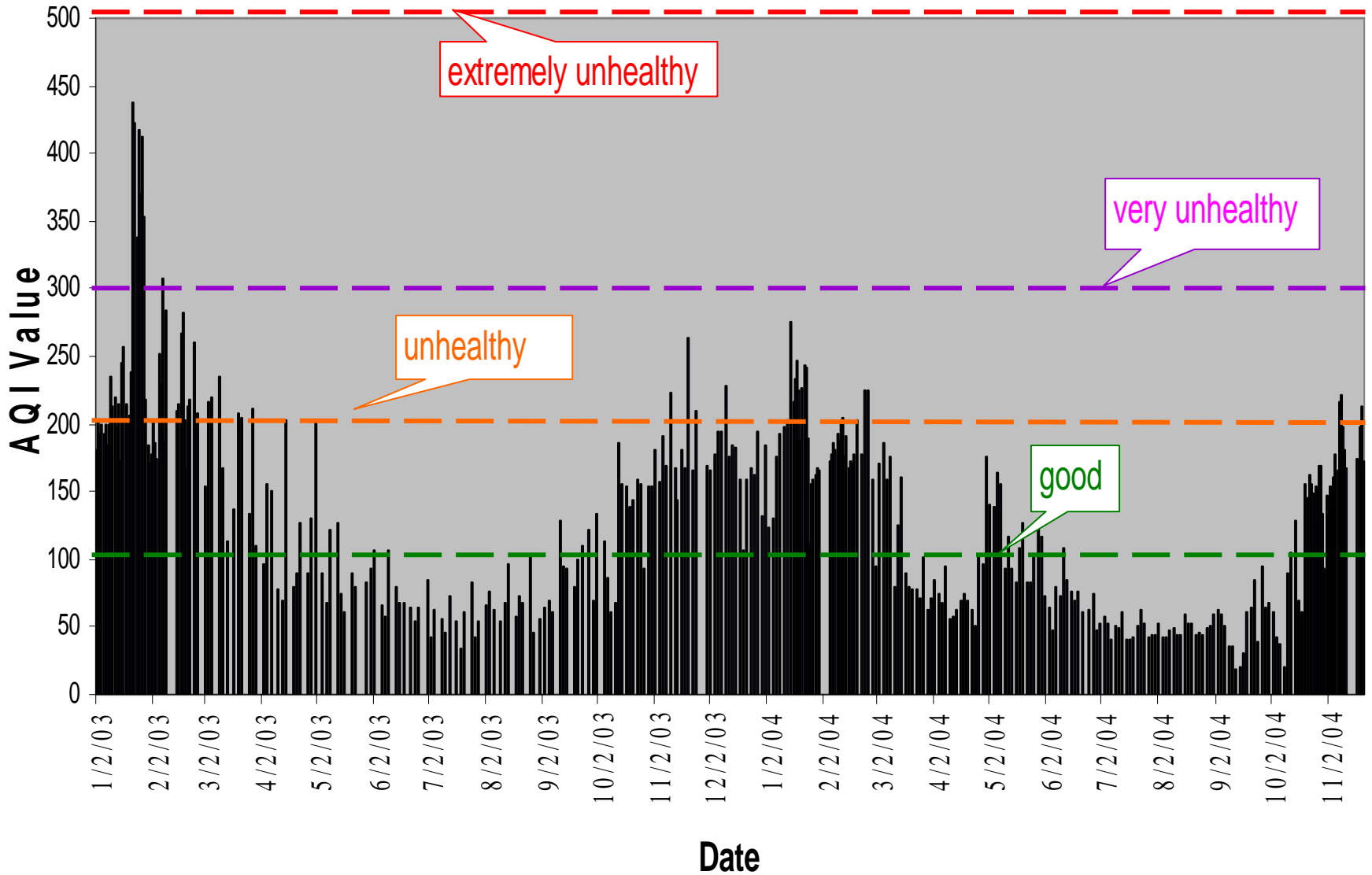From October 2002 to November 2003**

**Fig. 3 Nitrogen Oxides at CAMS, Sangsad Bhaban
Monthly Maximum, Average and Minimum NOx
From November 2002 to November 2003**
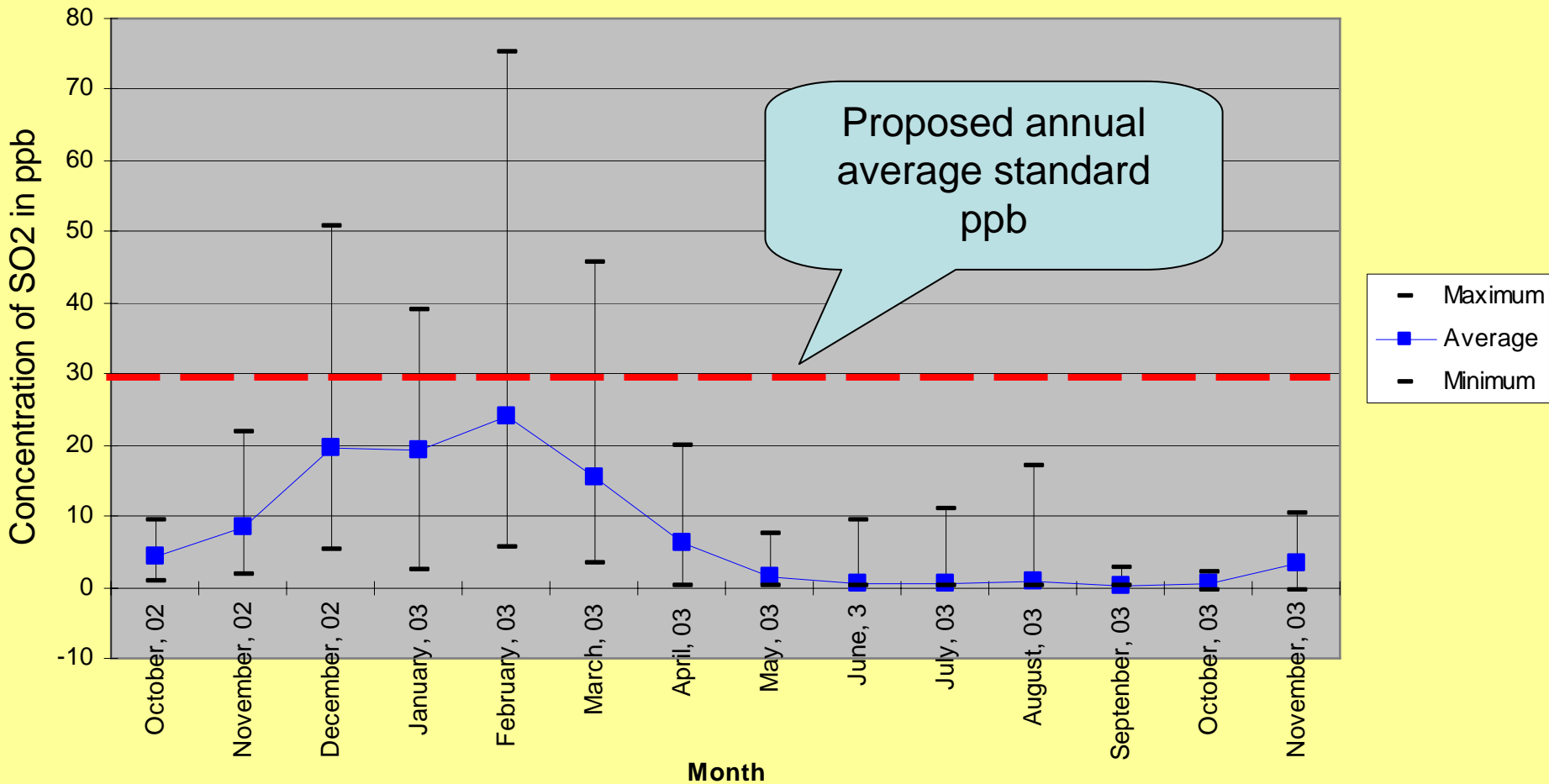
**Source:Trends in Ambient Air Quality in the Dhaka City
Shahana Akhter, S M Abdul Quadir and Amir H. Khan**

Daily Air Quality Index 2003 - 2004

Conditions for Estimating Health Impacts

- **Average Daily PM10 (Nov 03 – Oct 04) : 125 µg/m3**

- **Population (02) Exposed in Dhaka city: 10,000,000.**

- **Adult Population: 61.8%** (Population Census, BBS 2003)

- **Crude Mortality Rate per 1000 persons: 4** (BBS2003)

- **Percentage of asthmatic population is assumed to be: 5%**

- **The Coefficient Of CRF for Mortality associated with 1µg/m^3 change in PM$_{10}$.**

  - **0.1   (As World Average)**
  - **0.04 (From Delhi Study)**

Health Benefits of Reducing PM10 for Two Different Scenarios

Health Impact	20% Reduction	Reduction to National Standard
Premature Mortality	1000, 400*	3000, 1200*
Respiratory Hospital Admission (RHA)	3,000	9,000
Emergency Room Visit (ERV)	58,850	176,550
Restricted Activity Days (RAD)	8,883,750	26,651,250
(children) Lower Respiratory Illness (LRI)	161,395	484,185
Asthma Attacks	407,500	1,222,500
Respiratory Symptom Days (RSD)	45,750,000	137,250,000
Chronic Bronchitis (CB)	15,300	45,900

❖ *Taken coefficient from Delhi as 0.04 for per µg/m^3 change in PM$_{10}$

Economic Valuation of Health Benefits

- **Willingness to Pay (WTP) approach is used for valuing Health Impact.**

- **Estimates of WTP to reduce risk of death and to avoid illness do not exist for Bangladesh**

- **Transfer of WTP estimates from US to Bangladesh**

- **Most conservative WTP estimates are Taken from available literature**

Transferring WTP Estimates from US to Dhaka City

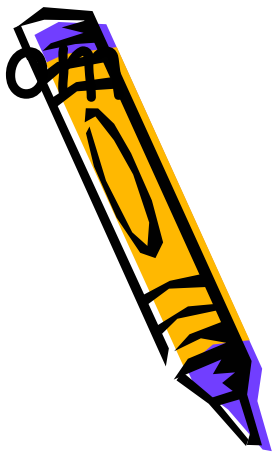$$WTP_{D,t} = WTP_{US,t}[GNI_D / GNI_{US}]^{\varepsilon_t}$$

Where,

$WTP_{D,t}$ = WTP estimate for Dhaka for health impact type t

$WTP_{US,t}$ = WTP estimate for US for health impact type t

GNI = Per Capita Gross National income

ε_t = Income elasticty of WTP of Health effect type t

- Conservative approach of benefit transfer
- Income elasticity of 1 provides conservative estimates

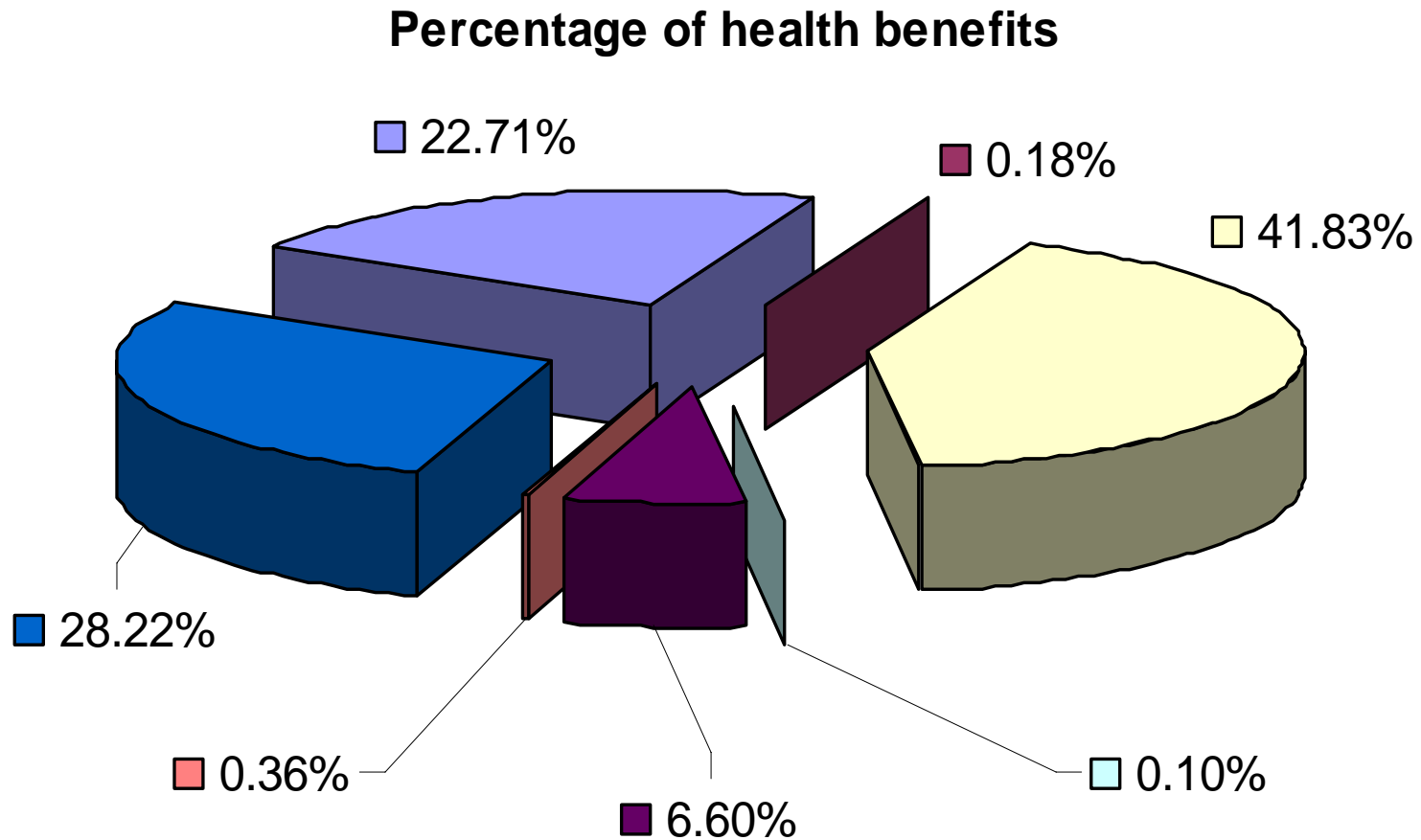# WTP Estimates for per Case Mortality and Morbidity

Health Impact	$WTP_{US,t}$ US income level, 1990 US$*	$WTP_{D,t}$ Dhaka, 2004, US$ (per Case)
Premature Mortality	1,620,000	29,704
Respiratory Hospital Admission (RHA)	4,225	77.47
Emergency Room Visit (ERV)	126	2.31
Restricted Activity Days (RAD)	53	0.97
(children) Lower Respiratory Illness (LRI)	44	0.806
Asthma Attacks	63	1.15
Respiratory Symptom Days (RSD)	44	0.806
Chronic Bronchitis (CB)	195,000	3,575.55

- * Source: Lvovsky et al. 2000

Annual Health Benefits due to Reduction of PM$_{10}$

Health Impact	Benefits of 20% reduction, US$	Benefits from Reduction to National Standard, US$
Premature Mortality	29,704,584	89,113,752
Respiratory Hospital Admission (RHA)	232,411	697,233
Emergency Room Visit (ERV)	135,964	407,893
Restricted Activity Days (RAD)	8,633,376	25,900,128
(children) Lower Respiratory Illness (LRI)	130,212	390,636
Asthma Attacks	470,735	1,412,205
Respiratory Symptom Days (RSD)	36,910,696	110,732,088
Chronic Bronchitis (CB)	54,705,942	164,117,827
TOTAL	130,923,921	392,771,763

Percentage of Health Benefits from Reduction of PM10 to the National Standard

Percentage of health benefits

- 22.71% (Mortality)
- 0.18% (RHA)
- 41.83% (CB)
- 0.10% (LRI(children))
- 6.60% (RAD)
- 0.36% (Asthma Attacks)
- 28.22% (RSD)

□ Mortality ■ RHA □ CB □ LRI(children) ■ RAD ■ Asthma Attacks ■ RSD

Health Benefits as a Percentage of Different Economic Indicators

Economic Indicator	Benefits from 20% reduction		Benefits from Reduction to National Standard	
	National Per capita GNI as 432$	Dhaka per capita as 770$	National per capita as 432$	Dhaka per capita as 770$
National budget 2004-2005	1.37%	2.45%	4.12%	7.34%
National Health Budget 2004-2005	21.05%	37.52%	63.15%	112.55%
Total Budget of DCC 2002-2003	115.97%	206.71%	347.92%	620.14%
GNI 2004	0.22%	0.40%	0.67%	1.20%

Further Study Plan

- Establish CRF of Mortality for Dhaka City
- Estimation of Mitigation Cost to Reduce PM_{10}/ Air Pollution
  - Focusing Mainly on Transport System
- Cost - Benefit Analysis, including Ancillary Benefit Estimation

Thank You

For Your Attention