NILU OR: 56/95 App.

Air Quality
Emissions Exposure
URBAIR
Abatement Damage
Cost

Urban Air Quality Management Strategy in Asia

GREATER BOMBAY City Specific Report

APPENDICES

Prepared under contract from
The World Bank
Asia Technical Division

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URBAIR

Urban Air Quality Management Strategy in Asia

GREATER BOMBAY

Appendices

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Preface

In view of the potential environmental consequences of continuing growth of Asian metropolitan areas, the World Bank and UNDP launched the Metropolitan Environmental Improvement Program (MEIP) in five Asian metropolitan areas - Beijing, Bombay, Colombo, Jakarta, and Metro Manila. In 1993, Kathmandu joined the intercountry program as the sixth MEIP city. The mission of MEIP is to assist Asian urban areas tackle their rapidly growing environmental problems. Presently, MEIP is supported by the governments of Australia, Netherlands and Belgium.

Recognizing the growing severity caused by industrial expansion and increasing vehicle population, the World Bank started the Urban Air Quality Improvement (URBAIR) initiative in 1992 as a part of the MEIP. The first phase of URBAIR covered four cities - Bombay, Jakarta, Kathmandu, and Metro Manila. URBAIR is an international collaborative effort involving governments, academia, international organizations, NGOs, and the private sector. The main objective of URBAIR is to assist local institutions in these cities to develop action plans which would be an integral part of their air quality management system (AQMS) for the metropolitan regions. The approach used to achieve this objective involves the assessment of air quality and environmental damage (e.g. on health, materials), the assessment of control options, and comparison of costs of damage and costs of control options (cost-benefit or cost-effectiveness analysis). From this, an action plan can be set up containing the selected abatement measures, for implementation in the short/medium/long term.

The preparation of this city-specific report for Bombay is based upon the collection of data and specific studies carried out by the local consultants, and upon workshops and fact-finding missions carried out in April and August 1993, and May 1994. A first draft of the report was prepared by Norwegian Institute for Air Research (NILU) and Instituut voor Milieuvraagstukken (IVM, Institute for Environmental Studies) before the first workshop, based upon general and city-specific information available from earlier studies. A second draft report was prepared before the second workshop, with substantial inputs from the local consultants, and assessment of air quality, damage and control options, and cost analysis carried out by NILU and IES.

This report contains the appendices to the main report.

Acknowledgements are presented in the main report. Here, the contribution from the Air Quality Monitoring Section of the Municipal Corporation of Greater Bombay (MCGB) is especially acknowledged. Their contribution of air quality data, as presented in Appendix 1, was made available through Mr. V.S. Mahajan, Deputy City Engineer and Mrs. J.M. Deshpande, Scientist in Charge of Air Quality Monitoring.

Contents

Appendix 1

Air quality status, Greater Bombay

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1. Description of past and present measurement programs

Stations and parameters

The Municipal Corporation of Greater Bombay (MCGB) monitors the air quality within the city limits, and Maharashtra Pollution Control Board (MPCB) monitors air quality in the rest of Bombay Metropolitan Region (BMR). The MCGB has adapted the United States Environmental Protection Agency (USEPA) designed method to establish an air quality monitoring program. This includes determining the frequency and procedure of sampling and analysis of the samples.

MCGB has measured ambient air quality regularly at 22 stations in Greater Bombay over 15 years now. The pollutants measured are sulfur dioxide (SO_2), total suspended particles (TSP), oxides of nitrogen (NO_x) and ammonia (NH_3). Ambient air quality is also occasionally measured at selected traffic junctions in Bombay for SO_2, NO_x, carbon monoxide (CO) and benzo(a)pyrenes from total and respirable particulates.

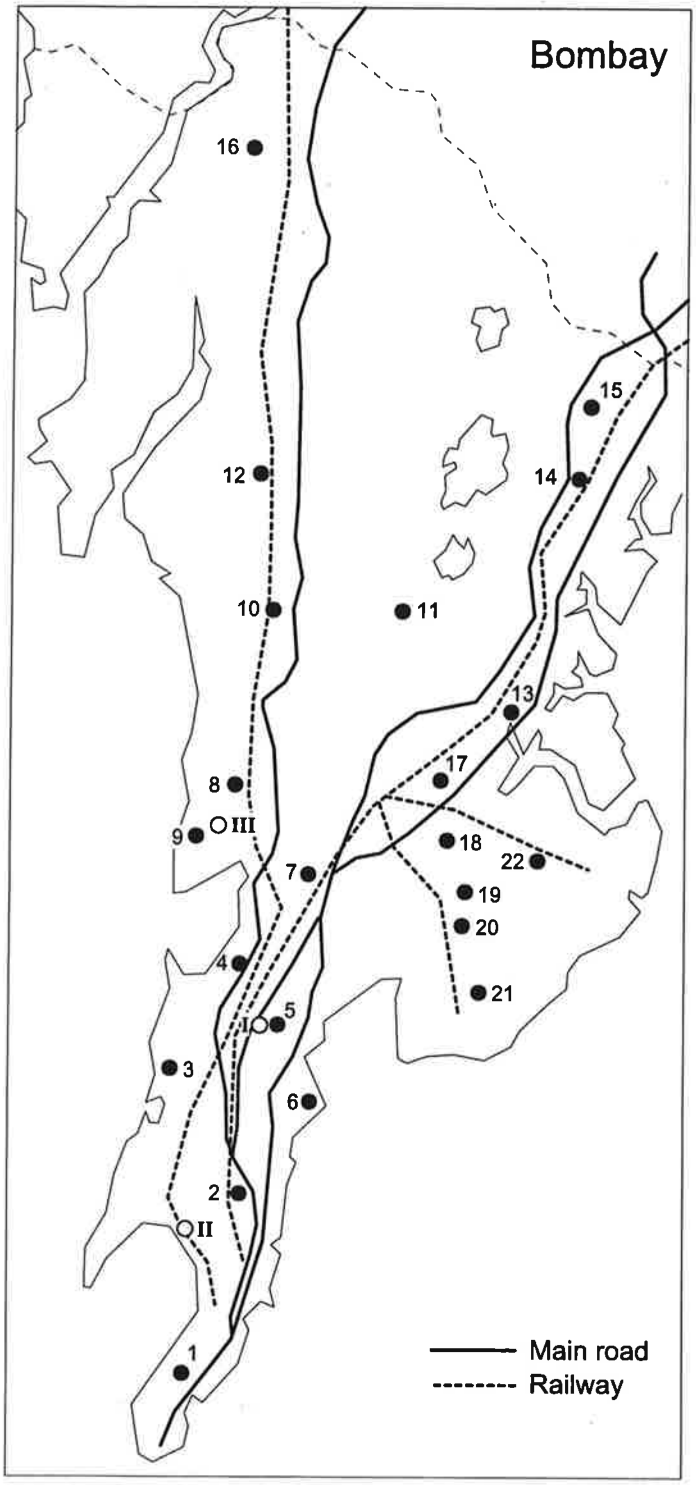
The MCGB air quality monitoring network in Bombay is shown in Figure 1. There are few details available as to the location of these measuring sites, except that they are located at fixed points, most of them on terraces of municipal buildings, 10-12 m above the ground. A few stations are located 3-4 m above the ground. The stations are visited once a week and operated continuously for 24 hours, but the sampling period is 8 hours, giving three samples in 24 hours. Sampling is performed 1-4 days a month and not necessarily on a fixed weekday.

Since 1978 NEERI (National Environmental and Engineering Research Institute) has operated United Nations GEMS (Global Environment Monitoring System) air monitoring stations in Bombay. These sites are also shown in Figure 1. At these sites SO_2, TSP and NO_2 is measured. Monitoring was discontinued in 1988 and recommenced in January 1990.

Both MCGB and NEERI monitor at Parel. The results are somewhat different, as shown e.g. in Annex I, since the sites are not exactly the same, measurements are done on different days, and analysis is done in different laboratories.

In 1991 and 1992 an air quality monitoring program was performed at 7 stations around the Thal RCF industrial complex south of Bombay. This study was co-ordinated by Projects and Development India (PDIL) and RCF. The measurements included TSP, SO_2, NO_x and NH_3 on an 8 hourly basis.

Also in 1991 and 1992 measurements of air quality was performed at 5 stations even further to the south around the Vikram Ispat Ltd, Salav Project site. The measurements included TSP, SO_2, NO_x, THC and CO on an 8 hourly basis 8 days in each two month periods. The measurement stations were located 1-7 km from the plant. There are no information as to which agency actually did the analysis.



MCGB
1. Colaba (C/R)
2. Babula Tank (I/R)
3. Worli Naka (C)
4. Dadar (C)
5. Parel (I/C/R)
6. Sewree (I)
7. Sion (C)
8. Khar (C/R)
9. Supari Tank (R)
10. Andheri (I/C)
11. Saki Naka (I)
12. Jogeshwari (I)
13. Ghatkopar(I/C/R)
14. Bhandup (I)
15. Mulund (I)
16. Borivali (R)
17. Tilaknagar (C)
18. Chembur Naka (C/R)
19. Maravali (I)
20. Aniknagar (I)
21. Mahul (I)
22. Mankhurd (R)

GEMS
I: Parel
II: Kalbadevi
III: Bandra

I: Industrial
C: Commercial
R: Residential

Figure 1: MCGB and GEMS air quality monitoring network in Greater Bombay.

Measurement and analysis methods

The measurement methods used by MCGB are listed in Table 1.

Table 1: Measurement methods used by MCGB in Bombay.

Parameter	Analysis method
Suspended particulates (TSP)	Gravimetric. High volume sampler.
Sulfur dioxide (SO_2)	Pararosaniline method.
	SO_2 is collected in midget impinger and absorbed in a solution of TCM (Potassium Tetrachloromercurate)
Nitrogen oxides as NO_2	TGS Ansa Method. Midget impinger.

As part of the URBAIR study, a comparison of results of gravimetric weighing of glass-fibre high-volume filters were carried out. Pre-weighted filters from NILU were brought to Bombay, weighted, exposed (24-hour sampling), weighted again and returned to NILU for last weighting. Also MCGB-type filters went through the same procedure. The results were quite good, in that the net particle weight on 6 filters (net weight range 66.4-131.6 mg) (NILU figures) deviated on the average about 4% (highest at NILU). Maximum difference was about 15%.

2. Analysis of measurement results

The Municipal Corporation of Greater Bombay (MCGB) has operated 22 measuring stations in Greater Bombay for the last 15 years. In addition NEERI has operated 3 GEMS stations in the same period. At all stations SO_2, TSP and NO_x is measured and in addition NH_3 at the MCGB stations. The MCGB stations are operated once a week, 1-4 days a month.

There are few details about the results other than annual mean concentrations. Annual mean values for fixed 8 hour periods (1200-2000 hrs, 2000-0400 hrs, 0400-1200 hrs) for the period June 1992-May 1993 are also given.

Total suspended particles (TSP)

Annual mean and 98th percentile TSP levels from the GEMS/NEERI stations are shown in Figures 2 and 3. The TSP concentrations are well above the WHO guidelines. In 1990 annual TSP levels were about 170-220 $\mu g/m^3$ and 98th percentile levels about 400-500 $\mu g/m^3$ at these stations.

Annual TSP levels at the MCGB stations are shown in Figure 4, for the period 1978-1990. These values are probably mean values from all the 22 stations in operation. The 1990 level was 243 $\mu g/m^3$, a little higher than at the NEERI stations. The 1990 level was the lowest since 1984. The highest level, 383 $\mu g/m^3$, was recorded in 1987.

Data from 18 stations from the period June 1992-May 1993 show a mean value of 207 $\mu g/m^3$, that means an even lower level than in 1990, and about the same level as during the period 1978-1984, see Figure 5.

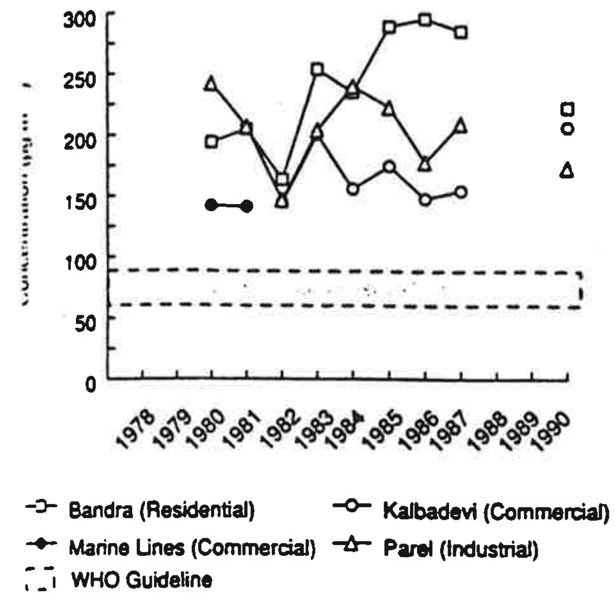


Figure 2: Annual mean suspended particulate matter (TSP) at GEMS/NEERI stations (μg/m³).

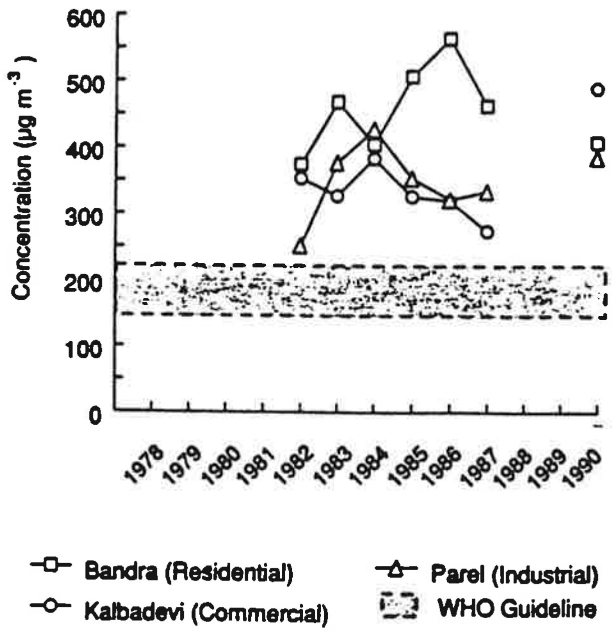


Figure 3: Annual 98 percentile suspended particulate matter (TSP) concentrations at GEMS/NEERI stations (μg/m³).

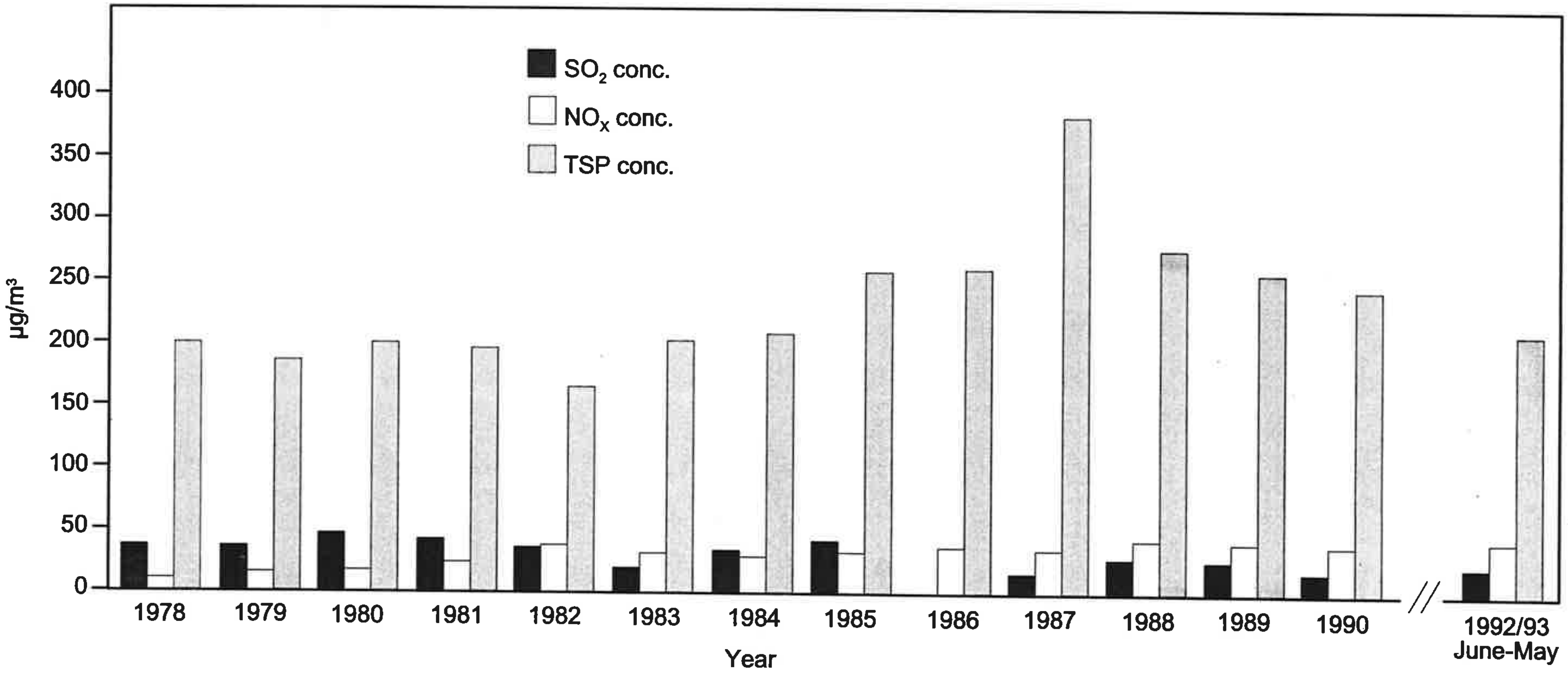


Figure 4: Annual mean concentrations of SO_2, NO_2, and TSP at MCGB stations (µg/m³).

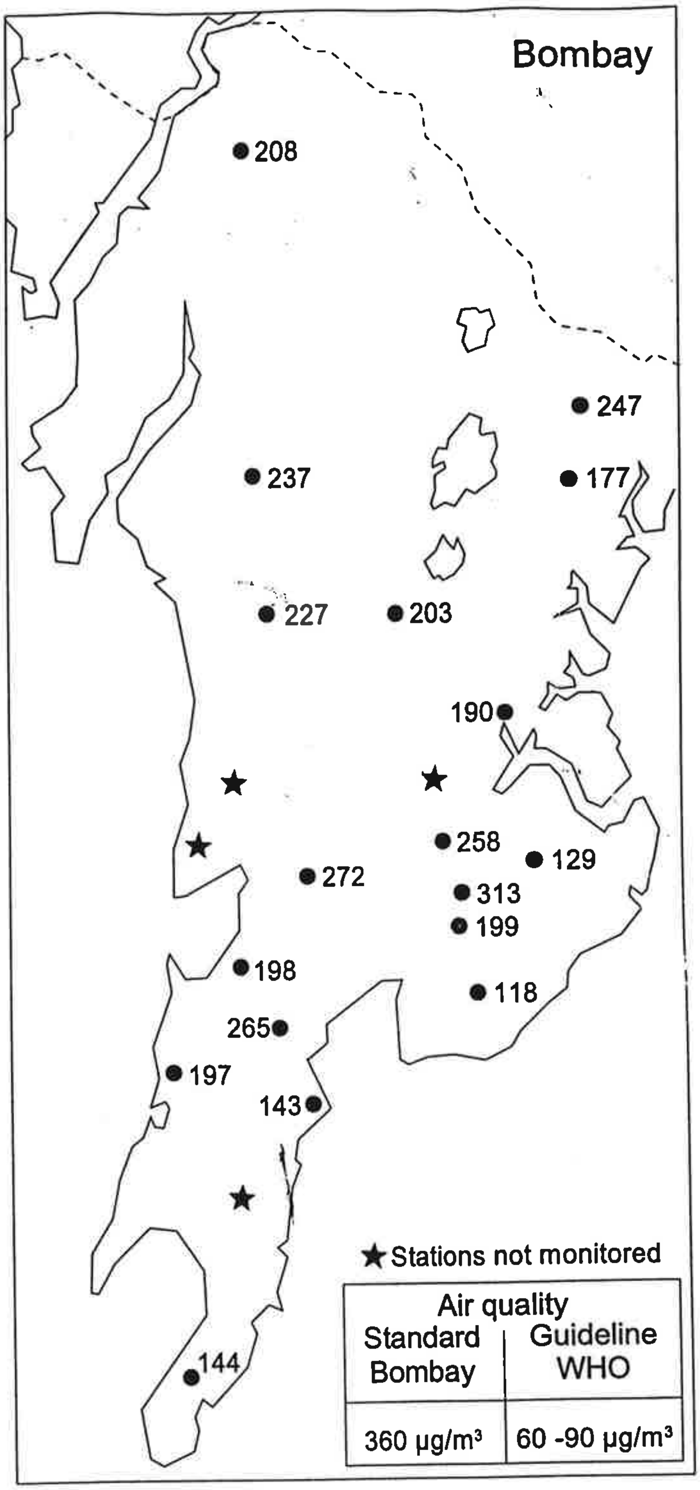


Figure 5: Mean TSP concentrations at MCGB stations in the period June 1992-May 1993 (µg/m³).

Data tables for all stations, with monthly average SO_2, TSP, NO_x and NH_3 values are enclosed as Annex II to this Appendix.

Figure 5 shows the highest annual concentration at the Maravali station (313 µg/m^3) situated in an industrial area. The Colaba, Sewree, Mahul and Mankhurd stations observed the lowest concentrations (118-144 µg/m^3). Compared to the year 1987, 1993-92 TSP concentrations has fallen 20-30% at the Worli Naka, Dadar, Parel, Sewree and Saki Naka stations, while there is no change in the TSP level at the Sion and Chembur Naka stations.

Figures 6 and 7 show, as examples, the monthly averages at two selected sites, Parel and Saki-Naka, for 1987/88 and 1992/93. Similar figures for all available MCGB sites for 1992/93 are enclosed in Annex III to this Appendix. There is a considerable variation in the monthly mean TSP concentrations as shown in Figures 6 and 7. The lowest concentrations are measured during the months July-September, the monsoon season. The highest concentrations are usually measured during the months November-March. During the rainy season mean concentrations are usually lowered by a factor between 2 and 3 compared to the dry season.

There is a very little information available as to maximum 8 hour TSP levels. Data from April 1992, however, show maximum values much higher than the monthly mean values, see Table 2. During April 1992 maximum 8 hour values varied between 265 µg/m^3 and 1 365 µg/m^3. Maximum values seems to be between 1.5 and 3 times higher than monthly mean values.

Figure 8 shows that TSP concentrations usually is about 30% higher during the hours 1200-2000 than during the night time and during the morning period. This is probably due to the general activity pattern. Why NO_x and SO_2 do not follow this pattern, cannot be explained by available information.

Ambient air quality data Parel (µg/m3)

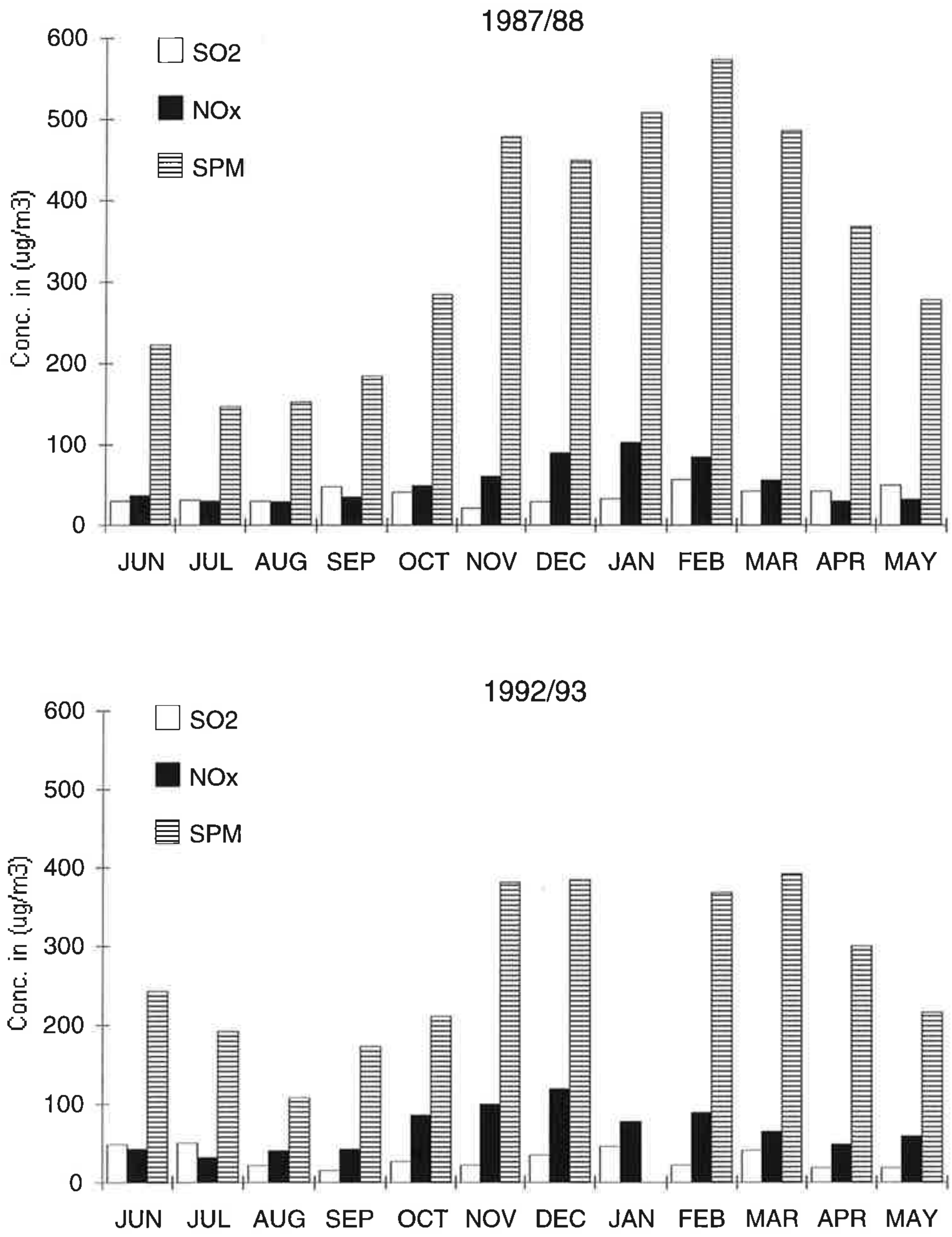


Figure 6: Monthly mean SO_2, NO_x and TSP concentrations at the Parel station during the periods June 1987-May 1988 and June 1992-May 1993 (µg/m³).

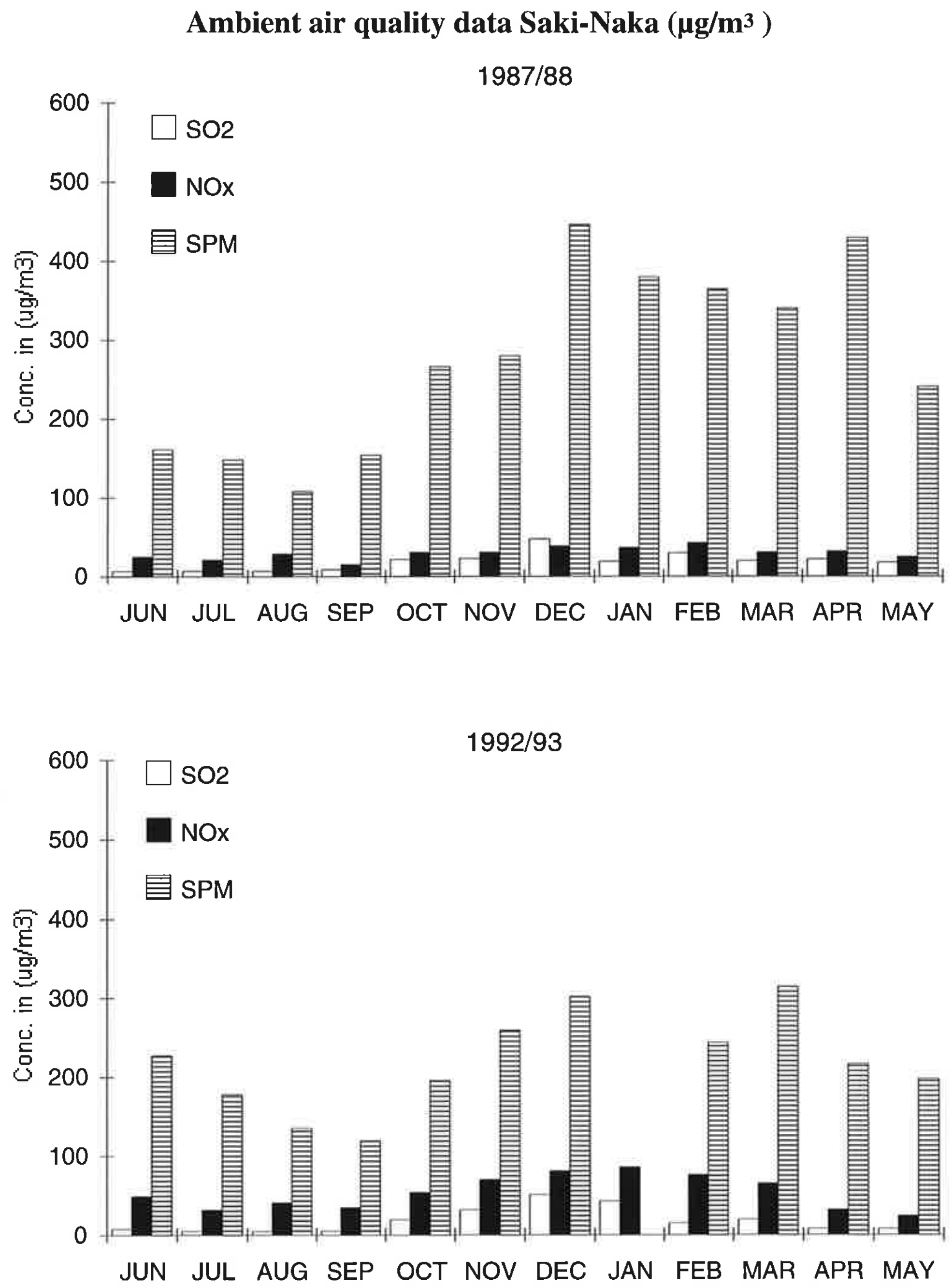


Figure 7: Monthly mean SO_2, NO_x and TSP concentrations at the Saki Naka station during the periods June 1987-May 1988 and June 1992-May 1993 (µg/m³).

Table 2: Concentrations of SO_2, NO_2, NH_3 and TSP from MCGB stations in April 1992 (µg/m³).

Sites	SO_2		NO_2		NH_3		TSP	
	A.M.	MAX	A.M.	MAX	A.M.	MAX	A.M.	MAX
1. Colaba	8	20	26	36	37	57	176	265
2. Babula Tank	-	-	-	-	-	-	-	-
3. Worli	13	90	43	78	56	96	281	645
4. Dadar	9	28	31	54	60	79	238	408
5. Parel	23	72	37	61	41	65	360	834
6. Sewree	39	91	31	59	50	82	225	393
7. Sion	18	60	89	126	59	87	465	1 365
8. Khar	-	-	-	-	-	-	-	-
9. Supari Tank	-	-	-	-	-	-	-	-
10. Andheri	20	55	32	90	55	97	348	659
11. Sakinaka	16	28	41	93	38	77	273	504
12. Jogeshwari	7	13	26	49	61	109	337	495
13. Ghatkopar	11	29	25	52	48	104	353	556
14. Bhandup	50	96	29	62	56	106	320	662
15. Mulund	7	20	20	38	43	65	275	533
16. Borivali	6(?)	6	15	28	37	44	199	291
17. Tilaknagar	-	-	-	-	-	-	-	-
18. Chemburnaka	14	31	45	83	57	88	319	496
19. Maravali	12	54	55	119	73	165	207(?)	381
20. Anik Nagar	23	63	36	59	97	168	259	379
21. Mahul	-	-	-	-	-	-	-	-
22. Mankhurd	14	56	39	85	46	94	250	395

A.M.: Monthly average conc. Max.: Maximum 8-hour conc.

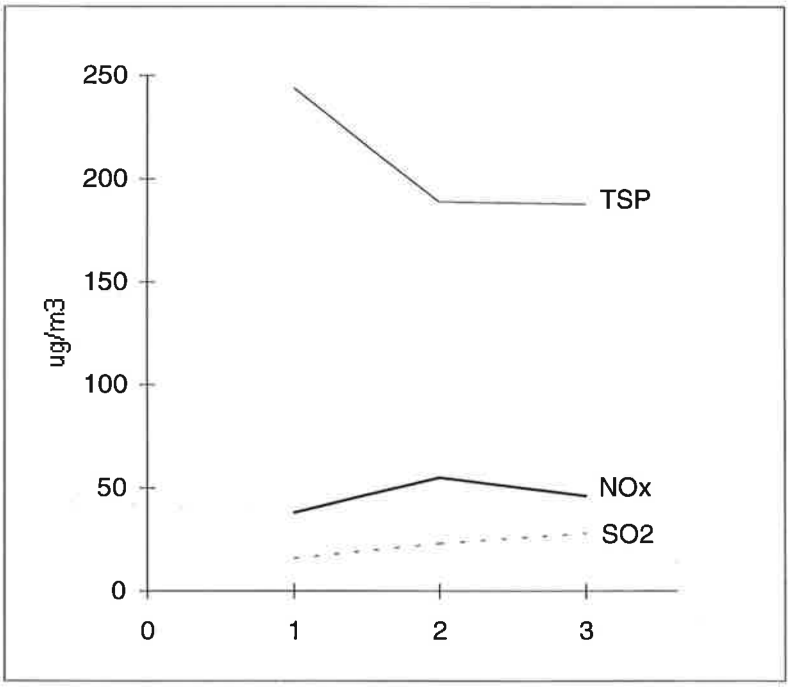


Figure 8: 8 hour mean annual TSP, NO_x and SO_2 values (18 stations) for the period June 1992-May 1993 (µg/m³).
1 = 1200-2000 hrs, 2 = 2000-0400 hrs, 3 = 0400-1200 hrs

There are only a few TSP data available from highly exposed traffic sites in Bombay. In 1991 and 1992, 3 or 4 days measurements of SO_2, NO_x, TSP and CO were performed at 6 traffic junctions in Greater Bombay. TSP mean values ranged from 480 $\mu g/m^3$ to more than 1 300 $\mu g/m^3$ and maximum 8 hour values ranged from about 550 $\mu g/m^3$ to more than 3 100 $\mu g/m^3$. These values are considerably higher than from the stations in the MCGB air quality monitoring network and show that TSP could be a very serious problem close to the main roads. These high values are probably caused by resuspension of road dust and not so much by direct exhaust emissions from the cars.

In 1989-1990 Sharma and Patil (1991, 1992) did some measurements of mass concentration of size-distributed aerosols using a quartz crystal microbalance cascade impactor (QCM-CI). The instrument operates at a low flow rate (0.24 l/min) and separates the aerosols into 10 size fractions. The 50% cut-off sizes varies from 25 µm to 0.05 µm. For comparison conventional High Volume Sampler was also used. These samples were analysed for size distribution by a Centrifugal Analysing System (CAS) and Image Analyser System (IAS).

Samples were taken one day on hourly basis each week at two sites. Site 1 (CESE, IIT, Bombay) is a relatively clean area and Site 2 (Hindustan Ciba-Geigy Ltd, Bhandup) is a "mixed region" with highly polluting industries surrounded with dense population. Site 2 was along the highway Lal Bahadur Shastri (LBS) Marg with a peak traffic density of about 2 000 vehicles per hour. It is not clear if the Bhandup site is the same as the Bhandup site in the BMC network, but from maps it is obviously in the same region.

The TSP values collected by the high volume sampler were much higher than total particulate collected by QCM-CI ($\leq$ 25 µm) for both sites: 180 and 541 $\mu g/m^3$ by high volume sampler as compared to 86 and 110 $\mu g/m^3$ by QCM-CI. But the cumulative percentage of particulates $\leq$ 25 µm was approximately equal by the two instruments. PM_{10} values (particles with diameter $\leq$ 10 µm) were about 85-90% of total mass collected by the QCM-CI measurement method and the mass segregated by the CAS/IAS analyser system ($\leq$ 45 µm) on high volume samples. This shows that PM_{10} levels are much lower than TSP levels and that the difference is highest in the most polluted areas where the mass of particles $\geq$ 45 µm dominates.

TSP high volume samples at Site 1 and Site 2 in 1989 were analysed for 27 chemical species using inductively coupled plasma emission spectroscopy (ICP-MS), energy dispersive x-ray fluorescence spectroscopy (XRF) and UV/VIS spectrophotometry. Factor analysis applied on 19 marker elements extracted 7 factors indicating 7 major source types contributing to aerosol mass at the sampling sites. It was found that soil related elements were attached with more than one factor indicating collinearity of sources. However, results obtained indicated many anthropogenic sources present in the region like ferrous and non-ferrous industrial emissions, combustion processes such as refuse burning, oil and coal burning, road transport and secondary emissions.

Table 3 shows the annual average concentrations of TSP and the 27 analysed elements at the two sites for 1989. The concentrations were much higher at Site 2 than at Site 1, especially for TSP, Al, Cr, S, Si, V, and Zn.

Table 3: Annual average TSP and its components (ngm^{-3}).

Component	Site 1 Mean	Site 2 Mean
TSP*	130.21	800.71
Al*	2.31	10.54
As	273.60	695.50
Br	244.20	384.40
Ca*	4.82	8.43
Cd	35.70	75.70
Cl*	9.13	11.08
Co	25.70	30.50
Cr	39.00	104.10
Cu	290.80	436.20
Fe*	2.95	5.06
K*	1.27	2.27
La	36.70	48.20
Mg	705.60	802.05
Mn	401.90	635.00
Na*	5.87	8.20
Ni	35.00	79.10
Pb*	0.55	1.21
S*	0.94	4.75
Sb	86.80	104.00
Si*	3.59	9.48
Sn	95.10	189.10
Ti	471.50	661.00
V	109.50	311.00
Zn	204.90	785.50
SO_4^{--}*	1.59	1.77
NO_3^{-}*	1.03	1.14
NH_4^{+}	739.90	868.90

Background TSP levels

There are no data available from real background stations, but measurements are performed south of Bombay both around the Thal RCF industrial Complex and during the Vikram Ispat Ltd. Salav Project. Especially the Thal RCF data are interesting.

During the 1991/92 Thal RCF project TSP, SO_2, NO_x and NH_3 were measured at 7 locations. The number of 8 hour observations ranged between 84 and 141. Arithmetic mean TSP values ranged between 79.8 $\mu g/m^3$ and 117.6 $\mu g/m^3$ and maximum 8 hour mean values ranged from 164 $\mu g/m^3$ to 234 $\mu g/m^3$. Even though local industrial emissions are supposed to contribute, the measured TSP levels around the Thal RCF Complex are quite lower than at all MCGB stations in Greater Bombay, pointing out the great importance of local emission sources in Bombay.

Sulfur dioxide (SO_2)

Annual mean SO_2 concentrations from the GEMS/NEERI sites are shown in Figure 9. The concentrations dropped significantly between 1980 and 1987 to well below WHO annual guideline levels, and increased substantially again in 1990, but are still within the WHO guideline range.

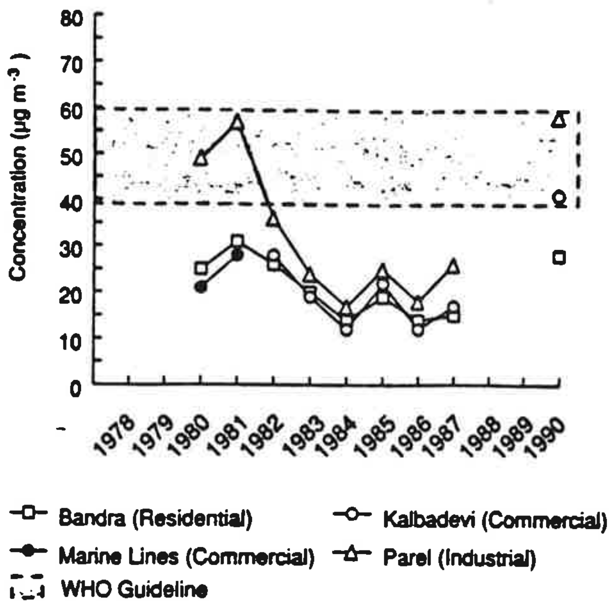


Figure 9: Annual mean sulphur concentrations at GEMS/NEERI stations (µg/m³).

Annual SO_2 levels at the MCGB sites are shown in Figure 4. These values are mean values from all the 22 stations in operation. The 1990 level was 18 µg/m³, well below that at the NEERI stations. The 1990 level was the same as in 1987, while the SO_2 concentrations at the NEERI sites increased substantially from 1987 to 1990. The reason for this difference between NEERI and MCGB sites is not known. The MCGB data from the period June 1992-May 1993 show a mean value of 22 µg/m³, that is a little bit higher than in 1990.

Figure 10 shows annual mean SO_2 levels for the period June 1992-May 1993. These levels are ranging from 7 µg/m³ at the Mankhurd station to 50 µg/m³ at the Bhandup site. These values are all within the WHO guideline of 50 µg/m³.

As shown in Figures 6 and 7, there is a quite similar seasonal variation for SO_2 and TSP at the Saki Naka station, while this seasonal variation is not so clear for SO_2 at the Parel station. The reason for this is not known. It is also difficult to explain why SO_2 levels at most stations usually are higher during the late night and morning period than during the rest of the day as shown in Figure 8.

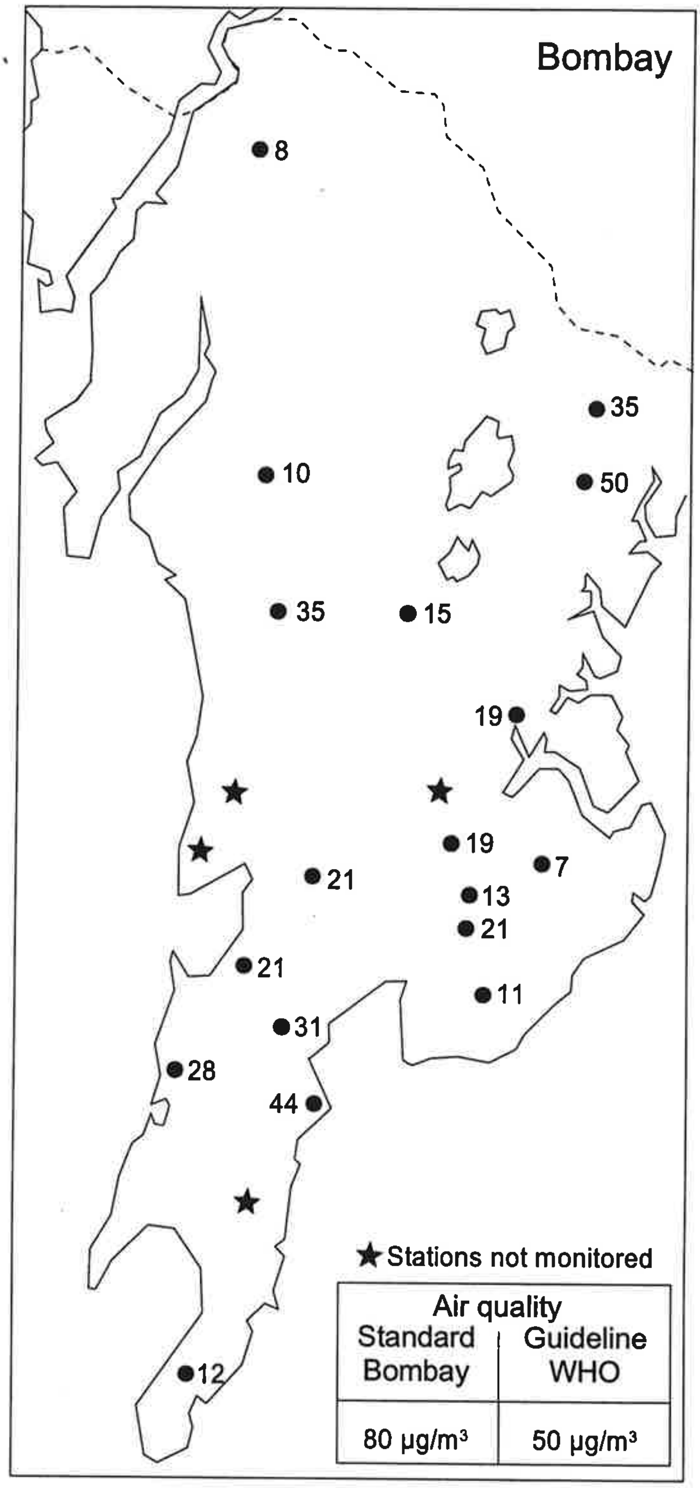


Figure 10: Mean SO_2 concentrations at MCGB stations in the period June 1992-May 1993 (µg/m³).

Available data from April 1992 from 17 MCGB stations show maximum SO_2 values (8 hour mean values) between 13 µg/m³ and 96 µg/m³, see Table 2.

A few measurements at traffic junctions in 1991 and 1992 show mean values ranging from 38 µg/m³ to 117 µg/m³ at 6 stations and maximum 8 hour values from 80 µg/m³ to 162 µg/m³. SO_2 concentrations at traffic junctions therefore seem to be considerably higher than at the MCGB network. The Indian Guideline value for short-term (24 hourly) in Industrial & Mixed Use areas is 120 µg/m³.

Air quality data around the Thal RCF Complex in 1991 and 1992 show mean values from 2.3 µg/m³ to 5.7 µg/m³ and maximum 8 hour values from 11.4 µg/m³ to 24.8 µg/m³ at 7 stations. These values are considerably lower than in the Greater Bombay area.

Nitrogen oxides (NO_x as NO_2)

Annual 98th percentile NO_2 levels at GEMS/NEERI sites are shown in Figure 11 (annual mean levels are not shown in reports available at NILU). Annual 98th percentile levels have dropped significantly from 1987 to 1990. Concentrations are relatively consistent suggesting NO_2 concentrations to be evenly distributed throughout the city.

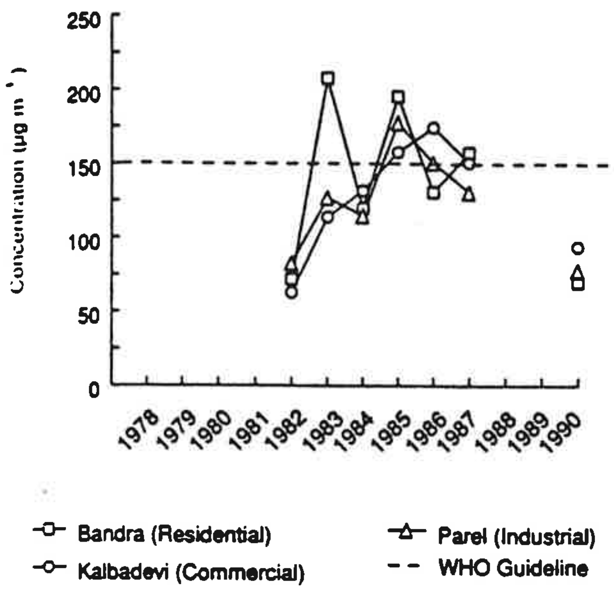


Figure 11: Annual 98 percentile nitrogen oxide concentrations at GEMS/NEERI stations (µg/m³).

Annual mean concentrations at MCGB sites are shown in Figure 4. These values are probably mean values from all 22 stations. The mean value in 1990 was 40 µg/m³, and the level has varied between 30 µg/m³ and 44 µg/m³ the last ten years. MCGB sites NO_x level has increased about 10% from 1987 to 1990, while 98th percentile values at GEMS/NEERI sites have dropped significantly from 1987 to 1990. As very little details about monitoring methodology and site location are available for both monitoring networks, direct comparison of the data is not attempted. MCGB data from June 1992-May 1993 show a mean of 46 µg/m³ indicating that the NO_x level still is rising.

Figure 12 shows mean NO_x concentrations for the period June 1992-May 1993. The levels are ranging from 20 µg/m³ at the Mahul site to 83 µg/m³ at the Sion site.

As shown in Figures 6 and 7 the seasonal NO_x variation seems to be quite similar as for TSP. The NO_x levels usually are highest during the night time (Figure 8), while TSP concentrations are highest at daytime and SO_2 concentrations are highest at late night and morning hours.

Available data from April 1992 from 17 MCGB stations show maximum NO_x values (8 hour mean values) between 28 µg/m³ and 126 µg/m³, see Table 2. The Indian guideline value for 24 hours in industrial areas is 120 µg/m³.

1991 and 1992 NO_x measurements at some traffic junctions show mean values from 56 µg/m³ to 175 µg/m³ and maximum 8 hour values from 83 µg/m³ (Worli Naka site) to 296 µg/m³ (VT site). As for TSP and SO_2 these values are much higher than at the MCGB monitoring stations, indicating traffic emissions to be very important.

Air quality data around the Thal RCF Complex in 1991 and 1992 show mean NO_x values between 10.2 µg/m³ and 17.0 µg/m³ and maximum 8 hour mean values between 28.0 µg/m³ and 52.2 µg/m³ at 7 stations. These values are considerably lower than in the Greater Bombay area.

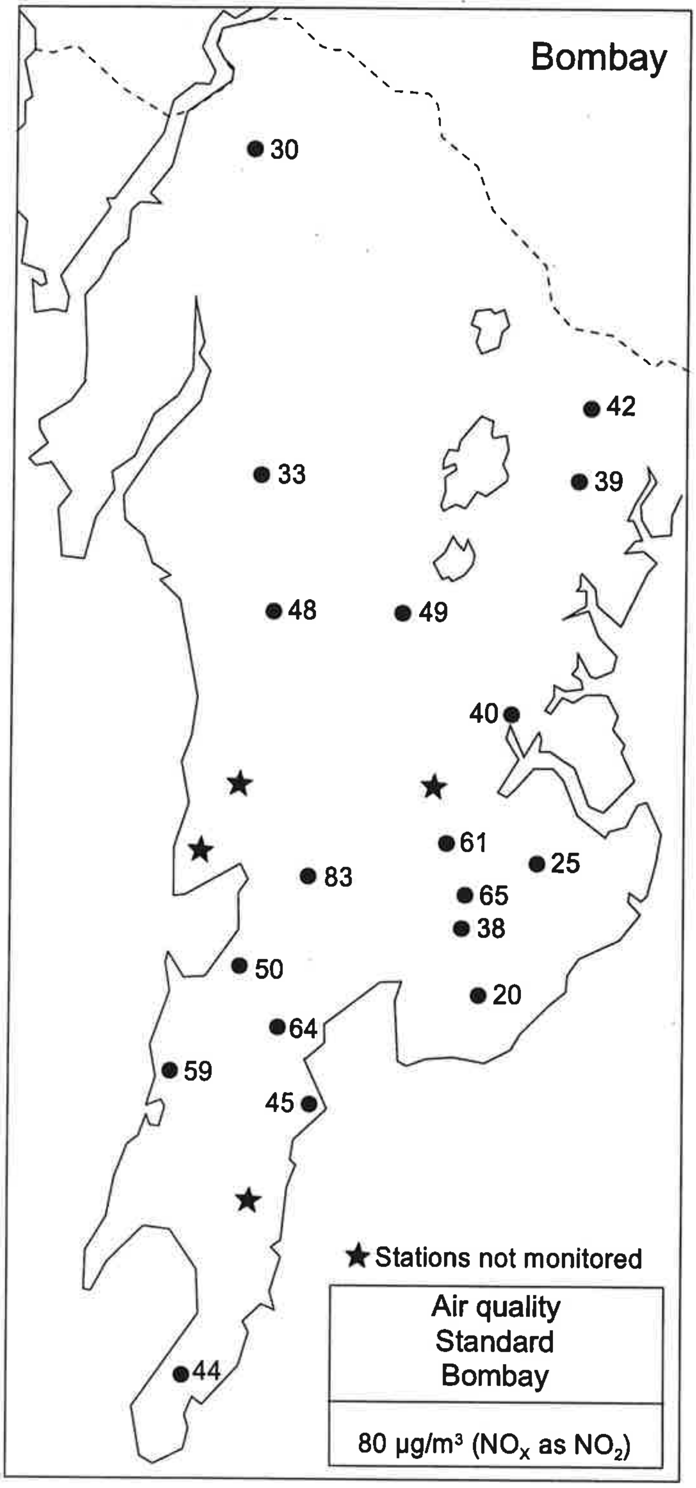


Figure 12: Mean NO_x concentrations at MCGB stations in the period June 1992-May 1993 (µg/m³).

Lead (Pb)

Monthly mean concentrations of lead during the Air pollution survey of Greater Bombay in 1971-1973 ranged from 0.4 µg/m^3 to 2.4 µg/m^3.

Lead was monitored at the 22 MCGB sites during the years 1980-1987. The Greater Bombay area was divided into 6 sub-areas; South Bombay, Central Bombay, Western Suburb, Eastern Suburb, Petrochemical Complex and Urban Clean (Borivali station).

This study showed an increasing trend in the whole area and the highest levels in the Eastern Suburb zone. The annual mean levels ranged from 0.5 µg/m^3 to 1.3 µg/m^3. The highest monthly mean level was 17.9 µg/m^3 at the Mulund site in October 1984.

As an example annual mean Pb concentrations in the Central Bombay area are shown in Figure 13. Annual mean concentrations for 4 stations range from 0.2 µg/m^3 to 1.1 µg/m^3. The highest level (probably mean monthly value) was 8.4 µg/m^3 at Dadar in January 1985. The second highest level of 6.2 µg/m^3 was recorded during February 1987 at Parel. The annual mean levels of Pb in this area showed an increasing trend during the years 1980-1987. From 1980 to 1987 the annual mean Pb level nearly doubled.

There is no information available about Pb monitoring at the MCGB stations after 1987.

Monitoring undertaken in 1990 at the GEMS/NEERI sites indicates that annual airborne Pb levels have fallen significantly since the 1970's to between 0.25 µg/m^3 and 0.33 µg/m^3, well below the WHO guideline of 1 µg/m^3. It is likely that kerbside levels will be much higher.

As shown in the TSP paragraph annual Pb levels at two sites in 1989 were 0.55 µg/m^3 and 1.21 µg/m^3, the latter site being close to a road. In the most heavily traffic-exposed city centre streets it is likely that Pb levels are even higher.

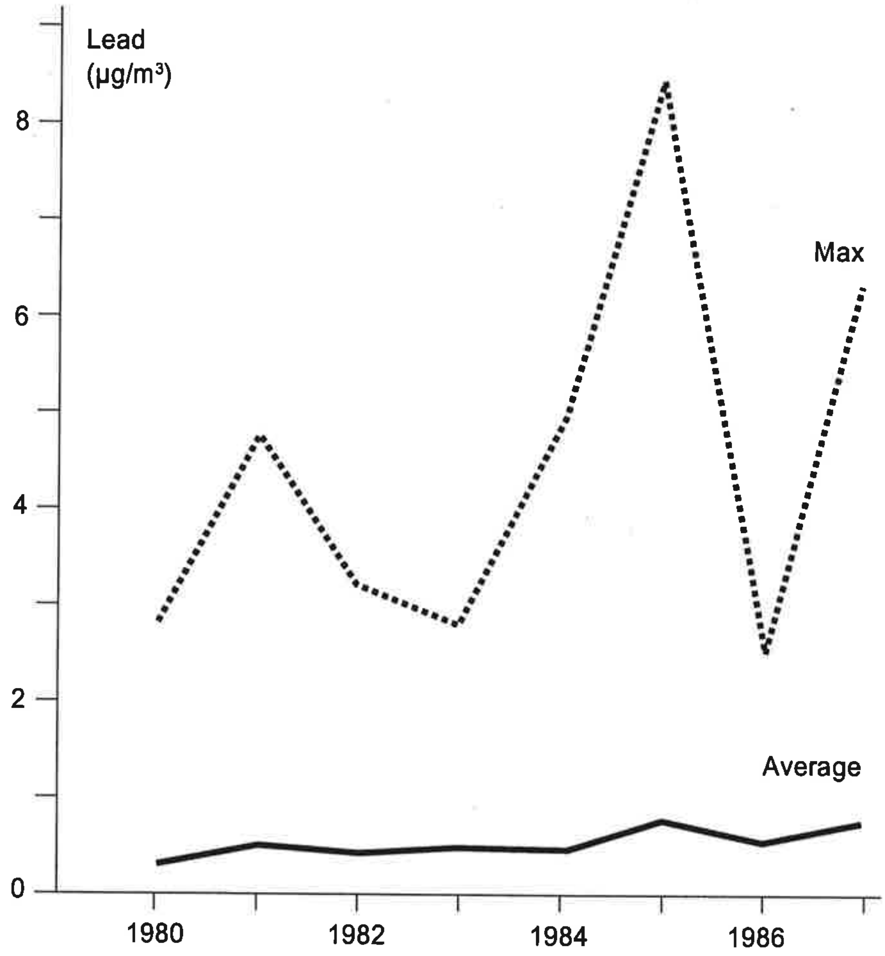


Figure 13: Annual trend of lead in Central Bombay during the years 1980-1987 (µg/m³) (Worli Naka, Dadar, Parel and Sewree stations).

Carbon monoxide (CO)

Some short-term CO roadside surveys have been undertaken between 1984 and 1987. Monitoring was performed at several roadside sites during periods of peak traffic flow. 8 hour mean values ranged between 4 mg/m³ and 21 mg/m³. A maximum hourly concentration of 50 mg/m³ was recorded at the Haji Bachoo Ali Hospital. Maximum hourly concentrations were generally around 23-29 mg/m³, close to the WHO guideline of 30 mg/m³. These roadside surveys are not representative of ambient background levels which are likely to be much lower.

CO has also been measured at 6 traffic junctions on a few days in 1991 and 1992. Mean values ranged from 5.1 mg/m³ (Worli Naka) to 11.1 µg/m³ (VT station) and maximum values ranged from 7 mg/m³ (Nana Chowk) to 15.6 mg/m³ (Mahim).

CO was also measured during the Vikram Ispat Ltd. Salav project south of Bombay in the period January 1991-June 1992. The values usually ranged from 0.3 mg/m^3 to 0.5 mg/m^3, and only a few 8 hour values were above 1 mg/m^3. These values seem to represent ambient background levels.

Ozone (O_3)

Ozone is not measured in Bombay. Some monitoring should be started to identify the levels of ambient urban O_3 in and near Bombay.

Ammonia (NH_3)

Ammonia is routinely measured at the MCGB sites, but information about the results are very limited. The April 1992 report shows mean values between 37 µg/m^3 and 97 µg/m^3 and maximum values between 44 µg/m^3 and 168 µg/m^3. The highest observed 24 hour maximum NH_3 value was 1 995 µg/m^3 at the Maravali station in 1985. There is no available information on NH_3 standards.

Air quality data at 7 stations around the Thal RCF Complex in 1991 and 1992 show mean NH_3 values ranging from 5.5 µg/m^3 to 46.7 µg/m^3. Maximum 8 hour values ranged from 15 µg/m^3 to 233 µg/m^3. These values are somewhat lower than in the Greater Bombay area.

Benzo(a)pyrenes

Occasionally samples of total and respirable TSP are taken at traffic junctions with heavy traffic. The level of benzo(a)pyrenes from total TSP ranges between 2.7 µg/m^3 and 13 µg/m^3, and the level of benzo(a)pyrenes from respirable TSP ranges between 2.3 µg/m^3 and 8.4 µg/m^3. There are no information on standards for benzo(a)pyrenes, but the measured levels seem to be quite high.

3. References

Sharma, V.K. and Patil, R.S. (1991) In situ measurements of atmospheric aerosols in an industrial region of Bombay. *J. Aerosol Sci., 22,* 501-507.

Sharma, V.K. and Patil, R.S. (1992) Size distribution of atmospheric aerosols and their source identification using factor analysis in Bombay, India. *Atmos. Environ., 26B,* 135-140.

Sharma, V.K. and Patil, R.S. (1992) Chemical composition and source identification of Bombay aerosol. *Environ. Technol., 13,* 1043- .

Annex I

Intercomparison of gravimetric weighing analysis of glass-fibre high-volume filters between MCGB and NILU laboratories

NORSK INSTITUTT FOR LUFTFORSKNING - NORWEGIAN INSTITUTE FOR AIR RESEARCH
POSTBOKS 64, N-2001 LILLESTRØM

NILU

Office of the Dy. City Engineer (Civil)
Env. Sanitation & Projects
New Transport Garage Bldg. 3rd Floor
Dr. E. Moses Rd.
Worli
BOMBAY 400 018
INDIA

Att.: Mr. V.S. Mahajan, Dy. City Engineer

Deres ref./*Your ref.*:	Vår ref./*Our ref.*:	Dato/*Date:*
	STL/EMN/O-92117	20 August 1993

Dear Sir,

with reference to your letter of 4 May this year I hereby enclose Tables and Figures giving the results of our comparison of weighing results on the High volume sampler filters performed by your laboratory, and by NILU, as also handed over to you in Bombay on 4 August.

The comparison of weighing results comes out quite favourably. The results show the following main features:

- The weights recorded at your laboratory are on the average about 4 mg higher than those recorded at NILU, varying between -15 mg and +11 mg
- The net weights recorded at NILU were also on the average somewhat higher than recorded by MCGB. NILU net weights were on the average 4.9% higher than MCGB net weights (for 6 samples), varying between +15.3% and -8.8%.
- Comparison of results from co-located samplers, one with MCGB filter paper, and one with Whatman GF/A filter paper (used by NILU) show that the MCGB filters give somewhat higher concentrations.
  This is an interesting result. The reason for this effect cannot be determined from this experiment. It may possibly be connected with irreversible absorption of water wapor in the MCGB filters, or to loss of fibers from the Whatman filters.

The results from this limited experiment supports the good quality of the particle weight data given by your laboratory.

Sincerely yours,

Steinar Larssen
Head of department
LOCAL AIR QUALITY

Postal address:
P.O. Box 64
N-2001 LILLESTRØM, Norway

Office address:
Elvegt. 52
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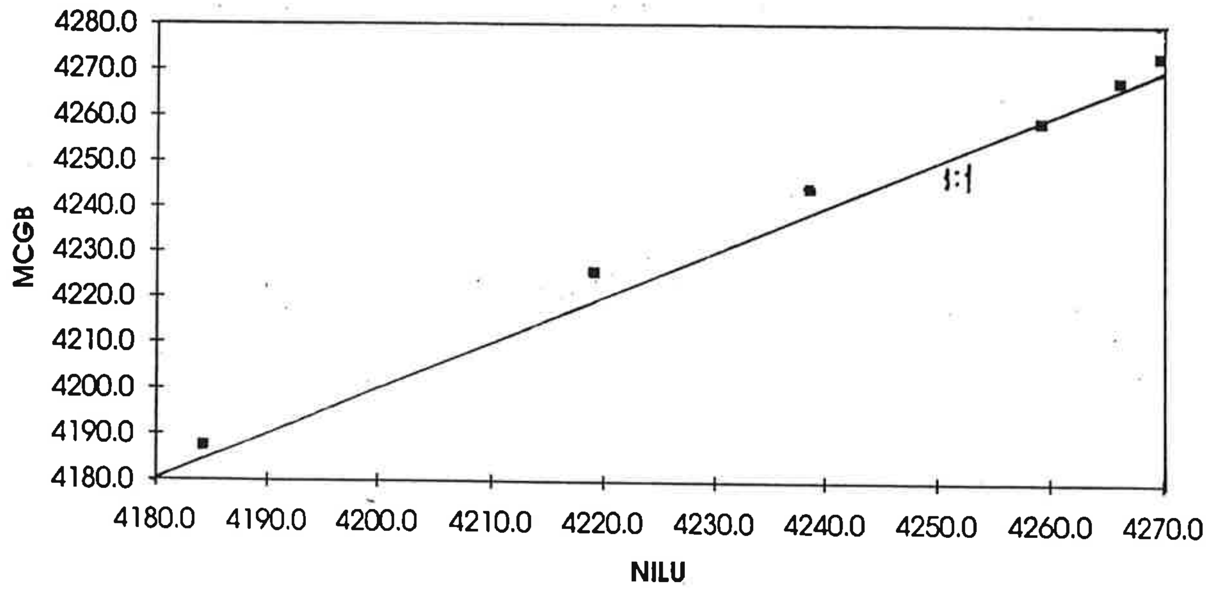
Telefax : 63 81 92 47
Telex : 74854 nilu n

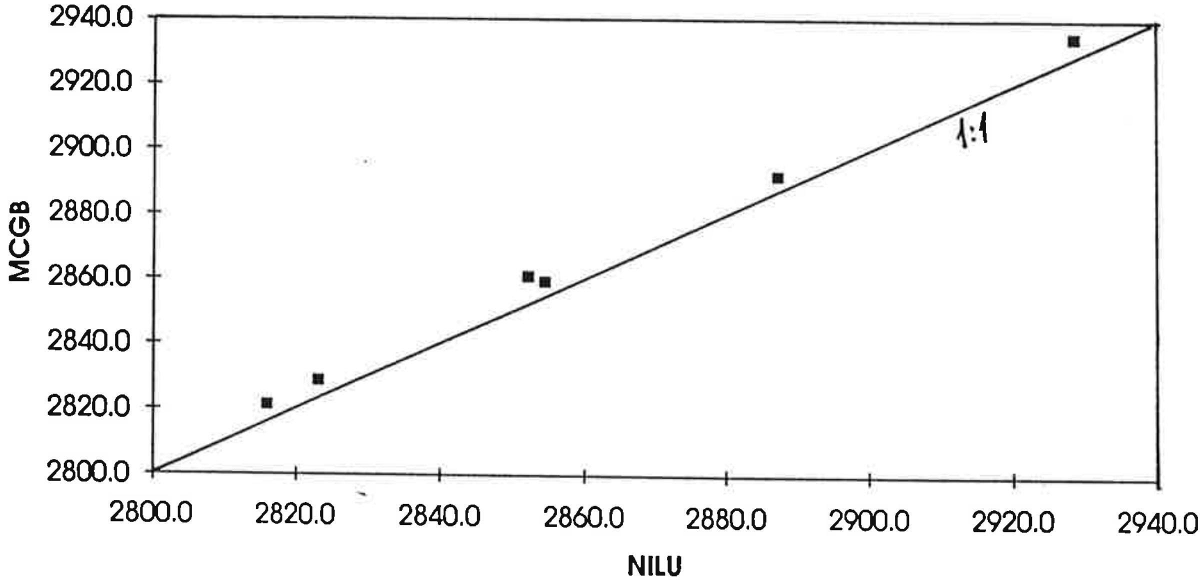
Bank: 5102.05.19030
Postgiro: 0813 3308327

BOMBAY TSP, Test filters									
	Weight before		Weight after		Net weight, mg		m³	µg/m3	Station
Filter no.	NILU	MCGB	NILU	MCGB	NILU	MCGB		MCGB	
1	4219.1	4225.6	4308.3	4309.2	89.2	83.6	303.6	275	SION
2	4184.3	4187.5	4250.7	4247.8	66.4	60.3	331.2	182	SION
3	4259.1	4259.0	4369.1	4354.4	110.0	95.4	393.6	242	JOGESHWARI
4	4269.6	4273.3	4355.1	4367.0	85.5	93.7	412.8	227	JOGESHWARI
5	4266.0	4267.9	4397.6	4397.9	131.6	130.0	379.2	343	MARAVLI
6	4238.6	4244.4	4328.9	4330.2	90.3	85.8	379.2	226	MARAVLI
7	4245.3	4253.4	4249.8		4.5				unexposed
8	4202.8	4213.7	4210.9		8.1				▪
9	4224.3	4234.5	4232.7		8.4				▪
10	4228.8	4236.5	4234.3		5.5				▪
K-488		2712.8	2854.4	2859.4		146.6	493.5	297	JOGESHWARI
K-489		2708.9	2815.9	2821.3		112.4	528.0	213	JOGESHWARI
K-500		2735.9	2928.0	2934.8		198.9	475.2	419	MARAVLI
K-501		2733.3	2852.1	2860.9		127.6	480.0	266	MARAVLI
K-506		2742.6	2887.1	2892.2		149.6	435.6	343	SION
K-507		2740.0	2823.1	2828.8		88.8	480.0	185	SION
K-544			2762.0	2766.9					unexposed
K-545			2753.3	2756.5					▪

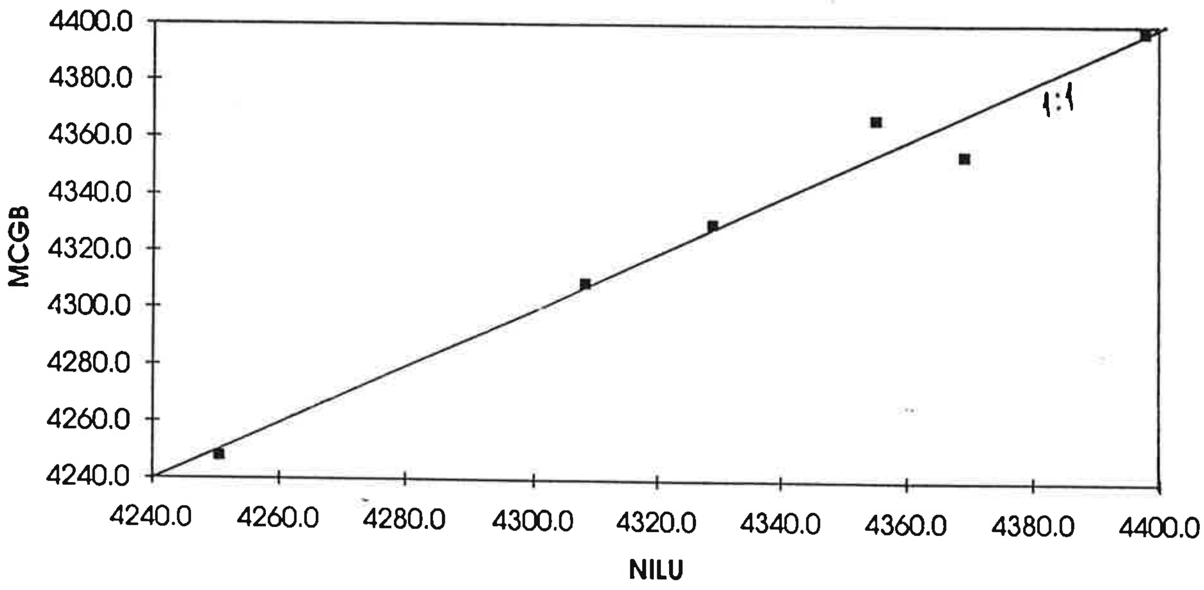
Weight before, filter 1 - 6

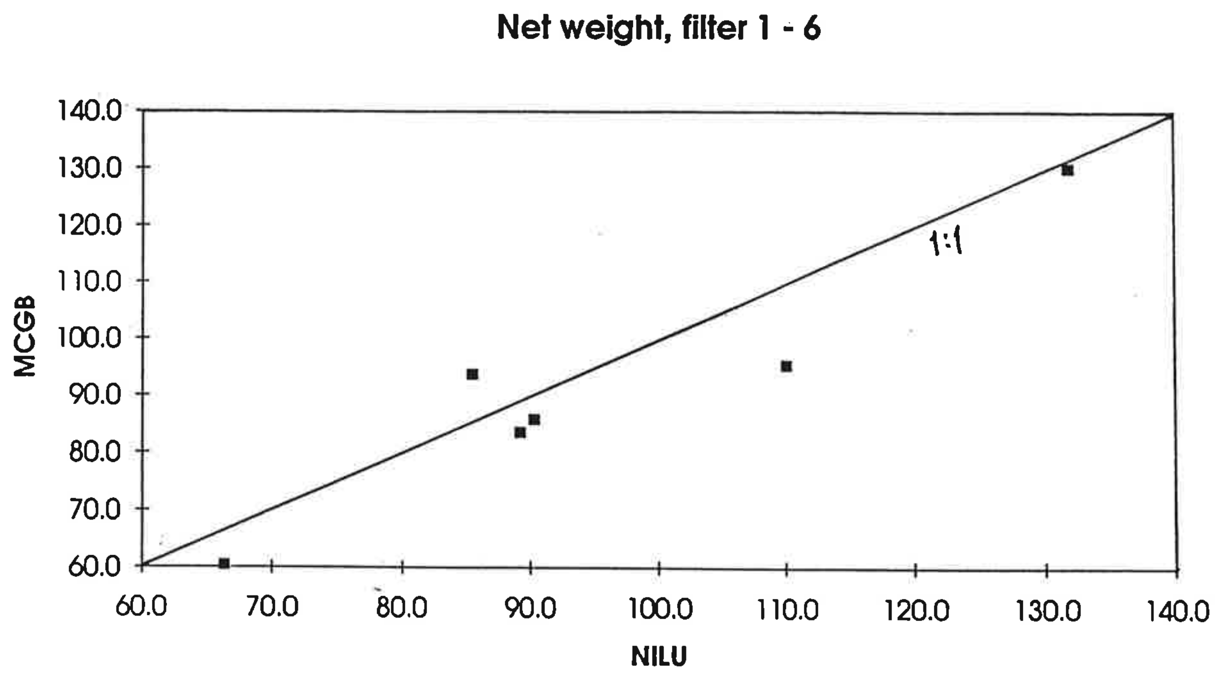


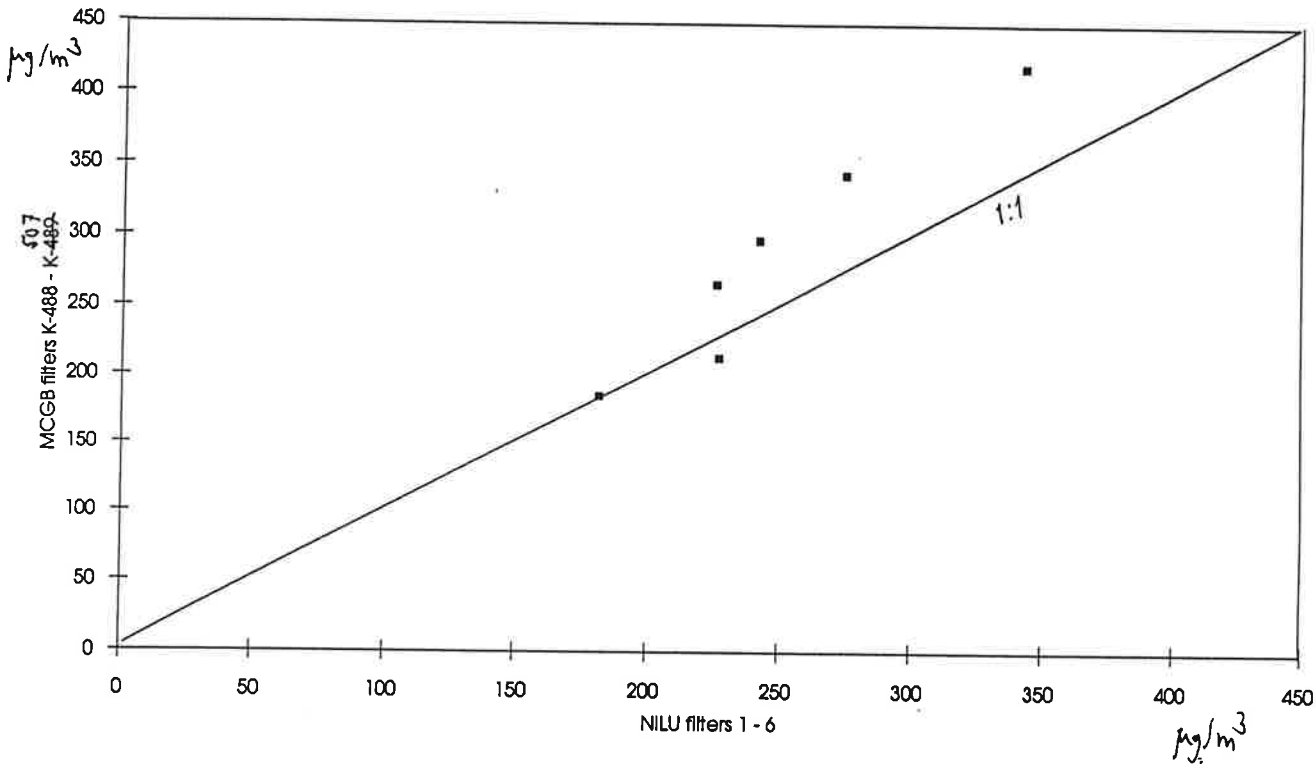
Weight after, filter K-488, K-489, K-500, K-501, K-506 and K-507



Weight after, filter 1 - 6




Net weight, filter 1 - 6
MCGB
140.0
130.0
120.0
110.0
100.0
90.0
80.0
70.0
60.0
1:1
60.0
70.0
80.0
90.0
100.0
110.0
120.0
130.0
140.0
NILU


µg/m3
MCGB filters K-488 - K-489
450
400
350
300
250
200
150
100
50
0
1:1
0
50
100
150
200
250
300
350
400
450
NILU filters 1 - 6
µg/m3

Annex II

Monthly averages for SO_2, TSP, NO_x and NH_3, MCGB sites, for the period 1978-1990

AMBIENT AIR QUALITY IN BOMBAY
STATION :- COLABA (A1)

Units :-microgrammes/m3

JANUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	36	159	42					
1982	44	157	56					
1983	105	249	69					
1984	69	195	93					
1985	50	216	59					
1986	39	264	84	96				
1987	12	235	84	131				
1988	21	240	93	64				
1989	13	236	87	68				
1990	26	299	93	70				
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	70	283	55					
1982	35	143	33					
1983	31	142	44					
1984	73	211	77					
1985	49	218	63					
1986	13	210	71	82				
1987	12	297	60	171				
1988	21	302	68	88				
1989	16	273	74	70				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982	30	132	39					
1983	17	137	21					
1984	31	241	48					
1985	25	233	32	67				
1986	20	225	43	87				
1987	8	271	32	108				
1988	8	227	40	67				
1989	9	260	53	35				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982	9	95	11					
1983	21	133	19					
1984	9	175	37					
1985	35	205	29	52				
1986	17	154	39	96				
1987	10	240	35	90				
1988	11	225	17	54				
1989	10	174	29	67				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982	9	86	14					
1983	14	98	13					
1984	12	157	18					
1985	10	120	13	43				
1986	16	205	27	72				
1987	6	218	29	129				
1988	19	116	10	56				
1989	14	176	23	47				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982	13	89	10					
1983	15	90	12					
1984	9	91	10					
1985	6	82	11	23				
1986	8	126	32	75				
1987	6	144	20	81				
1988	6	126	20	42				
1989	6	112	18	29				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	6	91	5					
1982	6	82	6					
1983	13	119	15					
1984	9	92	11					
1985	6	113	10	37				
1986	7	151	14	64				
1987	9	89	18	20				
1988	7	133	14	33				
1989	6	88	17	27				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	6	71	6					
1982	6	74	8					
1983	10	112	15					
1984	12	118	8					
1985	6	115	9	20				
1986	7	102	20	89				
1987	6	77	17	74				
1988	6	106	10	32				
1989	6	66	14	30				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	22	83	17					
1982	7	74	14					
1983	11	105	12					
1984	17	90	29					
1985								
1986	7	115	29	82				
1987	19	81	32	52				
1988	8	62	29	22				
1989	12	95	29	25				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	48	99	35					
1982	52	128	61					
1983	19	134	30					
1984	33	131	51					
1985	27	149	27	55				
1986	6	158	30	20				
1987	6	154	35	78				
1988	12	188	69	31				
1989	13	133	42	44				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	58	105	48					
1982	49	113	58					
1983	57	227	74					
1984	57	160	62					
1985	50	219	40	110				
1986	14	284	52	178				
1987	10	242	71	68				
1988	13	215	89	24				
1989	22	178	61	78				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

DECEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	72	193	56					
1982	71	233	60					
1983	71	206	92					
1984	68	210	76					
1985	41	234	45	35				
1986	10	269	77	152				
1987	9	313	60	66				
1988	28	214	57	28				
1989	24	209	70	82				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AMBIENT AIR QUALITY IN BOMBAY

STATION :- BABULA TANK (A2)

Units :-microgrammes/m3

JANUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	112	548	49					
1981	95	328	60					
1982	11	274	39					
1983	213	360	92					
1984	109	298	95					
1985	88	323	56					
1986	56	521	68	158				
1987	66	388	92	125				
1988	26	476	90	92				
1989	27	400	94	74				
1990	20	458	101					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	70	283	55					
1982	35	143	33					
1983	31	142	44					
1984	73	211	77					
1985	49	218	63					
1986	13	210	71	82				
1987	12	297	60	171				
1988	21	302	68	88				
1989	16	273	74	70				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982	30	132	39					
1983	17	137	21					
1984	31	241	48					
1985	25	233	32	67				
1986	20	225	43	87				
1987	8	271	32	108				
1988	8	227	40	67				
1989	9	260	53	35				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982	9	95	11					
1983	21	133	19					
1984	9	175	37					
1985	35	205	29	52				
1986	17	154	39	96				
1987	10	240	35	90				
1988	11	225	17	54				
1989	10	174	29	67				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982	9	86	14					
1983	14	98	13					
1984	12	157	18					
1985	10	120	13	43				
1986	18	205	27	72				
1987	6	218	29	129				
1988	19	116	10	56				
1989	14	176	23	47				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982	13	89	10					
1983	15	90	12					
1984	9	91	10					
1985	6	82	11	23				
1986	8	126	32	75				
1987	6	144	20	81				
1988	6	126	20	42				
1989	6	112	18	29				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	6	91	5					
1982	6	82	6					
1983	13	119	15					
1984	9	92	11					
1985	6	113	10	37				
1986	7	151	14	64				
1987	9	89	18	20				
1988	7	133	14	33				
1989	6	88	17	27				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	6	71	6					
1982	6	74	8					
1983	10	112	15					
1984	12	118	8					
1985	6	115	9	20				
1986	7	102	20	89				
1987	6	77	17	74				
1988	6	106	10	32				
1989	6	66	14	30				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	22	83	17					
1982	7	74	14					
1983	11	105	12					
1984	17	90	29					
1985								
1986	7	115	29	82				
1987	19	81	32	52				
1988	8	62	29	22				
1989	12	95	29	25				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	48	99	35					
1982	52	128	61					
1983	19	134	30					
1984	33	131	51					
1985	27	149	27	55				
1986	6	158	30	20				
1987	6	154	35	78				
1988	12	188	69	31				
1989	13	133	42	44				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	58	105	48					
1982	49	113	58					
1983	57	227	74					
1984	57	160	62					
1985	50	219	40	110				
1986	14	284	52	178				
1987	10	242	71	68				
1988	13	215	89	24				
1989	22	178	61	78				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

DECEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	72	193	56					
1982	71	233	60					
1983	71	206	92					
1984	68	210	76					
1985	41	234	45	35				
1986	10	269	77	152				
1987	9	313	60	66				
1988	28	214	57	28				
1989	24	209	70	82				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AMBIENT AIR QUALITY IN BOMBAY
STATION :- WORLI-NAKA (A3)

Units :-microgrammes/m3

JANUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	119	284	49					
1982	92	213	49					
1983	135	365	51					
1984	108	374	55					
1985	109	273	5	241				
1986	65	418	65	178				
1987	38	400	77	140				
1988	40	364	106	113				
1989	27	400	102	98				
1990	73	444	119					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	77	345	44					
1982	40	250	25					
1983	79	299	31					
1984	132	324	52					
1985	61	245	84	85				
1986	37	398	52	44				
1987	19	310	64	170				
1988	41	334	95	74				
1989	12	246	67	80				
1990	45	311	87					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	66	264	29					
1982	39	303	32					
1983	38	304	25					
1984	95	305	48					
1985	72	376	76	20				
1986	22	233	40	50				
1987	16	278	49	95				
1988	37	318	58	40				
1989	10	277	57	23				
1990	35	247	53					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982	55	304	18					
1983	17	211	13					
1984	56	228	16					
1985	41	245	28	102				
1986	42	236	38	103				
1987	26	235	28	114				
1988	8	205	35	50				
1989	32	278	40	78				
1990	19	267	66					
1991	10	214	28					
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980		180	11					
1981	20	202	8					
1982	12	225	16					
1983	43	190	17					
1984	15	264	9					
1985	21	153	21	37				
1986	20	239	24	64				
1987	9	202	28	69				
1988	40	231	25	63				
1989								
1990	10	178	24					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	22	171	17					
1981	38	247	8					
1982	22	171	10					
1983	80	154	17					
1984	45	182	10					
1985	8	236	16	28				
1986	11	206	18	73				
1987	7	216	26	51				
1988	11	206	34	64				
1989								
1990	6	215	18					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	179	148	6					
1981	51	163	11					
1982	14	148	9					
1983	40	131	17					
1984	88	130	10					
1985	7	189	11	38				
1986	7	217	14	61				
1987	13	186	28	44				
1988	6	146	23	38				
1989								
1990	6	160	18					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	21	198	5					
1981	49	163	7					
1982	11	91	10					
1983	39	68	17					
1984	164	167	17					
1985	6	210	13	29				
1986	28	172	18	79				
1987	12	143	33	95				
1988	6	153	24	28				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	43	143	9					
1981	79	126	23					
1982	17	108	16					
1983	48	115	14					
1984	49	158	17					
1985	41	178	25	45				
1986	22	193	31	58				
1987	8	187	31	95				
1988	13	129	47	30				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	74	272	16					
1981	118	150	33					
1982	77	257	56					
1983	92		31					
1984	28	201	19					
1985	69	243	42	86				
1986	40	309	58	128				
1987	19	221	51	114				
1988	57	272	82	42				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	106	281	48					
1981	141	247	48					
1982	135	159	79					
1983	104	369	77					
1984	73	226						
1985	81	370	46	191				
1986	95	345	70	79				
1987	51	352	94	109				
1988	70	300	95	73				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

DECEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	176	341	48					
1981	172	336	48					
1982	92	283	79					
1983	141	372	77					
1984								
1985	47	366	46	139				
1986	53	376	70	165				
1987	47	355	94	128				
1988	53	371	95	98				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AMBIENT AIR QUALITY IN BOMBAY
STATION :- DADAR (A4)

Units :-microgrammes/m3

JANUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	44	294	29					
1981	59	245	46					
1982	45	212	47					
1983	58	333	50					
1984	65	232	73					
1985	56	327	74					
1986	50	323	67	116				
1987	21	371	69	158				
1988	22	413	97	63				
1989	34	355	70	67				
1990	33	411	88					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	46	453	30					
1981	40	317	43					
1982	40	227	40					
1983	32	262	38					
1984	55	259	61					
1985	44	290	62					
1986	34	336	68	51				
1987	14	359	45	108				
1988	27	347	68	75				
1989	31	331	64	78				
1990	39	366	94					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	51	336	32					
1981	40	217	33					
1982	28	255	41					
1983	12	221	26					
1984	63	220	56					
1985	63	283	47	23				
1986	38	315	42	72				
1987	14	294	37	104				
1988	15	322	41	58				
1989	13	267	37	46				
1990	9	202	47					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	
1978								
1979	37	241	20					
1980	44	216	18					
1981	27	211	22					
1982	16	145	21					
1983	27	158	28					
1984	21	214	31					
1985	22	200	27	40				
1986	39	253	43	157				
1987	8	205	26	720				
1988	20	285	23	75				
1989	17	258	31	74				
1990	9	176	28					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	26	243	20					
1980	20	104	11					
1981	11	125	14					
1982	17	129	16					
1983	26	112	22					
1984	12	163	21					
1985	38	173	22	178				
1986	36	373	21	20				
1987	13	231	22	86				
1988	20	180	15	62				
1989	17	238	28	30				
1990	7	161	19					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	
1978								
1979	18	195	15					
1980	21	115	22					
1981	19	137	9					
1982	18	128	12					
1983	35	136	21					
1984	55	121	20					
1985	29	139	18	50				
1986	60	190	26	48				
1987	11	190	32	55				
1988	10	146	22	38				
1989	22	1278	22	46				
1990	7	164	31					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	33	150	15					
1980	105	176	7					
1981	36	116	14					
1982	12	108	16					
1983	26	223	20					
1984	42	131	16					
1985	44	136	18	60				
1986	19	162	20	71				
1987	13	141	21	60				
1988	9	146	25	28				
1989	23	116	29	42				
1990	9	131	21					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	
1978								
1979								
1980	42	154	11					
1981	41	135	8					
1982	36	100	12					
1983	7	93	12					
1984	30	99	28					
1985	68	177	18					
1986	41	165	24	30				
1987	11	99	25	86				
1988	8	99	25	73				
1989	15	141	20	25				
1990	17	87	21	22				
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	52	128	19					
1980	45	70	11					
1981	46	101	21					
1982	19	90	24					
1983	39	121	29					
1984	35	99	32					
1985								
1986	11	125	30	78				
1987	12	157	36	100				
1988	22	87	28	26				
1989	42	97	31	41				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	
1978								
1979	58	279	27					
1980	23	191	19					
1981	65	144	33					
1982	48	227	65					
1983	33	184	40					
1984	31	193	45					
1985	44	195	32	100				
1986	34	300	48	107				
1987	17	266	52	100				
1988	26	368	55	34				
1989	48	195	45	87				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	62	169	28					
1980	68	256	31					
1981	76	161	43					
1982	34	163	46					
1983	69	229	74					
1984	61	244	65					
1985	51	298	38	161				
1986	31	298	53	101				
1987	14	276	57	71				
1988	39	378	53	29				
1989	40	291	72	195				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

DECEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	
1978								
1979	51	226	32					
1980	53	297	42					
1981	69	201	43					
1982	63	269	71					
1983	114	317	97					
1984	48	270	58					
1985	31	319	39	113				
1986	31	361	43	99				
1987	20	322	78	43				
1988								
1989	42	351	82	197				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AMBIENT AIR QUALITY IN BOMBAY
STATION :- PAREL (A5)

Units :-microgrammes/m3

JANUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	158	348	42					
1979	100	346	10					
1980	109	291	33					
1981	84	247	49					
1982	75	318	43					
1983	98	330	26					
1984	84	418	101					
1985								
1986	44	463	63	239				
1987	29	476	90	168				
1988	33	509	103	108				
1989	36	426	57	130				
1990	56	315	123					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	141	217	34					
1979	122	314	13					
1980	105	349	35					
1981	154	339	53					
1982	75	315	28					
1983	52	322	41					
1984	79	438	80					
1985								
1986	31	507	64	67				
1987	18	483	83	177				
1988	57	575	85	47				
1989	37	487	66	101				
1990	33	432	92					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	94	318	32					
1979	99	308	9					
1980	123	353	30					
1981	99	234	39					
1982	57	246	35					
1983	30	278	37					
1984	130	307	73					
1985								
1986	29	413	47	65				
1987	20	438	52	123				
1988	42	487	56	73				
1989	37	420	48	54				
1990	31	355	63					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	85	222	12					
1979	76	328	23					
1980	84	249	21					
1981	89	251	22					
1982								
1983	61	173	18					
1984	56	272	37					
1985	72	266	37	83				
1986	46	318	45	85				
1987	24	372	48	105				
1988	42	369	30	71				
1989	38	277	36	91				
1990	24	286	38					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	65	184	5					
1979	126	301	19					
1980	86	158	18					
1981	46	221	17					
1982	31	201	24					
1983	65	132	24					
1984	25	221	21					
1985	74	187	19	36				
1986	27	322	35	68				
1987	24	391	34	107				
1988	50	279	32	52				
1989	36	317	32	41				
1990	28	297	33					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	107	243	11					
1979	89	274	18					
1980	96	123	21					
1981	82	262	11					
1982	61	114	14					
1983	109	140	25					
1984	83	138	15					
1985	45	139	21	38				
1986	25	146	32	121				
1987	30	223	37	65				
1988	21	216	50	69				
1989	51	263	26	45				
1990	17	156	30					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	164	211	6					
1979	49	241	15					
1980	64	133	8					
1981	41	156	12					
1982	48	154	16					
1983	56	160	22					
1984	82	160	24					
1985	28	131	14	26				
1986	30	183	25	68				
1987	31	147	30	62				
1988	24	123	24	43				
1989	27	143	19	52				
1990	18	143	27					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	91	277	5					
1979	41	246	14					
1980	72	107	6					
1981	54	234	15					
1982	16	126	11					
1983	54	169	24					
1984	81	160	23					
1985	63	163	27	52				
1986	47	152	25	38				
1987	30	153	29	47				
1988	20	135	24	30				
1989	52	128	25	33				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	100	178	8					
1979	84	205	34					
1980	151	129	14					
1981	74	158	20					
1982	51	140	29					
1983	68	174	25					
1984	57	135	37					
1985								
1986	42	216	41	82				
1987	48	185	35	127				
1988	36	128	32	30				
1989	77	145	26	36				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	97	256	16					
1979	137	236	34					
1980	117	223	30					
1981	154	218	48					
1982	91	230	80					
1983	71	139	44					
1984	62	243	53					
1985	67	225	43	100				
1986	47	354	70	163				
1987	41	285	49	117				
1988	37	302	43	94				
1989	67	253	47	90				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	54	260	14					
1979	82	239	35					
1980	125	240	36					
1981	85	246	57					
1982	91	232	81					
1983	75	304	67					
1984								
1985	84	385	50	157				
1986	49	411	78	99				
1987	21	479	61	209				
1988	60	369	65	199				
1989	46	325	56	217				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

DECEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	67	358	12					
1979	79	367	36					
1980	144	290	62					
1981	107	177	55					
1982	84	327	94					
1983	105	366	101					
1984								
1985	74	405	68	316				
1986	29	426	104	290				
1987	29	450	90	249				
1988	47	387	69	186				
1989	40	441	70	202				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AMBIENT AIR QUALITY IN BOMBAY
STATION :- SEWREE (A6)

Units :-microgrammes/m3

JANUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	45	280	40					
1982	47	179	41					
1983	83	278	54					
1984	44	255	50					
1985	71	255	42	75				
1986	52	276	52	162				
1987	21	256	55	156				
1988	25	327	84	82				
1989	36	260	62	57				
1990	30	326	71					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	83	429	55					
1982	42	202	23					
1983	46	212	28					
1984	65	296	49					
1985	102	311	56	71				
1986	58	258	50	124				
1987	18	296	55	156				
1988	63	290	84	82				
1989	29	360	57	57				
1990	24	260	71					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	69	226	34					
1982	46	234	35					
1983	33	179	26					
1984	64	254	40					
1985	93	217	32	49				
1986	63	321	45	149				
1987	20	253	29	111				
1988	51	247	43	46				
1989	21	221	55	51				
1990	38	240	41					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	49	244	22					
1982	33	136	11					
1983	50	168	19					
1984	43	223	22					
1985	112	142	24	65				
1986	60	220	32	120				
1987	22	356	35	110				
1988	52	301	36	73				
1989	33	221	36	69				
1990	26	217	30					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	56	140	21					
1981	40	161	13					
1982	36	122	13					
1983	28	127	9					
1984	21	183	12					
1985	106	197	16	30				
1986	49	216	19	75				
1987	21	228	22	110				
1988	48	176	15	58				
1989	37	251	23	53				
1990	14	92	15					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	50	125	11					
1981	56	129	9					
1982	42	85	8					
1983	46	117	13					
1984	22	104	8					
1985	13	133	10	25				
1986	37	160	26	86				
1987	18	152	22	69				
1988	13	117	12	65				
1989	10	160	11	67				
1990	22	127	17					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	110	178	9					
1981	33	115	13					
1982	36	76	8					
1983	13	107	13					
1984	57	101	11					
1985	29	130	13	102				
1986	49	171	22	89				
1987	26	123	16	43				
1988	18	104	19	30				
1989	27	96	21	62				
1990	20	126	16					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	115	255	8					
1981	28	111	11					
1982	24	107	13					
1983	39	125	16					
1984	56	142	10					
1985	39	175	12	45				
1986	73	133	25	88				
1987	25	132	22	82				
1988	25	89	20	32				
1989	40	98	27	43				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	79	160	10					
1981	28	87	18					
1982	15	94	16					
1983	20	95	13					
1984	42	112	17					
1985								
1986	46	120	33	87				
1987	24	91	18	100				
1988	21	83	19	22				
1989	39	137	22	49				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	76	294	20					
1981	47	116	26					
1982	66	93	38					
1983	23	106	20					
1984	36	200	32					
1985	23	130	19	126				
1986	20	179	38	62				
1987	25	187	27	117				
1988	28	174	36	42				
1989	40	188	50	84				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	76	263	26					
1981	59	171	26					
1982	36	110	33					
1983	37	136	42					
1984	41	199	44					
1985	62	257	44	229				
1986	20	247	47	147				
1987	14	186	41	155				
1988	43	174	40	67				
1989	29	176	38	106				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

DECEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	50	267	36					
1981	60	190	41					
1982	58	161	46					
1983	54	251	51					
1984	58	254	42					
1985	49	285	30	109				
1986	26	266	64	245				
1987	16	208	40	81				
1988	33	259	69	57				
1989	24	236	59	94				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AMBIENT AIR QUALITY IN BOMBAY
STATION :- SION (A7)

Units :-microgrammes/m3

JANUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	49	303	48					
1982	34	354	39					
1983	82	342	51					
1984	48	304	69					
1985	83	374	137	83				
1986	41	363	65	97				
1987	33	412	74	123				
1988	32	428	128	87				
1989								
1990	43	527	127					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	71	421	50					
1982	44	236	31					
1983	47	249	43					
1984	49	308	55					
1985	50	365	80	72				
1986	33	352	63	65				
1987	18	432	77	100				
1988	23	360	88	70				
1989								
1990	26	522	121					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	50	275	40					
1982	34	331	23					
1983	29	229	38					
1984	63	301	50					
1985	46	267	49	50				
1986	33	363	40	50				
1987	10	365	51	89				
1988	14	417	63	45				
1989								
1990	12	300	77					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	32	277	25					
1982	16	189	17					
1983	29	146	22					
1984	21	302	26					
1985	38	234	39	119				
1986	27	279	34	89				
1987	9	283	40	73				
1988	24	349	42	62				
1989								
1990	11	284	65					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	11	182	14					
1982	18	193	15					
1983	17	122	14					
1984	9	165	20					
1985	30	273	19	20				
1986	22	245	26	47				
1987	14	291	39	49				
1988	23	249	42	56				
1989								
1990	11	249	30					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	26	100	31					
1981	12	310	10					
1982	13	318	10					
1983	31	129	13					
1984	24	134	12					
1985	16	103	25	22				
1986	22	196	28	64				
1987	8	151	28	64				
1988	7	197	29	79				
1989								
1990	7	201	32					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	12	171	9					
1981	16	235	15					
1982	13	103	10					
1983	15	89	17					
1984	20	101	14					
1985	10	251	17	20				
1986	8	206	20	66				
1987	8	163	30	86				
1988								
1989								
1990	7	173	25					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	17	127	9					
1981	11	102	11					
1982	8	105	11					
1983	15	107	20					
1984	33	148	20					
1985	48	163	28	20				
1986	12	145	19	98				
1987	7	124	25	86				
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	24	98	10					
1981	31	115	21					
1982	19	135	24					
1983	20	87	20					
1984	24	122	27					
1985								
1986	17	185	39	64				
1987	7	182	45	92				
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	50	253	20					
1981	71	178	35					
1982	61	213	53					
1983	41	211	33					
1984	34	214	50					
1985	48	281	41	54				
1986	31	278	52	102				
1987	18	299	63	89				
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	65	283	32					
1981	72	214	44					
1982	66	219	54					
1983	66	198	47					
1984	56	269	61					
1985	76	362	57	230				
1986	53	324	62	94				
1987	15	264	83	90				
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

DECEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	65	317	52					
1981	73	264	43					
1982	81	262	69					
1983	66	358	66					
1984	41							
1985	21	489	80	98				
1986		336	62	110				
1987	30	290	62	53				
1988								
1989		405	81	54				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AMBIENT AIR QUALITY IN BOMBAY
STATION :- SANTACRUZ (A9)

Units :-microgrammes/m3

JANUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	34	181	23					
1979	28	261	8					
1980	46	297	27					
1981	44	241	43					
1982	53	233	39					
1983	37	224	26					
1984	49	309	49					
1985	41	267	44					
1986	26	271	38	50				
1987	32	350	49	92				
1988	21	424	87	89				
1989	8	339	58	76				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	52	206	23					
1979	28	183	9					
1980	44	348	21					
1981	52	304	34					
1982	33	191	26					
1983	24	270	23					
1984	51	250	35					
1985	26	266	35					
1986	18	278	24	35				
1987	11	351	53	13				
1988	14	375	78	77				
1989	8	267	44	30				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	25	226	40					
1979	24	205	14					
1980	29	258	17					
1981	30	189	23					
1982	39	203	26					
1983	9	194	11					
1984	47	237	30					
1985	31	301	53	58				
1986	16	357	26	136				
1987	6	326	28	26				
1988	7	403	22	39				
1989	7	381	31	53				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	29	164	5					
1979	14	173	11					
1980	14	215	9					
1981	20	158	12					
1982	8	144	10					
1983	9	164	10					
1984	16	183	12					
1985	27	241	16	72				
1986	18	243	24	75				
1987	6	294	25	128				
1988	13	334	18	108				
1989	6	293	24	81				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	18	129	5					
1979	16	163	8					
1980	10	12	9					
1981	7	129	6					
1982	7	137	7					
1983	7	91	9					
1984	8	132	7					
1985	12	145	8	44				
1986	18	172	24	117				
1987	6	227	17	64				
1988	18	246	8	88				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	35	134	9					
1979	8	456	6					
1980	10	112	9					
1981	7	137	5					
1982	9	94	10					
1983	11	127	11					
1984	10	119	6					
1985	7	128	7	29				
1986	22	211	24	83				
1987	6	166	25	68				
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	15	135	6					
1979	6	133	6					
1980	6	108	5					
1981	6	113	5					
1982	7	61	7					
1983	10	136	9					
1984	9	119	7					
1985	7	129	8	41				
1986	6	190	9	20				
1987	8	160	8	49				
1988	6	138	6	45				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	8	118	6					
1979	7	149	6					
1980	8	168	5					
1981	6	64	5					
1982	7	84	7					
1983	16	101	24					
1984	18	125	5					
1985	8	156	9	29				
1986								
1987	6	120	11	64				
1988	6	144	20	20				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	30	86	6					
1979	16	136	8					
1980	18	78	7					
1981	22	82	14					
1982	19	88	20					
1983	15	45	27					
1984	15	105	17					
1985								
1986								
1987	8	151	20	64				
1988	7	89	11	27				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	36	189	11					
1979	34	170	15					
1980	44	153	15					
1981	57	124	29					
1982	27	182	42					
1983	39	243	31					
1984	12	196	14					
1985	36	222	31	50				
1986								
1987	22	270	47	69				
1988	10	287	49	20				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	42	235	14					
1979	46	154	24					
1980	48	164	23					
1981	62	140	36					
1982	26	128	42					
1983	51	267	35					
1984	49	226	40					
1985	48	356	38	122				
1986	36	337	62	64				
1987	8	254	46	49				
1988	45	322	66	27				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

DECEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	39	265	8					
1979	49	206	23					
1980	49	204	45					
1981	46	228	38					
1982	64	215	60					
1983	89	355	59					
1984	49	280	52					
1985	44	411	51	34				
1986	40	356	64	234				
1987	24	352	80	71				
1988	18	355	60	50				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AMBIENT AIR QUALITY IN BOMBAY

STATION :- ANDHERI (A10)

Units :-microgrammes/m^3

JANUARY

YEAR	SO_2	SPM	NO_x	NH_3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY

YEAR	SO_2	SPM	NO_x	NH_3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH

YEAR	SO_2	SPM	NO_x	NH_3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL

YEAR	SO_2	SPM	NO_x	NH_3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY

YEAR	SO_2	SPM	NO_x	NH_3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE

YEAR	SO_2	SPM	NO_x	NH_3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

DECEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AMBIENT AIR QUALITY IN BOMBAY
STATION :- SAKINAKA (A11)

Units :-microgrammes/m3

JANUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	69	387	22					
1981	61	233	29					
1982	73	233	36					
1983	89	385	41					
1984	118	298	59					
1985	60	314	33					
1986								
1987	25	438	30	156				
1988	19	380	37	106				
1989	26	393	63	28				
1990	33	487	55					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	41	352	14					
1981	67	358	34					
1982	17	228	44					
1983	58	320	31					
1984								
1985	32	266	19					
1986	32	384	37	55				
1987	16	341	30	115				
1988	30	365	43	78				
1989	22	389	42	29				
1990	23	353	43					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	23	285	12					
1981	48	266	21					
1982	58	337	24					
1983	21	311	16					
1984								
1985	25	351	37	41				
1986	37	384	27	53				
1987	13	465	28	103				
1988	20	340	31	46				
1989	14	366	48	39				
1990	12	323	28					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	31	229	20					
1980	43	262	17					
1981	37	325	18					
1982	36	163	22					
1983	46	244	26					
1984								
1985	34	244	16	133				
1986	43	346	28	91				
1987	7	308	22	79				
1988	22	430	32	53				
1989	15	356	38	72				
1990	8	328	28					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	17	251	16					
1980	28	153	11					
1981	17	200	8					
1982	14	230	18					
1983	33	159	17					
1984								
1985	20	229	11	31				
1986	25	257	18	69				
1987	20	234	24	31				
1988	18	241	25	56				
1989	15	308	26	20				
1990	9	212	17					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	14	140	15					
1980	43	119	16					
1981	55	145	8					
1982	28	114	8					
1983	27	182	11					
1984								
1985								
1986	17	147	21	67				
1987	7	161	25	41				
1988	9	172	30	62				
1989	8	208	26	37				
1990	6	174	21					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	30	133	15					
1980	6	110	6					
1981	19	134	10					
1982	34	107	17					
1983	12	86	14					
1984								
1985								
1986	8	170	14	59				
1987	7	148	21	46				
1988	8	126	28	25				
1989	6	127	15	58				
1990	6	152	24					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	25	167	10					
1980	27	121	7					
1981	9	124	7					
1982	12	106	9					
1983	19	151	19					
1984	17	166	12					
1985								
1986	23	129	16	53				
1987	7	108	29	88				
1988	6	176	19	29				
1989	6	128	27	38				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	67	94	20					
1980	52	91	9					
1981	55	105	14					
1982	38	143	24					
1983	27	121	25					
1984	18	125	18					
1985								
1986	43	180	28	52				
1987	9	154	15	81				
1988	10	130	28	28				
1989	27	182	27	55				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	69	209	18					
1980	73	185	12					
1981	95	146	17					
1982	81	210	62					
1983	39	162	23					
1984	65	41	33					
1985								
1986	49	329	33	104				
1987	22	266	31	53				
1988	28	241	43	26				
1989	31	200	32	57				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	82	198	18					
1980	67	180	20					
1981	99	173	37					
1982	121	223	41					
1983	67	221	33					
1984	59	262	30					
1985								
1986	30	303	30	71				
1987	23	280	31	55				
1988	51	295	53	34				
1989	24	292	39	44				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

DECEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	65	311	23					
1980	91	237	27					
1981	102	230	23					
1982	110	340	51					
1983	76	316	39					
1984	36	267	26					
1985	50	332	18	66				
1986	38	384	25	92				
1987	48	447	39	71				
1988	29	349	48	50				
1989	29	416	51	51				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AMBIENT AIR QUALITY IN BOMBAY
STATION :- GHATKOPAR (A13)

Units :-microgrammes/m3

JANUARY								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	72	304	11					
1980	100	452	27					
1981	96	246	35					
1982	102	216	30					
1983	140	286	52					
1984	78	400	56					
1985	33	349	53					
1986	75	460	51	66				
1987	52	436	69	156				
1988	32	445	63	86				
1989	40	364	59	57				
1990	38	498	58					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	71	288	8					
1980	67	327	30					
1981	137	300	49					
1982	46	281	22					
1983	67	253	32					
1984	69	391	41					
1985	57	339	31					
1986	35	433	48	48				
1987	52	505	47	131				
1988	34	359	40	86				
1989	39	471	64	73				
1990	37	488	70					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	75	355	8					
1980	73	416	28					
1981	54	243	21					
1982	49	269	22					
1983	56	290	39					
1984	46	372	36					
1985	105	311	45					
1986	46	428	45	66				
1987	21	438	26	135				
1988	47	225	40	39				
1989	19	437	37	60				
1990	10	329	65					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	38	279	12					
1980	60	277	19					
1981	48	365	22					
1982	24	217	15					
1983	31	196	21					
1984	10	280	27					
1985								
1986	44	407	35	136				
1987	7	312	29	142				
1988	27	491	23	67				
1989	19	343	30	84				
1990	11	339	26					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	15	322	16					
1980	45	183	12					
1981	10	191	14					
1982	19	140	16					
1983	29	181	13					
1984	12	267	23					
1985								
1986	32	343	25	73				
1987	7	266	20	111				
1988	21	265	23	59				
1989	25	312	33	60				
1990	7	216	19					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	15	140	16					
1980	29	129	14					
1981	9	163	7					
1982	18	101	8					
1983	22	107	14					
1984	12	121	12					
1985								
1986	13	172	17	82				
1987	6	122	18	134				
1988	7	223	71	108				
1989	13	366	17	56				
1990	6	153	25					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	11	143	12					
1980	9	116	8					
1981	9	82	9					
1982	14	105	9					
1983	11	110	18					
1984	7	98	13					
1985								
1986	6	211	14	51				
1987	6	130	17	50				
1988	6	104	20	53				
1989	9	128	21	55				
1990	6	117	11					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	10	178	10					
1980	32	78	8					
1981	7	88	7					
1982	6	79	18					
1983	17	160	22					
1984	14	112	13					
1985								
1986	26	148	26	63				
1987	8	98	22	69				
1988	6	122	14	21				
1989	7	97	22	32				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	40	325	9					
1979	78	184	16					
1980	60	97	10					
1981	51	101	17					
1982	19	112	17					
1983	16	97	22					
1984	19	141	20					
1985								
1986	37	135	38	57				
1987	9	167	18	67				
1988	11	113	28	22				
1989	28	145	29	33				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	34	211	10					
1979	100	211	21					
1980	64	209	17					
1981	84	131	22					
1982	83	215	51					
1983	81		31					
1984	19	162	24					
1985								
1986	33	308	39	46				
1987	15	237	34	90				
1988	64	294	53	25				
1989	82	255	37	55				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	35	245	10					
1979	106	154	27					
1980	83	207	22					
1981	81	154	31					
1982	92	218	45					
1983	73	345	51					
1984	48	203	33					
1985								
1986								
1987	27	276	41	45				
1988	88	334	67	23				
1989	61	323	59	66				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

DECEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	60	295	8					
1979	91	249	32					
1980	99	259	36					
1981	100	218	18					
1982	125	315	55					
1983	102	287	60					
1984	73	311	41					
1985	47	431	48	166				
1986	68	408	55	177				
1987	43	337	48	43				
1988	59	397	64	53				
1989	51	398	58	61				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AMBIENT AIR QUALITY IN BOMBAY
STATION :- BHANDUP (A14)

Units :-microgrammes/m3

JANUARY

YEAR	SO_2	SPM	NO_x	NH_3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY

YEAR	SO_2	SPM	NO_x	NH_3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH

YEAR	SO_2	SPM	NO_x	NH_3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL

YEAR	SO_2	SPM	NO_x	NH_3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY

YEAR	SO_2	SPM	NO_x	NH_3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE

YEAR	SO_2	SPM	NO_x	NH_3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

DECEMBER								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AMBIENT AIR QUALITY IN BOMBAY
STATION :- MULUND (A15)

Units :-microgrammes/m3

JANUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	96	267	31					
1982	92	252	26					
1983	136	290	30					
1984	125	387	61					
1985	52	334	25					
1986	41	385	29	80				
1987	32	405	43	96				
1988	41	361	31	76				
1989	58	363	57	85				
1990	55	432	39					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	143	399	35					
1982	99	281	23					
1983	94	332	30					
1984	73	319	33					
1985	21	361	16					
1986	27	382	29	50				
1987	24	382	22	87				
1988	34	382	31	83				
1989	47	389	58	83				
1990	45	357	39					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	83	248	26					
1982	53	252	18					
1983	44	317	28					
1984	31	320	20					
1985	125	345	30	20				
1986	36	341	30	93				
1987	11	345	24	165				
1988	29	331	20	53				
1989	15	306	35	35				
1990	19	309	46					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	47	361	14					
1982	25	175	24					
1983	17	223	14					
1984	14	266	21					
1985	100	231	19	154				
1986	33	297	20	69				
1987	23	371	17	118				
1988	26	339	16	62				
1989	16	214	20	47				
1990	11	259	28					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980								
1981	20	170	11					
1982	33	178	16					
1983	15	176	10					
1984								
1985	28	202	10	20				
1986	14	269	16	49				
1987	16	218	20	138				
1988	26	209	9	73				
1989	34	280	21	61				
1990	8	183	13					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	27	78	12					
1981	10	140	6					
1982	20	89	6					
1983	10	138	12					
1984	16	122	9					
1985	17	155	9	20				
1986	22	165	12	56				
1987	9	122	15	38				
1988	8	130	16	41				
1989	6	129	24	20				
1990		134	14					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	7	150	8					
1981	10	83	5					
1982								
1983	8	143	9					
1984	6	10	9					
1985	7	5	7	65				
1986	8	100	8	54				
1987	9	166	16	70				
1988	6	112	8	40				
1989	10	110	21	52				
1990	6	105	19					
1991		152						
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	29	102	7					
1981	13	75	6					
1982	8	82	9					
1983	16	105	26					
1984	12	125	9					
1985	9	141	9	39				
1986	9	135	11	54				
1987	8	90	16	60				
1988	9	113	15	28				
1989	8	112	15	45				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	62	116	10					
1981	48	96	10					
1982	42	150	19					
1983	9	86	19					
1984	14	133	13					
1985								
1986	11	161	19	51				
1987	19	195	18	89				
1988	16	85	19	21				
1989	22	112	30	29				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	125	196	16					
1981	116	102	15					
1982	139	225	50					
1983	44	104	31					
1984	20	231	27					
1985	55	198	18	20				
1986	28	289	21	93				
1987	29	264	32	70				
1988	46	190	36	25				
1989	31	179	32	33				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	122	216	24					
1981	103	160	30					
1982	181	221	49					
1983	69	270	37					
1984	49	266	24					
1985	69	379	16	34				
1986	36	347	30	59				
1987	22	305	29	61				
1988	70	332	47	21				
1989	49	232	35	29				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

DECEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979								
1980	129	302	38					
1981	112	186	30					
1982	122	259	41					
1983	98	298	52					
1984	49	310	18					
1985	98	442	22	23				
1986	39	374	33	139				
1987	32	336	32	41				
1988	49	339	55	45				
1989	68	311	41	44				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AMBIENT AIR QUALITY IN BOMBAY
STATION :- BORIVALI (A16)

Units :-microgrammes/m3

JANUARY								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	9	214	4					
1980	8	271	21					
1981	7	230	21					
1982	12	205	23					
1983	31	283	24					
1984	16	288	34					
1985	13	341	32					
1986	8	348	23	90				
1987	8	320	39	103				
1988	7	440	38	68				
1989	6	374	61	73				
1990	10	503	68					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	7	226	5					
1980	7	278	19					
1981	8	285	20					
1982	13	244	20					
1983	13	276	18					
1984								
1985	8	298	27					
1986	8	373	31	57				
1987	7	352	40	138				
1988	11	408	42	57				
1989	9	310	32	42				
1990	8	381	36					
1991	11							
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	8	208	5					
1980	14	283	15					
1981	9	244	18					
1982	10	240	25					
1983	11	180	14					
1984	13	216	19					
1985	13	282	27	46				
1986	13	431	28	67				
1987	8	287	15	67				
1988	11	295	18	45				
1989	8	256	22	69				
1990	7	314	27					
1991								

APRIL								
YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	6	140						
1980	18	257	13					
1981	9	238	9					
1982	9	164	12					
1983	12	182	12					
1984	10	179	11					
1985	10	218	13	136				
1986	22	331	17	110				
1987	6	225	13	47				
1988	14	351	8	67				
1989	7	224	16	52				
1990	6	255	25					

AMBIENT AIR QUALITY IN BOMBAY

STATION :- TILAKNAGAR (A17)

Units :-microgrammes/m3

JANUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	63	271	28					
1979	38	420	9					
1980	56	404	34					
1981	43	356	44					
1982	47	198	35					
1983	63	356	58					
1984	81	417	83					
1985	55	444	60					
1986	49	585	56	125				
1987	37	533	78	105				
1988	28	571	82	74				
1989	34	426	68	104				
1990	74	440	97					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	59	254	26					
1979	50	458	9					
1980	53	488	42					
1981	94	539	68					
1982	54	308	49					
1983	64	235	34					
1984	58	367	55					
1985	61	478	65	214				
1986	37	512	51	124				
1987	22	608	63	100				
1988	32	541	78	77				
1989	32	316	66	99				
1990	45	362	77					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	32	238	23					
1979	30	398	11					
1980	35	432	30					
1981	43	325	45					
1982	51	300	46					
1983	41	282	34					
1984	79	348	39					
1985								
1986	51	428	48	160				
1987	16	529	43	122				
1988	31	513	49	64				
1989	17	443	40	66				
1990	35	295	54					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	45	273	14					
1979	31	289	22					
1980	37	368	27					
1981	41	292	36					
1982								
1983	32	274	34					
1984	54	283	49					
1985	35	360	36	123				
1986	40	329	33	98				
1987	11	389	45	168				
1988	21	396	24	87				
1989								
1990	22	250	27					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	54	265	10					
1979	33	311	28					
1980	15	193	21					
1981	15	220	20					
1982	26	275	23					
1983	36	194	22					
1984	16	309	24					
1985	26	193	26	130				
1986	27	294	28					
1987	13	416	27	69				
1988	27	332	20	85				
1989				62				
1990	14	193	19					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	61	184	13					
1979	22	231	12					
1980	52	99	15					
1981	9	156	14					
1982	18	138	9					
1983	19	132	18					
1984	15	128	24					
1985	11	151	22	33				
1986	26	199	36	131				
1987	9	232	43	155				
1988	6	230	37	96				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	94	207	9					
1979	12	196	14					
1980	11	105	12					
1981	10	74	7					
1982	27	100	13					
1983	16	347	31					
1984	17	67	16					
1985	10	161	17	47				
1986	10	206	25	89				
1987	7	167	32	123				
1988	6	146	45	63				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	25	198	4					
1979	49	201	14					
1980	31	116	11					
1981	6	104	9					
1982	8	109	10					
1983	19	124	23					
1984	44	208	29					
1985	18	146	21	59				
1986	8	128	22	64				
1987	7	154	29	171				
1988	7	151	24	26				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	25	173	12					
1979	55	224	22					
1980	55	134	12					
1981	20	116	19					
1982	20	131	30					
1983	22	87	18					
1984	27	187	30					
1985	51							
1986	30	265	37	57				
1987	9	260	33	124				
1988	13	139	48	51				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	30	235	12					
1979	48	214	25					
1980	51	259	23					
1981	40	219	33					
1982	61	279	78					
1983	40	348	32					
1984	61	256	65					
1985	51	208	27	66				
1986	44	467	62	112				
1987	17	368	48	101				
1988	36	422	55	30				
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	26	297	12					
1979	29	240	18					
1980	51	306	29					
1981	94	155	34					
1982	45	283	66					
1983	71	263	69					
1984	86	367	61					
1985	58	494	50	177				
1986	51	425	60	112				
1987	16	421	58	86				
1988	50	460	60	27				

DECEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	28	345	5					
1979	29	216	22					
1980	59	302	49					
1981	59	219	28					
1982	33	434	62					
1983	87	412	66					
1984	56	387	49					
1985	52	466	35	93				
1986	54	457	56	74				
1987	48	392	57	41				
1988	40	474	88	52				

AMBIENT AIR QUALITY IN BOMBAY
STATION :- CHEMBUR NAKA (A18)

Units :-microgrammes/m3

JANUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	42	322	52					
1980	71	348	28					
1981	52	274	38					
1982	62	255	48					
1983	71	334	44					
1984	62	324	54					
1985	47	358	50	20				
1986	22	434	40	95				
1987	15	388	35	83				
1988	23	368	65	79				
1989	28	435	82	64				
1990	62	504	94					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	64	277	52					
1980	60	368	28					
1981	92	416	38					
1982	71	230	48					
1983	51	315	44					
1984	48	311	54					
1985	33	328	50	20				
1986	21	374	40	95				
1987	16	377	35	83				
1988	39	389	65	79				
1989	51	461	82	64				
1990	29	455	94					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	43	347	8					
1980	48	237	26					
1981	61	269	43					
1982	27	227	26					
1983	36	281	37					
1984	61	291	41					
1985	41	315	43	90				
1986	29	406	49	116				
1987	9	396	27	64				
1988	23	296	50	50				
1989	19	370	65	60				
1990	21	333	69					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	29	185	23					
1980	37	193	19					
1981	19	241	23					
1982	18	170	25					
1983	26	217	28					
1984	22	242	35					
1985	33	225	34	115				
1986	22	273	31	118				
1987	12	358	43	113				
1988	34	329	49	254				
1989	22	292	47	95				
1990	9	300	44					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	9	190	16					
1980	16	142	12					
1981	9	199	18					
1982	25	166	30					
1983	24	171	26					
1984	12	197	23					
1985	52	200	31	119				
1986	24	240	38	82				
1987	17	293	244	113				
1988	20	214	23	53				
1989	18	249	34	107				
1990	9	233	29					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	13	146	18					
1980	49	114	19					
1981	15	128	11					
1982	27	130	17					
1983	30	178	26					
1984	31	163	27					
1985	11	151	38	71				
1986	14	147	34	94				
1987	6	155	25	95				
1988	15	191	53	227				
1989	7	264	57	689				
1990	7	170	42					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	13	116	18					
1980	14	151	8					
1981	9	98	9					
1982	19	113	28					
1983	20	140	34					
1984	29	149	23					
1985	7	143	31	51				
1986	7	223	32	85				
1987	10	125	33	247				
1988	12	115	32	162				
1989	8	116	35	134				
1990	6	185	33					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978								
1979	29	226	16					
1980	39	126	12					
1981	11	401	12					
1982	7	117	13					
1983	11	203	31					
1984	41	183	26					
1985	9	169	29	55				
1986	8	144	24	61				
1987	8	111	19	177				
1988	13	146	39	34				
1989	9	134	31	129				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	26	201	8					
1979	53	189	19					
1980	52	96	11					
1981	40	102	19					
1982	27	124	24					
1983	8	198	27					
1984	39	150	32					
1985	24	156	27	54				
1986	12	163	33	56				
1987	10	152	27	65				
1988	9	132	47	128				
1989	25	134	39	83				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	22	212	7					
1979	63	145	23					
1980	66	230	18					
1981	58	123	30					
1982	58	187	49					
1983	26	216	30					
1984	32	184	39					
1985	28	233	31	25				
1986	22	369	64	154				
1987	16	259	49	133				
1988	33	261	62	48				
1989	45	207	51	46				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	21		9					
1979	45	95	26					
1980	68	218	24					
1981	43	130	36					
1982	70	210	45					
1983	36	340	42					
1984	40	277	38					
1985	37	361	33	105				
1986	17	299	37	124				
1987	23	258	48	77				
1988	43	261	52	35				
1989	27	306	61	65				
1990								
1991								
1992								

DECEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	36		9					
1979	56	414	27					
1980	81	236	36					
1981	99	232	32					
1982	68	258	51					
1983	76	299	65					
1984	58	336	43					
1985	36	431	31	64				
1986	23	40	40	199				
1987	23	4227	49	82				
1988	37	369	71	44				
1989	27	323	60	61				
1990								
1991								

AMBIENT AIR QUALITY IN BOMBAY
STATION :- ANIKNAGAR (A20)

Units :-microgrammes/m3

JANUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	65	176	24					
1979	47	206	5					
1980	36	154	16					
1981	25	160	18					
1982	43	135	19					
1983								
1984	26	263	61					
1985	37	332	59	152				
1986	27	238	59	327				
1987	19	327	51	192				
1988	47	360	89	176				
1989								
1990	27	409	55					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

FEBRUARY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	81	237	4					
1979	40	132	9					
1980	53	249	21					
1981	39	308	23					
1982	24	171	11					
1983								
1984	23	391	43					
1985	33	304	55					
1986	30	352	42	156				
1987	22	318	59	320				
1988	62	287	61	120				
1989	39	348	63	205				
1990	40	3220	72					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MARCH

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	27	190	18					
1979	30	182	5					
1980	30	220	16					
1981	43	164	22					
1982	86	169	18					
1983								
1984	65	261	45					
1985								
1986	41	387	39	200				
1987	14	290	37	208				
1988	39	493	37	160				
1989	18	306	38	274				
1990	23	231	53					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

APRIL

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	48	179	10					
1979	27	166	15					
1980	30	223	15					
1981	31	183	11					
1982								
1983								
1984	13	258	25					
1985	46	272	38	141				
1986	40	297	46	154				
1987	17	345	23	145				
1988	32	267	19	140				
1989	22	236	41	181				
1990	24	256	32					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

MAY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	43	145	8					
1979	43	205	17					
1980	18	159	18					
1981	28	126	14					
1982								
1983								
1984	14	133	26					
1985	34	193	24	84				
1986	27	332	28	102				
1987	9	202	28	265				
1988	23	194	19	137				
1989	18	257	27	115				
1990	9	90	18					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JUNE

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	105	233	11					
1979	42	186	10					
1980	68	156	11					
1981								
1982								
1983								
1984	29	154	17					
1985	19	95	28	95				
1986	22	144	24	111				
1987	36	181	21	20				
1988	52	173	32	113				
1989	37	229	16	46				
1990	20	125	21					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

JULY

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	92	273	7					
1979	20	324	16					
1980	43	127	15					
1981	14	47	6					
1982	22	122	6					
1983								
1984	38	121	27					
1985	20	126	22	49				
1986	11	134	22	72				
1987	15	119	20	90				
1988	33	97	27	51				
1989	19	75	20	157				
1990	27	141	27					
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

AUGUST

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	29	219	8					
1979	28	320	13					
1980	37	115	13					
1981	12	143	7					
1982	9	100	15					
1983	38	112	23					
1984	34	115	27					
1985	26	112	20	45				
1986	15	113	19	84				
1987	26	104	26	82				
1988	15	136	21	34				
1989	17	73	24	55				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

SEPTEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	34	157	9					
1979	25	127	11					
1980	58	104	10					
1981	23	74	8					
1982	24	121	36					
1983	19	66	26					
1984	41	134	32					
1985								
1986	17	125	26	104				
1987	16	190	31	199				
1988	14	93	17	35				
1989	38	110	26	67				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

OCTOBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	32	230	8					
1979	33	141	12					
1980	43	144	12					
1981	16	56	9					
1982	40	162	58					
1983	40	225	48					
1984	35	224	43					
1985	38	284	35	54				
1986	38	245	53	175				
1987	67	171	20	119				
1988	28	171	35	42				
1989	60	206	46	145				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

NOVEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	25	173	9					
1979	29	101	9					
1980	32	129	14					
1981	12	83	9					
1982								
1983	35		50					
1984	25	213	34					
1985	31	290	30	131				
1986	23	249	34	154				
1987	22	229	44	103				
1988	51	270	54	23				
1989	31	233	45	128				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

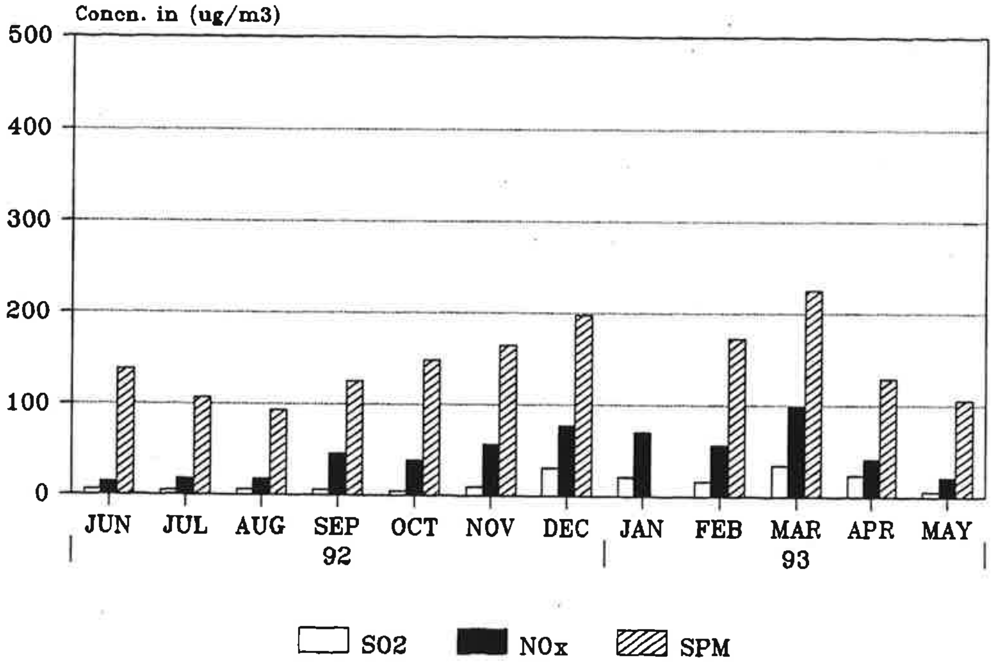
DECEMBER

YEAR	SO2	SPM	NOx	NH3	RELATIVE HUMIDITY	TEMP.	WIND DIRECTION	WIND SPEED
1978	30	181	7					
1979	34	128	14					
1980	66	155	24					
1981	19	115	13					
1982								
1983	56	277	64					
1984	75	253	46					
1985	46	333	39	123				
1986	29	266	53	196				
1987	29	240	38	92				
1988	34	256	49	33				
1989	26	315	54	34				
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								

Annex III

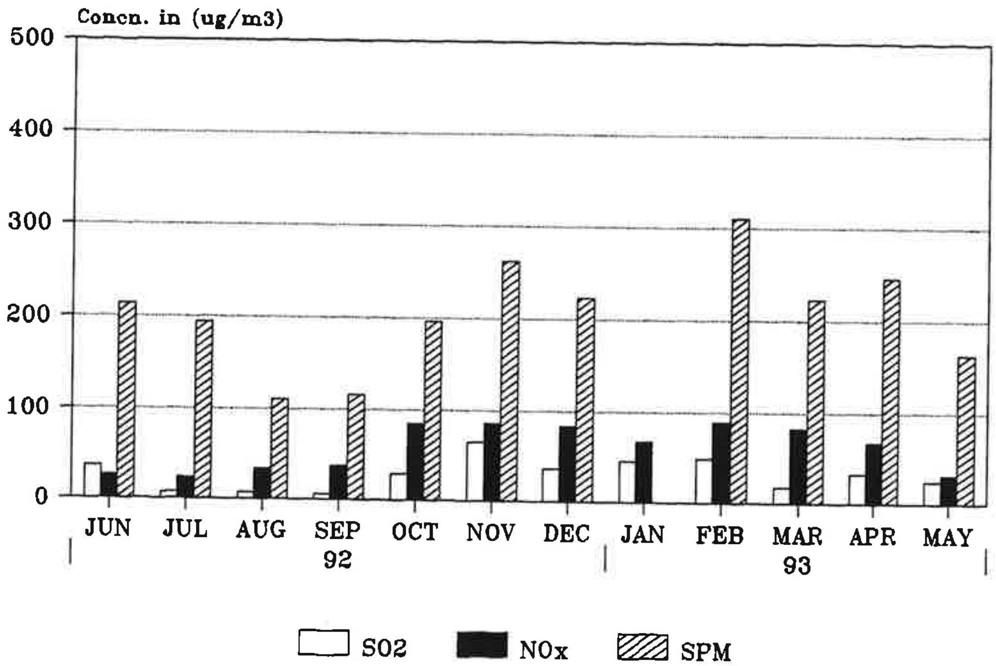
Monthly average SO_2, NO_x and TSP at MCGB and GEMS (NEERI) stations, for the URBAIR period June 1992-May 1993

AMBIENT AIR QUALITY DATA - COLABA
MONITORING AGENCY: M.C.G.B.



All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA - WORLI NAKA
MONITORING AGENCY: M.C.G.B.



All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA – PAREL
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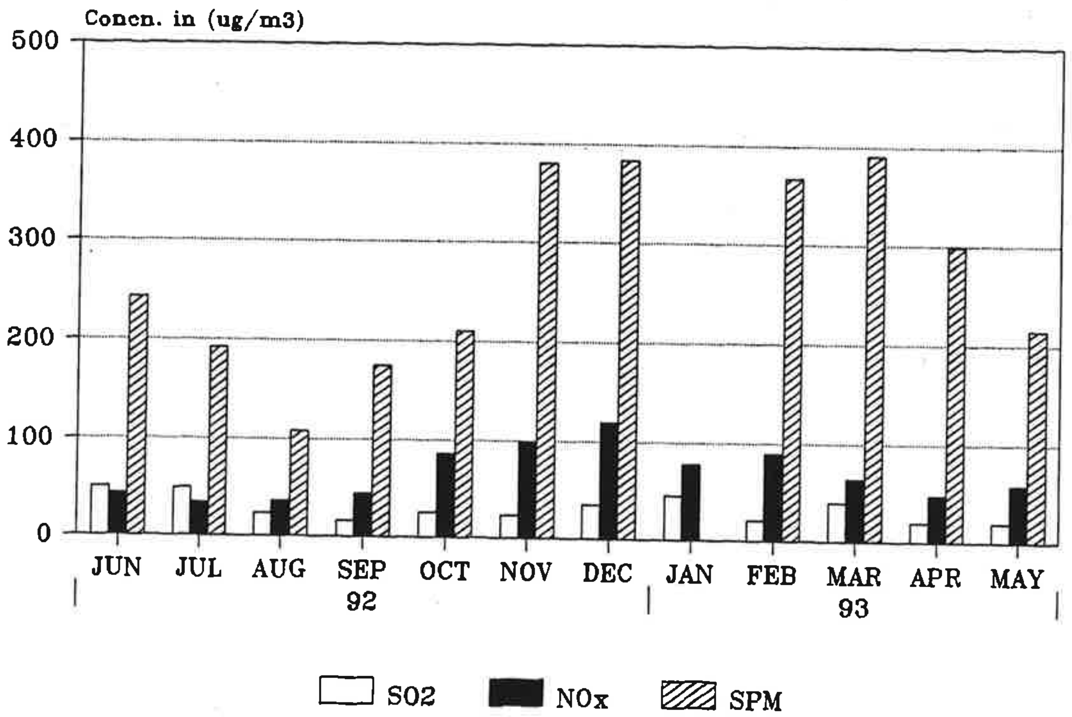
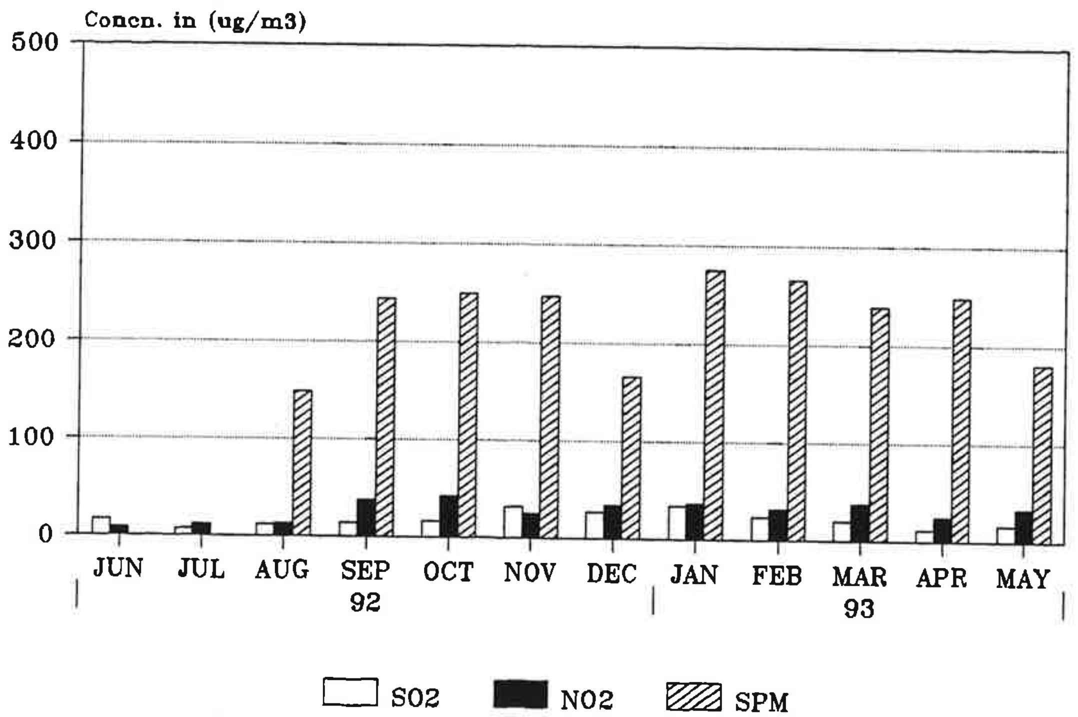


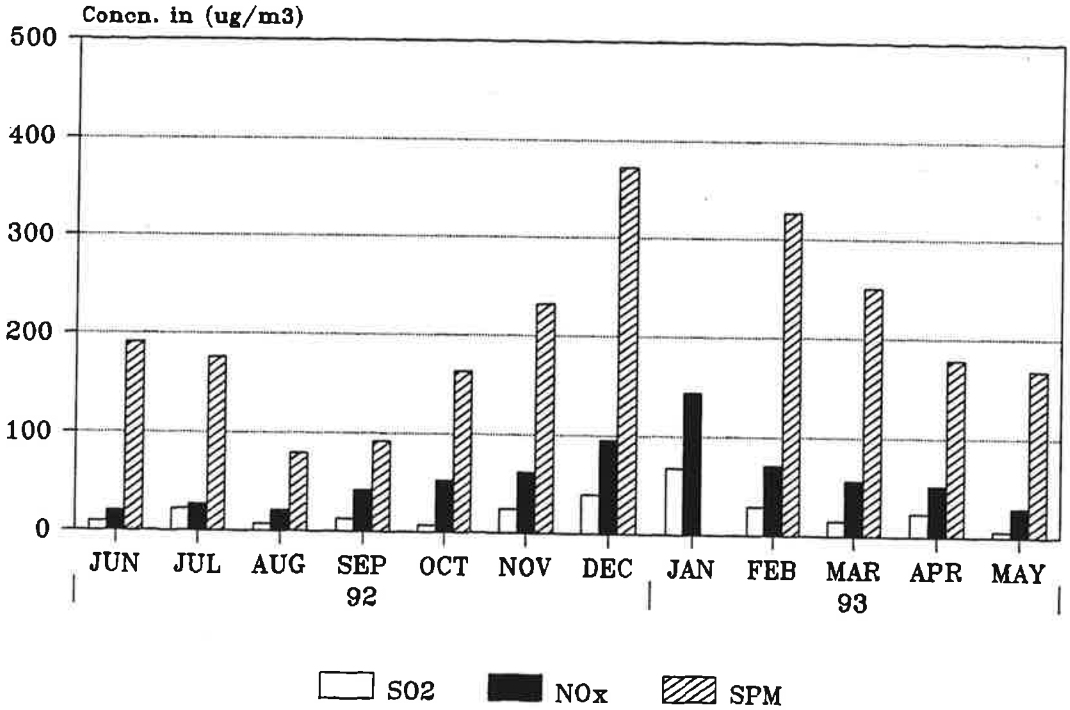
All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA – PAREL
MONITORING AGENCY: NEERI (GEMS)



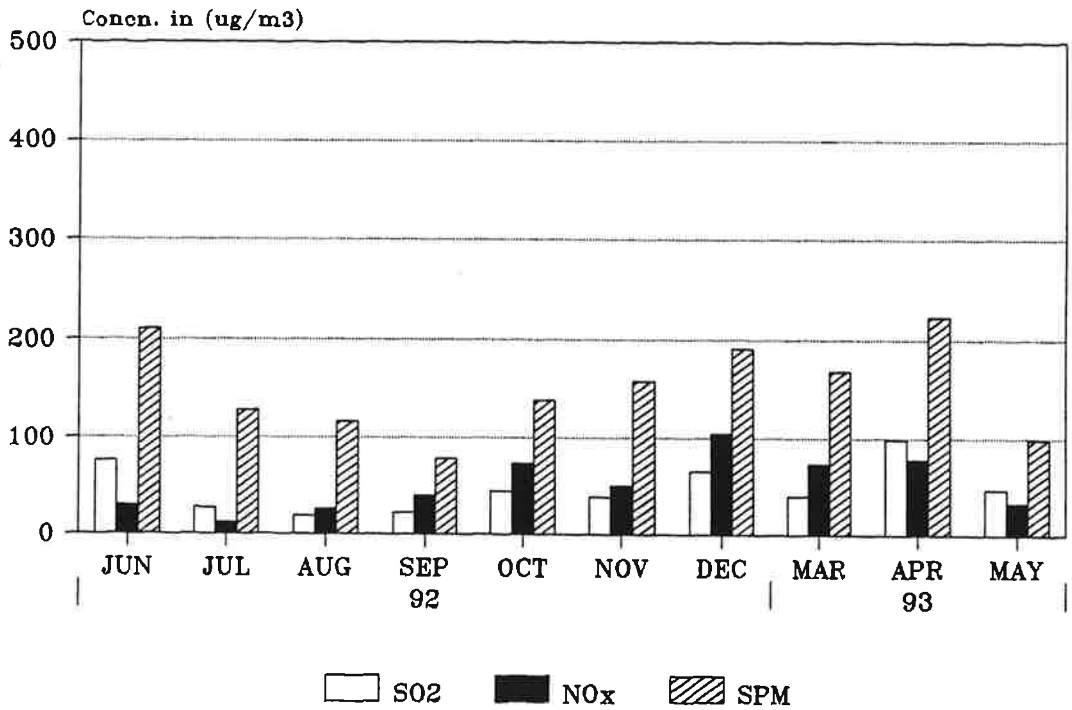
All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA – DADAR
MONITORING AGENCY: M.C.G.B.



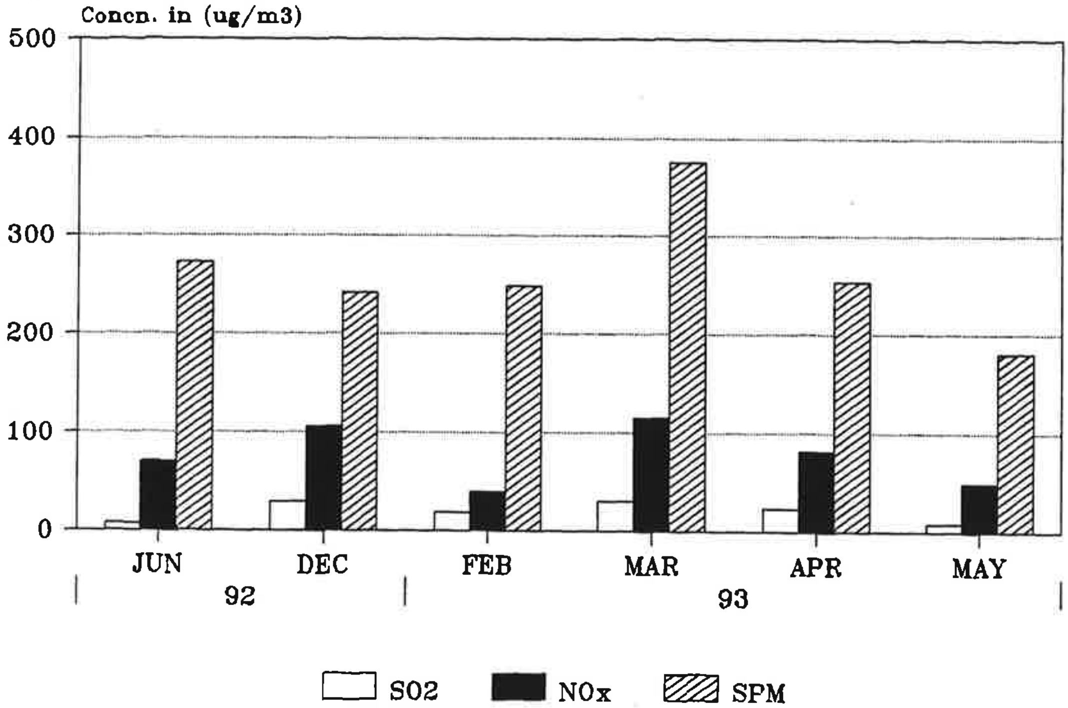
All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA – SEWREE
MONITORING AGENCY: M.C.G.B.



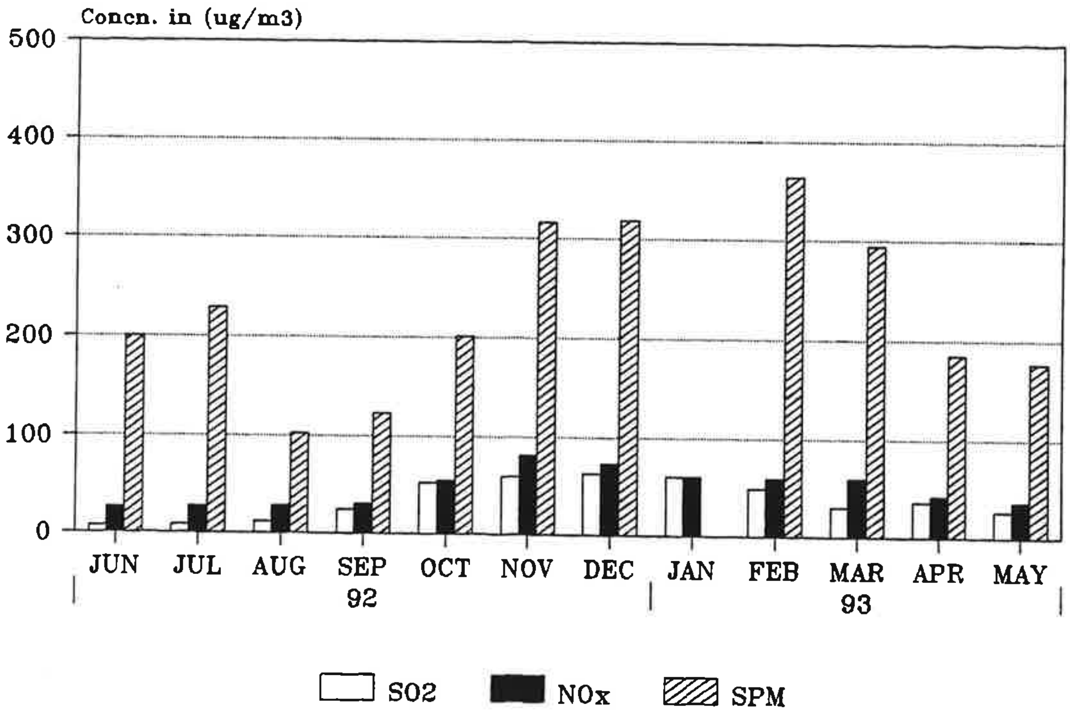
All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA – SION
MONITORING AGENCY: M.C.G.B.



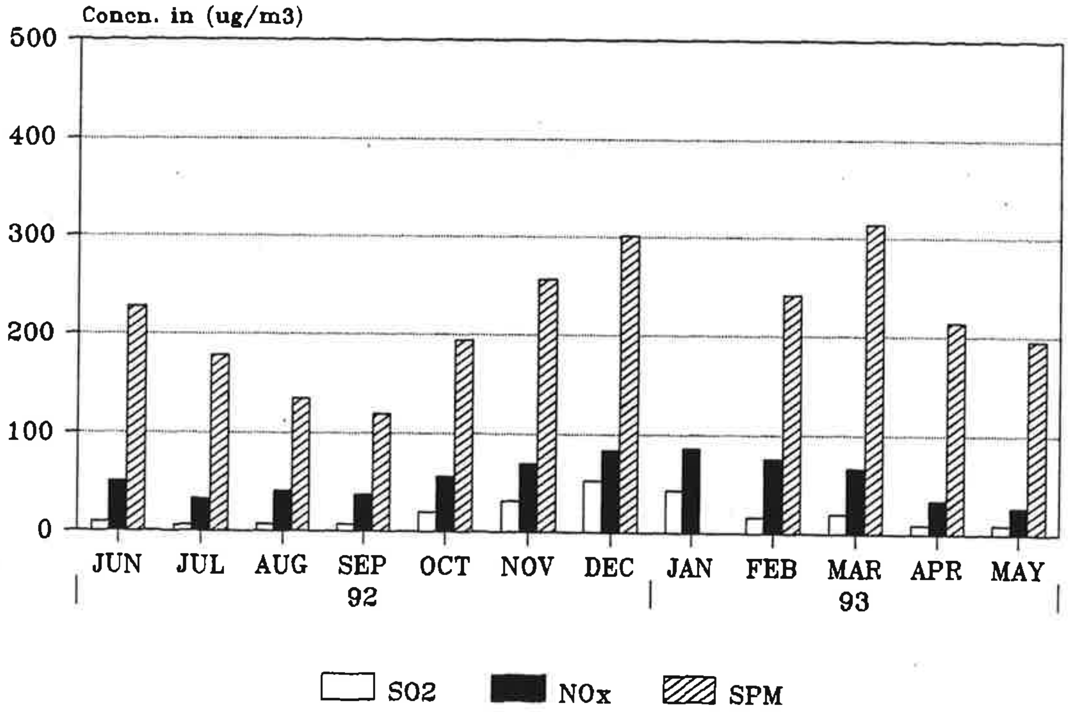
All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA – ANDHERI
MONITORING AGENCY: M.C.G.B.



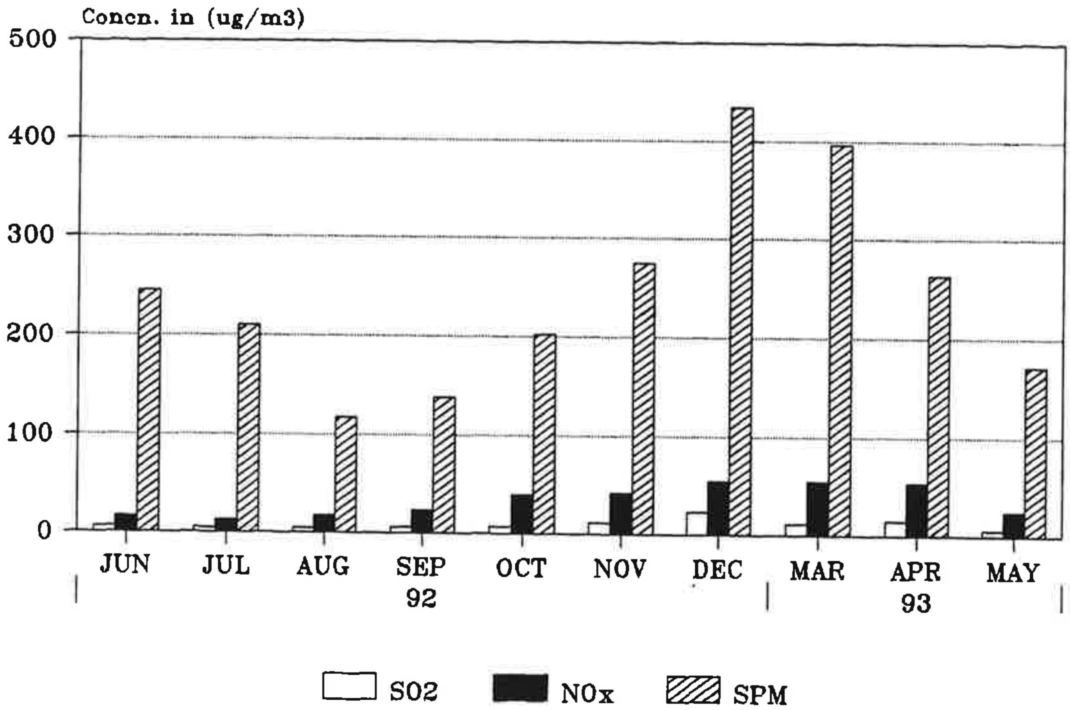
All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA – SAKI NAKA
MONITORING AGENCY: M.C.G.B.



All values in Microgram/cu.m.

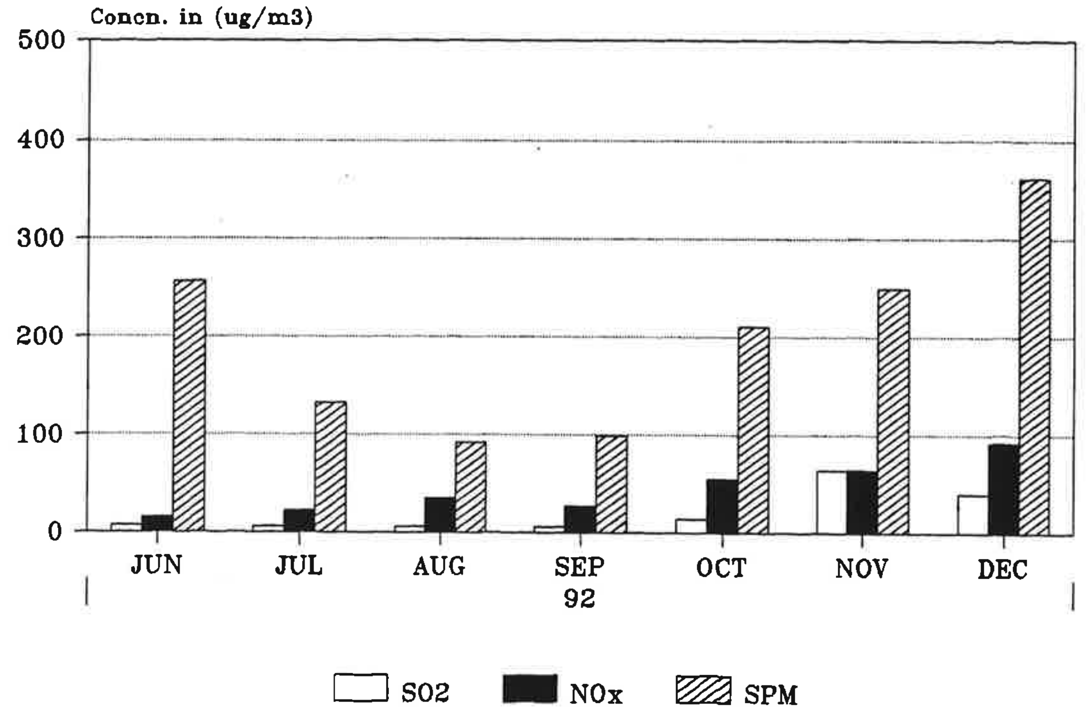
AMBIENT AIR QUALITY DATA – JOGESHWARI
MONITORING AGENCY: M.C.G.B.



All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA – GHATKOPAR

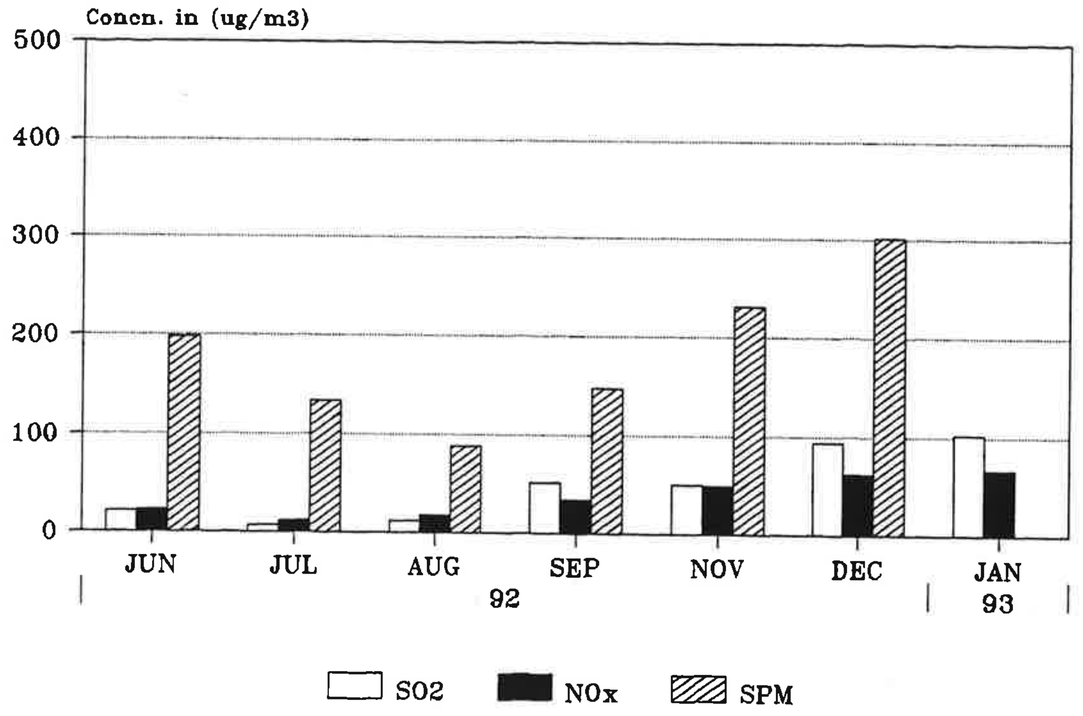
MONITORING AGENCY: M.C.G.B.



All values in Microgram/cu.m.

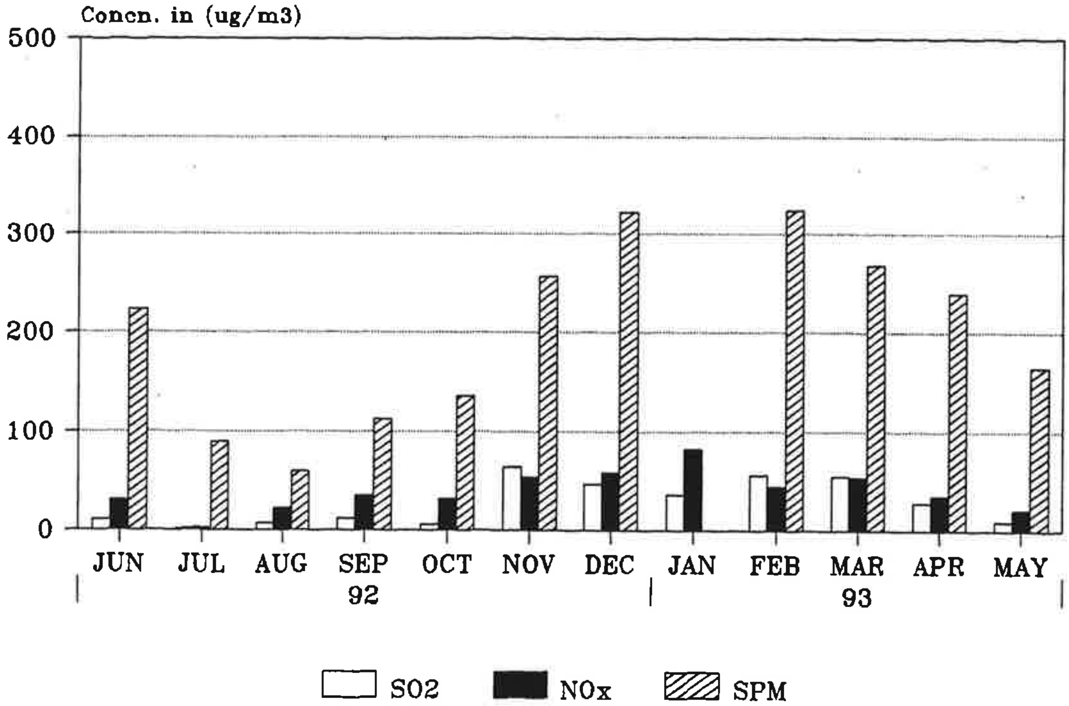
AMBIENT AIR QUALITY DATA – BHANDUP

MONITORING AGENCY: M.C.G.B.



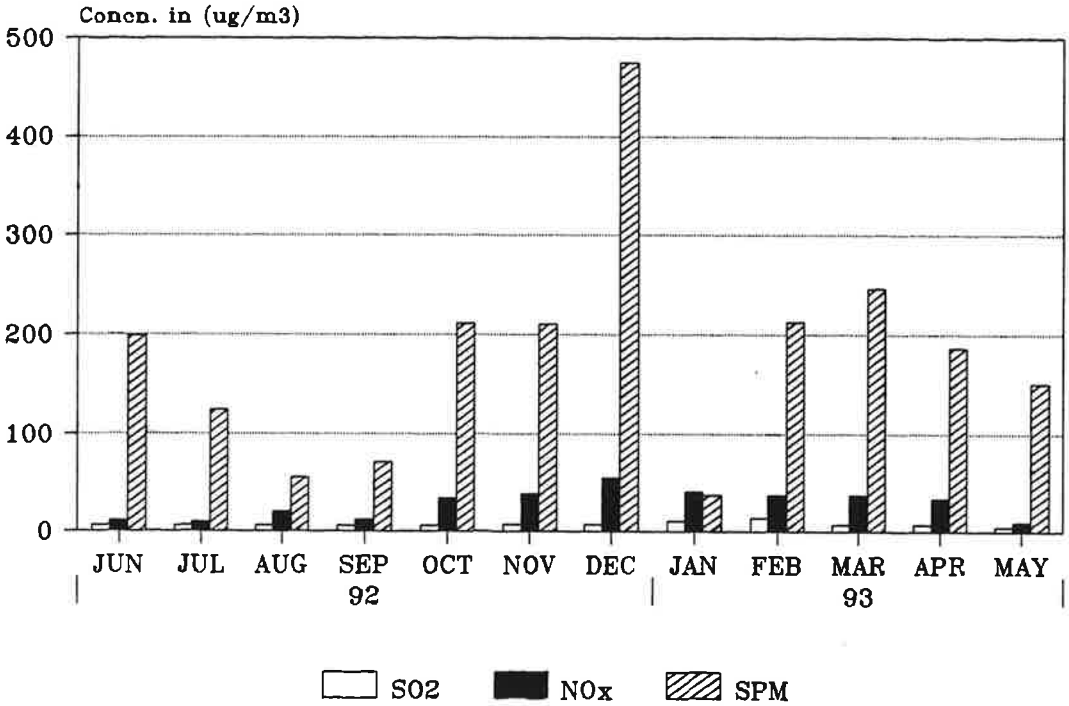
All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA – MULUND
MONITORING AGENCY: M.C.G.B.



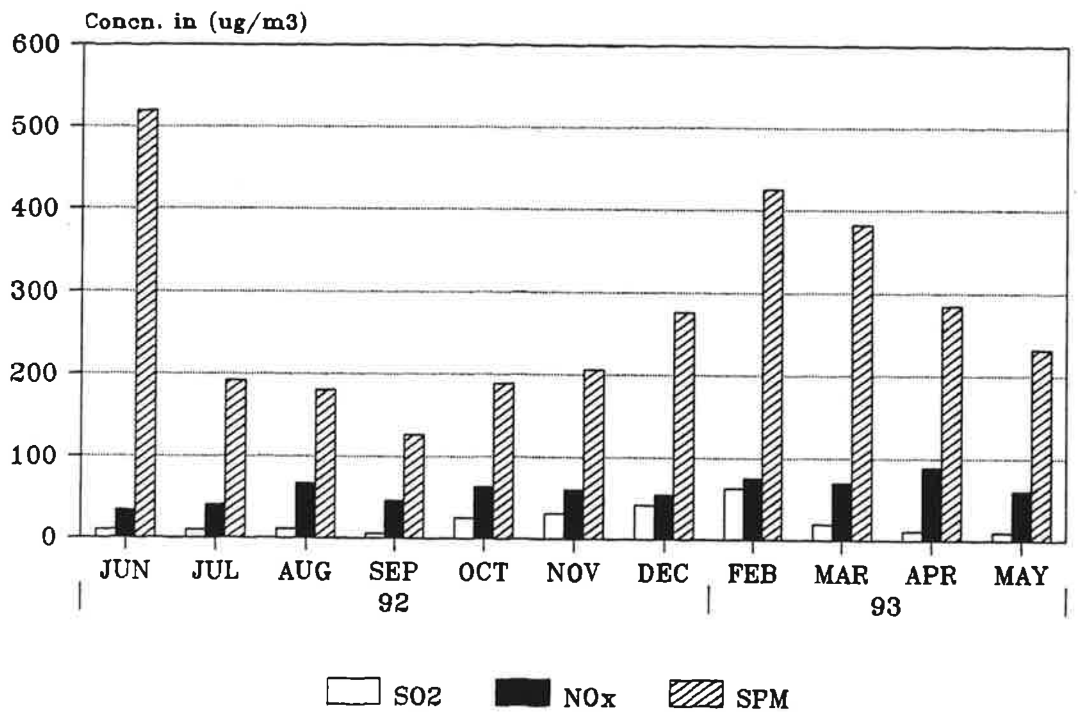
All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA – BORIVALI
MONITORING AGENCY: M.C.G.B.



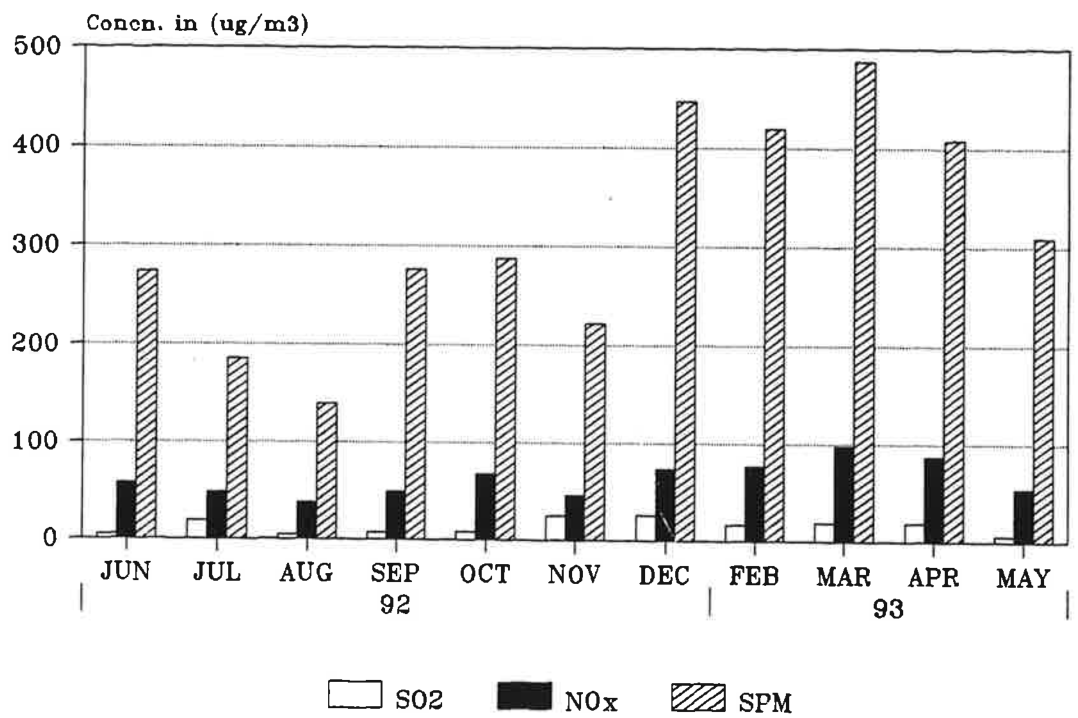
All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA - CHEMBUR NAKA
MONITORING AGENCY: M.C.G.B.



All values in Microgram/cu.m.

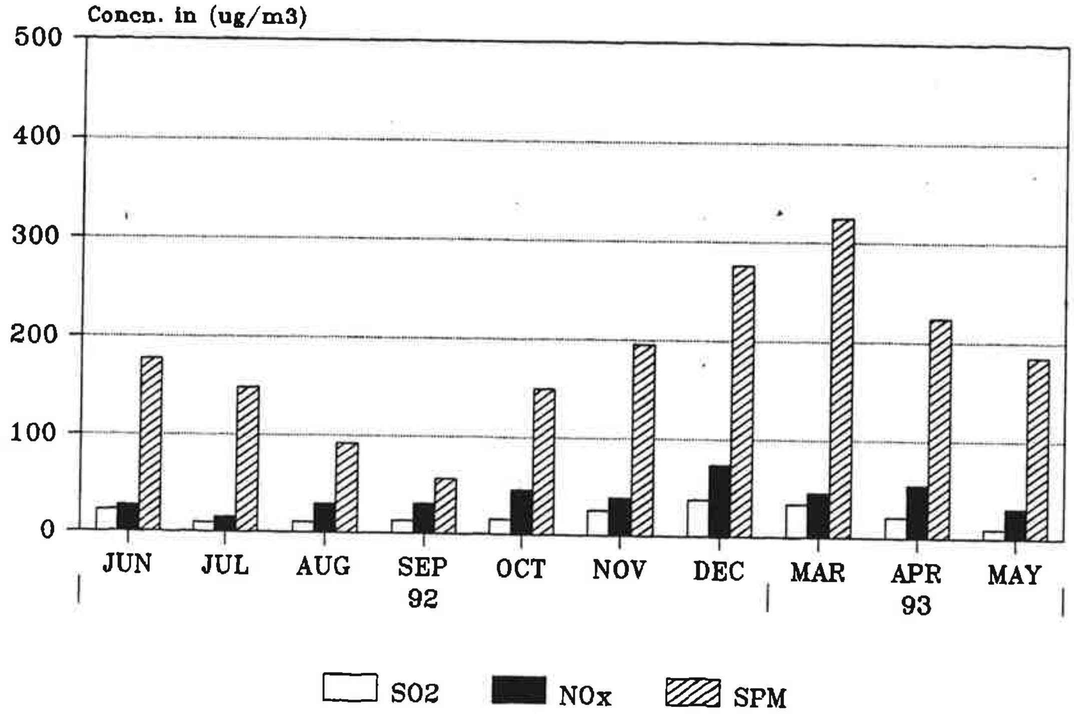
AMBIENT AIR QUALITY DATA - MARAVALI
MONITORING AGENCY: M.C.G.B.



All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA – ANIKNAGAR

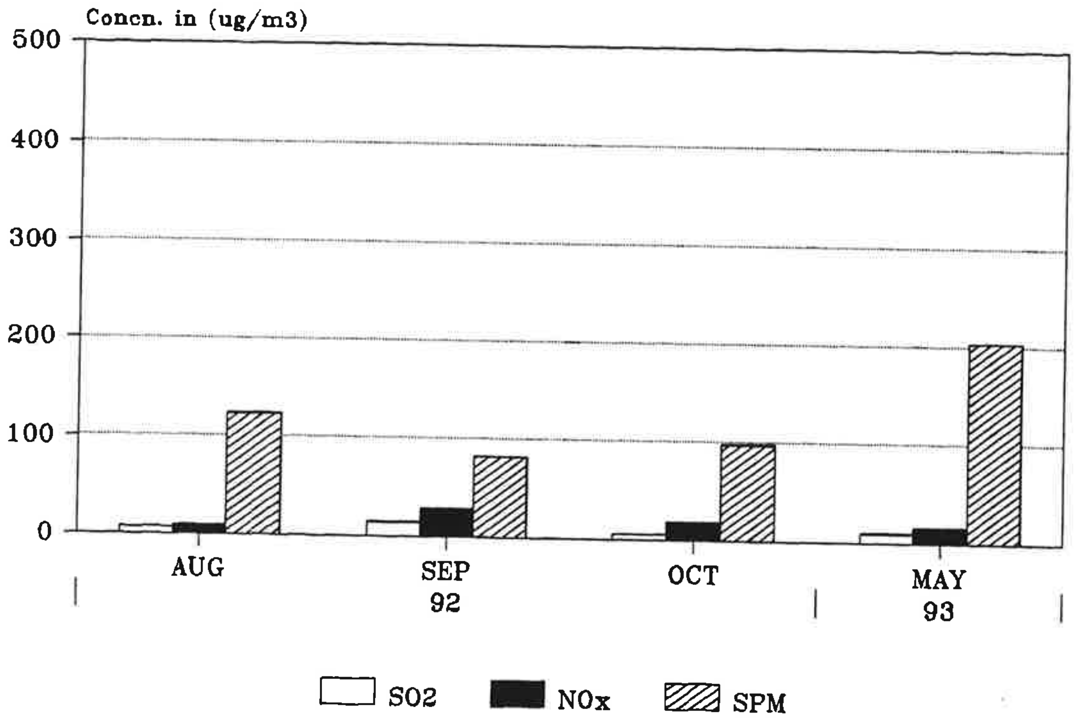
MONITORING AGENCY: M.C.G.B.



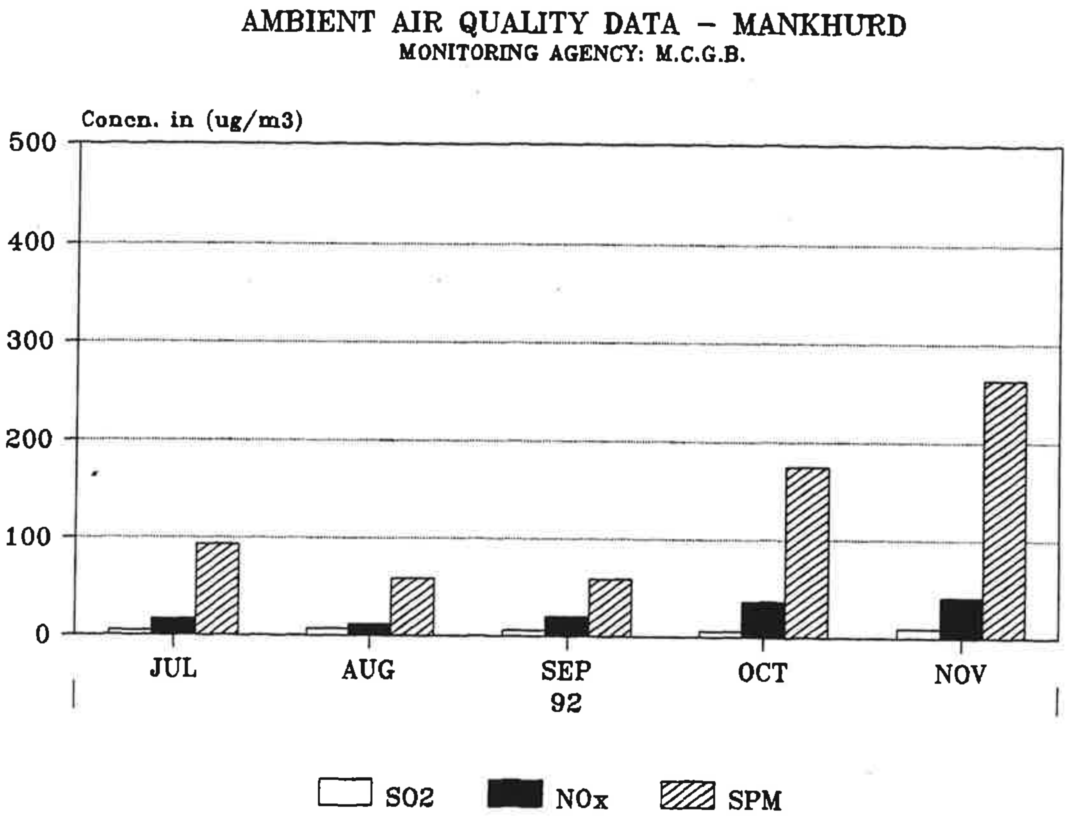
All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA – MAHUL

MONITORING AGENCY: M.C.G.B.

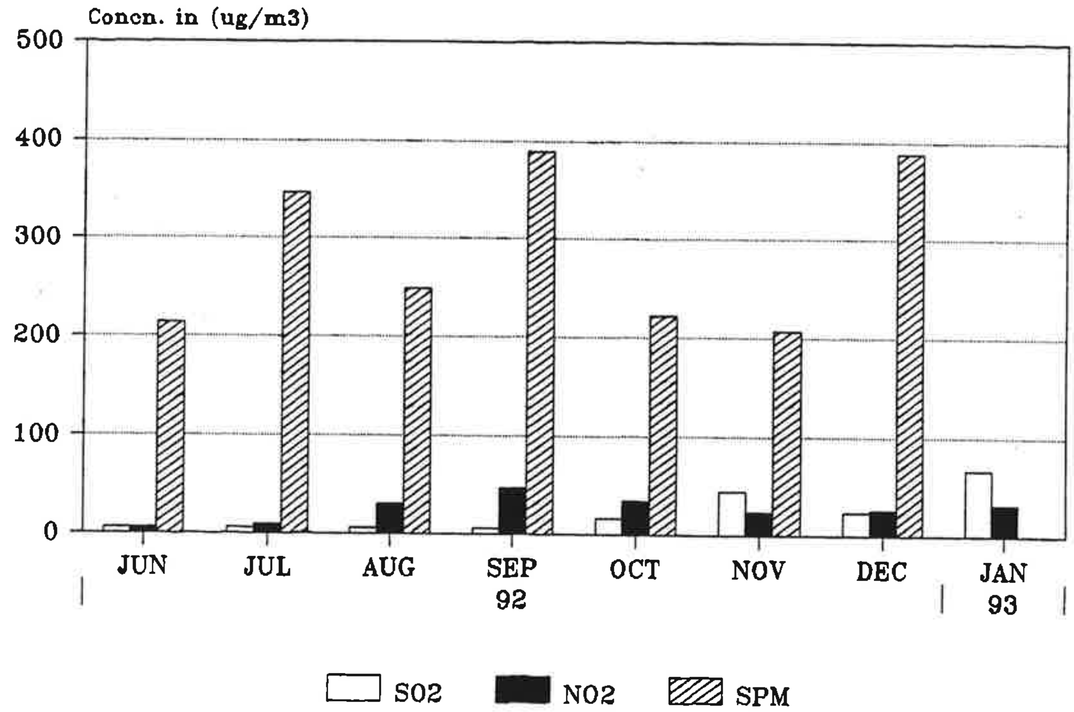


All values in Microgram/cu.m.



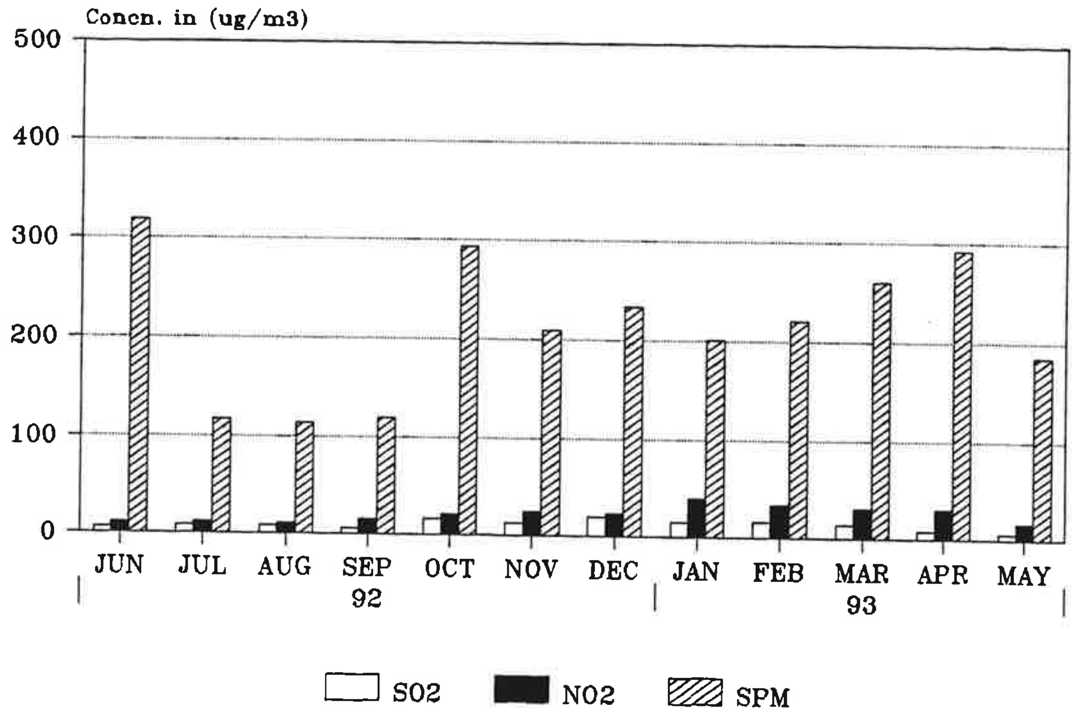
All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA – BANDRA
MONITORING AGENCY: NEERI



All values in Microgram/cu.m.

AMBIENT AIR QUALITY DATA – KALBADEVI
MONITORING AGENCY: NEERI



All values in Microgram/cu.m.

Appendix 2

Air Quality Guidelines

Air Quality Guidelines

National Ambient Air Quality Standards in India

These were established in 1994, and are given in Table 1 below.

Table 1: Nationa Ambient Air Quality Standards.

Pollutants	Time weighted average	Concentration in ambient air			Method of measurements
		Industrial area	Residental, Rural and other areas	Sensitive of Area	
Sulphur Dioxide SO_2	Annual average* 24 hours**	80 µg/m^3 120 µg/m^3	60 µg/m^3 80 µg/m^3	15 µg/m^3 30 µg/m^3	1. Improved West and Geake method 2. Ultraviolet fluorescence
Oxides of Nitrogen as NO_2	Annual average* 24 hours*	80 µg/m^3 120 µg/m^3	60 µg/m^3 80 µg/m^3	15 µg/m^3 30 µg/m^3	1. Jacob & Hochheiser modified (Na-Arsenite) Method 2. Gas Phase Chemiluminescence
Suspended Particulate Matter (SPM)	Annual average* 24 hours**	360 µg/m^3 500 µg/m^3	140 µg/m^3 200 µg/m^3	70 µg/m^3 100 µg/m^3	High Volume sampling, (Average flow rate not less than 1.1 m^3/minute)
Respirable matter (size less than 10 µm) (PM_{10})	Annual average* 24 hours**	120 µg/m^3 150 µg/m^3	60 µg/m^3 100 µg/m^3	50 µg/m^3 75 µg/m^3	Respirable particulate matter sampler
Lead (Pb)	Annual average* 24 hours**	1.0 µg/m^3 1.5 µg/m^3	0.75 µg/m^3 1.00 µg/m^3	0.50 µg/m^3 0.75 µg/m^3	ASS method after sampling using PM 2000 or equivalent Filter paper
Carbon Monoxide (CO)	8 hours** 1 hour	5.0 mg/m^3 10.0 mg/m^3	2.0 mg/m^3 4.0 mg/m^3	1.0 mg/m^3 2.0 mg/m^3	Non dispersive infrared spectroscopy

* Annual Arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform interval.

** 24 hourly/8 hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.

NOTE:

1. National Abient Air Quality Standard: The levels of air quality with an adequate margin of safety, to protect the public health, vegetation and property.
2. Whenevery and whenever two consecutive values exceed the limit specified above for the respective category, it would be considered adequate reason to institute regular/continuous monitoring and further investigations.
3. The State Government/State Board shall notify the sensitive and other areas in the respective states within a period of six months from the date of Notification of National Ambient Standards.

The Indian Standards differentiate between Industrial, Residential and Sensitive areas. Bombay is considered an Industrial area.

The Indian Standards for industrial areas are less restrictive than the WHO guidelines (see below) for SO_2 annual average, and especially for TSP and PM_{10} (the WHO recommended guideline for PM_{10} is 70 µg/m³, as 24 hour average). For NO_2, the Indian standards are stricter than WHO.

WHO Air Quality Guidelines and Standards

WHO air quality guidelines and standards are listed in Table 2.

Table 2: WHO Air Quality Guidelines/Standards (WHO, 1977a, 1977b, 1978, 1979, 1987)

Parameter		10 minute s	15 minutes	30 minute s	1 hour	8 hours	24 hours	1 year	Year of standard
SO_2	µg/m³	500			350		125[a]	50[a]	1987
SO_2	µg/m³						100-150	40-60	1979
BS[b]	µg/m³						125[a]	50[a]	1987
BS[b]	µg/m³						100-150	40-60	1979
TSP	µg/m³						120[a]		1987
TSP	µg/m³						150-230	60-90	1979
PM_{10}	µg/m³						70[a]		1987
Lead	µg/m³							0.5-1	1987, 1977b
CO	mg/m³		100	60	30	10			1987
NO_2	µg/m³				400		150		1987
NO_2	µg/m³				190-320[c]				1977[b]
O_3	µg/m³				150-200	100-120			1987
O_3	µg/m³				100-200				1978

Notes (WHO/UNEP 1992)

a Guideline values for combined exposure to sulphur dioxide and suspended particulate matter (they may not apply to situations where only one of the components is present).

b Application of the black smoke value is recommended only in areas where coal smoke from domestic fires is the dominant component of the particulates. It does not necessarily apply where diesel smoke is an important contributor.

c Not to be exceeded more than once per month.

Suspended particulate matter measurement methods (WHO/UNEP 1992)

BS = Black smoke; a concentration of a standard smoke with an equivalent reflectance reduction to that of the atmospheric particles as collected on a filter paper.

TSP = Total suspended particulate matter; the mass of collected particulate matter by gravimetric analysis divided by total volume sampled.

PM_{10} = Particulate matter less than 10 µm in aerodynamic diameter; the mass of particulate matter collected by a sampler having an inlet with 50 per cent penetration at 10 µm aerodynamic diameter determined gravimetrically divided by the total volume samled.

TP = Thoracic particles (as PM_{10}).

IP = Inhalable particles (as PM_{10}).

Appendix 3

Air pollution Laws and Regulations for India and Bombay

Contents

Page

LEGAL ASPECTS OF POLLUTION CONTROL - OPERATIONAL REQUIREMENTS

The Govt. of India has promulgated 3 important Acts in the field of pollution control. These are:-

i. The Water Pollution (Prevention & Control) Act, 1974

ii. The Air Pollution (Prevention & Control) Act, 1981

iii. The Environment Protection Act, 1986

According to these Acts, industry-specific discharge/emission standards called MINAS (Minimum National Standards) have been prescribed. A few general standards as applicable to SSI units for air pollution are given in Annexure. All industries including SSI units are to comply with these standards and meet other stipulations laid down in these Acts. The responsibility of enforcing the provisions of these Acts rests with the Central/State Pollution Control Boards. Depending on the location of unit, the concerned State Boards expect that the units in their jurisdiction will obtain their permission to discharge the pollutants, or their 'CONSENT.'

The legal position, is that all the existing units are to obtain the CONSENT of their respective Boards. New units, even before they start putting up the industry, have to obtain a NOC (No Objection Certificate) from the Board. In fact, now,financial institutions and banks, too, demand production of NOCs before disbursement of loans, even though the loans may have been sanctioned on the basis of the techno-economic feasibility of the project.

In order to obtain the NOC from a Pollution Control Board (PCB), an application is to be made with a complete project-report, including the proposed measures of controlling pollution. Since, pollution control is sitespecific, the PCBs also have to be apprised of the proposed project site and, sometimes, depending on the need, the Board may even ask for EIA (Environment Impact Assesment) reports for site clearance.

The Boards, because of fragile environmental condition, have declared some regions as sensitive. New industries, specially

....2/-

pollution-intensive types, may not be allowed in sensitive areas or may be prescribed much stricter standards. Proximity to protected monuments, national wild life parks or sanctuaries could also be the reasons for industries to obtain a prior site-clearance.

Non-compliance with the legal stipulation invites prosecution with fines and penalties and even imprisonment. Under EPA 86 the PCBs are even empowered to order closure of an unit if they believe it to be in public interest. Without going to the court of law, they can implement closure decisions by appraoching the authorities concerned directly to cut power and water supply to the violating units.

SALIENT FEATURES OF POLLUTION RELATED ACTS

The Air (Prevention and Control of Pollution) Act, 1981

An Act to provide for the prevention, control and abatement of air pollution, given assent by the President of India on March 29, 1981.

The Act has the following chapters :

Title of chapter

i. Preliminary
ii. Central and State Boards for the Prevention and Control of Air Pollution
iii. Powers and functions of Boards
iv. Prevention and Control of Air Pollution
v. Fund, Accounts and Audit
vi. Penalties and procedure
vii. Miscellaneous

Salient Features

Preliminary

Application : This Act is applicable to the whole of India.

Central and State Boards for the prevention and Control of Air Pollution

Constitution of State Board :

a. The State Government will appoint a Chairman, member representing institutions, industries, government departments and social bodies etc. and a member secretary as executive head.
b. In union territory Central Board is to act as State Boards.
c. The Board may appoint officers and other employees as it may fit for efficient functioning of the Board.

Powers and Functions of Boards

Functions of Central Board

The Central Board may

a. Advise the Central Government on any matter concerning the improvement of the quality of air and the prevention and control of abatement of air pollution,
b. plan the nation wide programme for air pollution abatement,

c. co-ordinate the activities of State Boards,
d. provide guidance and technical assistance to the State Boards,
e. plan and organise training of persons engaged in air pollution abatement programmes,
f. organise through media abatement plans,
g. collect, compile and publish technical and statistical data relating to air pollution,
h. lay down standards for the quality or air,
e. to establish and recognise a laboratory to enable it to perform its function under this Act.

Functions of State Boards

The functions of State Board shall be

a. to plan comprehensive programmes for air pollution abatement,
b. to advise the State Government on any matter concerning the air pollution abatement,
c. to collaborate with Central Board,
d. to collect and disseminate information relating to air pollution,
e. to inspect industrial plants at intervals as it may considers necessary and to give directions to related persons for air pollution abatement,
f. to lay down, in consultation with the Central Board standards for the quality of air, standard for emissions of air pollutants into the atmosphere for industrial plants, automobiles and other sources excluding ships and air crafts,
g. to establish or recognise a laboratory/laboratories to enable it to performs it functions efficiently.

Powers to give directions :

a. Central Board shall be bound by written direction issued by Central Government
b. and State Board shall be bound by written direction issued by Central Board or the State Government.

Prevention and control of Air Pollution

Power to declare air pollution Control Areas

The State Government may, after consultation with the State Board by official Gazette notification declare;

a. any area or areas within the State as "Air pollution control Area or Areas" for the purposes of this act.
b. alter any air pollution control area.

c. prohibition of usage of any fuel other than the approved fuel in air pollution control area,
d. prohibition of burning of any material (other than fuel) in any air pollution control area or part of it.

Restriction or use of certain indusrial plants :

a. No person shall without the prior consent of the State Board, operate any industrial plant for the purpose of any industry specified in the schedule in an air pollutions control area.
b. An application for the consent of the Board shall be accompanied by prescribed fee and shall be made in the prescribed form and shall contain the particulars of the industrial plant and other prescribed particulars.
c. The State Board may make such inquiries at it may deem fit in respect of the application for consent and shall follow the prescribed procedures.
d. Within a period of 4 months after the receipt of consent application the State Board shall by order in writing either grant or refuse it, for reasons recorded in the order.
e. Every person to whom consent has been granted by the State Board shall comply with the following conditions :

   i. The prescribed control systems shall be installed and operated in existing/proposed industry.
   ii. The existing control equipments if any shall be altered/replaced in accordance with the directions of State Board.
   iii. The control system as per clause (i) or (ii) will be kept under good conditions.
   iv. Chimney wherever necessary of prescribed specifications, shall be erected or reerected in the premises.
   v. And the condition prescribed from (i) or (iv) complete within the prescribed period.

f. If due to technological improvement, State Board may alter as a whole or part, of the conditions mentioned above.
h. In case of the transfer of the unit from of person to the other person the consent will deemed to be transferred with conditions.

Persons carrying on industry etc. not to allow emission of air pollutants in excess of the standards laid down by State Board

No person carrying on any industry specified in the schedule or industrial plants in any air pollution control area shall discharge or cause or permit to be discharged, the emission of any air pollutants in excess of the standard laid down by the State Board.

Power of entry and inspection

Any person empowered by a State Board shall have a right to enter, at all reasonable times with necessary assistance, any place,

a. for the purpose of performing any of the function entrusted to him,
b. for the purpose of examination of control system, inspection of related documents, to conduct search and to check weather all directions/ instruction, issued time to time are being followed,
c. all persons carrying on any industry specified in the schedule are bound to render all assistance to the persons empowered by the Board and delay or non co-operation shall be an offence under this Act.

Power to obtain information

The State Board or its empowered person may ask for any information like the type of pollutants and the level of emission from the occupier or the person carrying on any industry and can inspect the premises/control equipment for varifying purposes.

Power to take samples of air or emissions and procedure to be followed :

The State Board or any officer empowered by it shall have power to take, for analysis purpose sample of air or emission from any chimney, flue, duct or any other outlet in prescribed manner.

Report of the results of analysis of sample taken by Board

Where a sample of emissions has been sent for analysis by Board to the laboratory established or recognised by the State Board the Board's analyst shall analyse the sample and submit a report in the prescribed form.

State Air Laboratory

State Government may, by official notification, establish or specify one or more laboratory or institutions as state laboratory.

Analyst

The State Government may by official Gazette notification appoint Government Analyst.

Report of Analysts

The report of Government Analyst may be used as evidence in the court of the law.

Appeals

Any person aggrieved by an order made by the State Board will in 30 days may appeal to an appropriate Appellate Authority.

Fund, Accounts and Audit

a. The Central Board and every State Board shall have its own fund funded by Central Government/State Government.
b. The Central Board and every State Board shall prepare annual budget and annual report duly audited by competent authority.

Penalties and Procedures

Failure to comply with the orders or directions of the Board issued under the Act :

a. Whoever fail to comply with the provisions mentioned above be punishable with imprisonment upto 3 months or fines upto Rs 10,000 or both and incase the failure continue, with an additional fine upto Rs 10/- day during which the failure continue after the conviction for the first such failure.
b. If the failure continued beyond 1 year after the date of conviction the offender shall be punishable with imprisonment upto 6 months.

Penalties for certain acts

Who ever damage the Board's property fails, to furnished information asked for, obstruct any board's officer to perform his duty and makes false statement etc., shall be punished imprisonment upto 3 months or fine upto Rs 500/- or both.

Penalty for contravention of certain provisions of the Act

For any contravention of any the provisions of the cat for which no penalty has been else where provided in this Act shall be punishable with fine upto Rs 5000/- and with continuation of contravention a fine Rs 100/day after conviction for first contravention.

Offences by Companies and Government Departments

Where an offence under this act has been committed by a company/ government department every person who was at that time directly incharge of the company/department shall be deemed to be guilty of the offence and shall be liable to be prosecuted and punished accordingly unless he proves that the offence has been made without his knowledge.

Miscellaneous

a. State Central Government/State Government may supersede t. Central Board/State Board respectively.

b. The Central Government may amend the schedule of industries

THE SCHEDULE

1. Asbestos and asbestos product industries
2. Cement and cement products industries
3. Ceramic and ceramic product industries
4. Chemical ahd allied industries
5. Coal and lignite based chemical industries
6. Engineering industries
7. Ferrous metallurgical industries
8. Fertilizer industries
9. Foundries
10. Food and agricultural product industries
11. Mining industries
12. Nonferrous metallurgical industries
13. Ores/mineral processing industries including benefaction, pelletization etc.
14. Power (coal, petroleum and their products) generating plants and boiler plants
15. Paper and pulp (including paper products) industries
16. Textile processing industries (made wholly or in part of cotton)
17. Petroleum refineries
18. Petroleum products and petrochemical industries
19. Plants for recovery from and disposal of wastes
20. Incinerators

PCON IN

दूरभाष : 2217213 (4 Lines
Phones : 2217078, 221707

केन्द्रीय प्रदूषण नियंत्रण बोर्ड

(पर्यावरण एवं वन मंत्रालय, भारत सरकार)

CENTRAL POLLUTION CONTROL BOARD

(MINISTRY OF ENVIRONMENT & FORESTS, GOVERNMENT OF INDIA)

No.B-31012/2/91/PCI-II/

September 17, 1992

DIRECTIONS FROM THE CENTRAL POLLUTION CONTROL BOARD UNDER CLAUSE (b) OF SUB-SECTION 1 OF SECTION 18 OF THE AIR (PREVENTION & CONTROL OF POLLUTION) ACT, 1981

Whereas Clause (g) of Sub-section 1 of Section 17 of the Air (Prevention and Control of Pollution) Act, 1981 provides for laying down standards by a State Pollution Control Board in consultation with Central Pollution Control Board for emission of air pollutants into the atmosphere from industrial plants and automobiles.

And whereas the mass emission standards for petrol and diesel driven vehicles as given in Annexure I & II respectively, have been evolved and proposed to be made effective from 1st day of April, 1995.

As whereas it is further proposed to strive to attain the indicative standards by all the petrol and diesel driven vehicles as given in Annexure III & IV respectively for the year 2000.

Now, therefore, in exercise of the power vested with the Central Pollution Control Board under Clause (b) of sub-section 1 of Section 18 of the Air (Prevention and Control of Pollution) Act, 1981, the following directions are issued herewith:-

> **"The State Pollution Control Board shall ensure that on and from the 1st day of April 1995 all petrol and diesel driven vehicles shall be so manufactured that they comply with the mass emission standards as specified in the Annexure I and II respectively given herein above;**
>
> **The State Pollution Control Board shall also ensure to strive to attain the indicative standards by the petrol and diesel driven vehicles for the year 2000 as given in Annexure III and IV respectively".**

(A. BHATTACHARJYA)
Chairman

'परिवेश भवन' सी० बी० डी० कम आफिस काम्पलेक्स, ईस्ट अर्जुन नगर, दिल्ली-११००३२
'Parivesh Bhawan' C.B.D.-cum-Office Complex, East Arjun Nagar, Delhi-110032

Annexure-I

A) MASS EMISSION STANDARD FOR PETROL DRIVEN VEHICLES EFFECTIVE FROM 1.4.1995.

I TYPE APPROVAL TESTS

i) Passenger cars

Reference mass R(Kg)	CO g/km	HC + NO_x g/km
R < 1020	5.0	2.0
1020 < R < 1250	5.7	2.2
1250 < R < 1470	6.4	2.5
1470 < R < 1700	7.0	2.7
1700 < R < 1930	7.7	2.9
1930 < R < 2150	8.2	3.5
R > 2150	9.0	4.0

Note
1. The test will be as per Indian driving cycle with cold start.
2. There should be no cranckcase emission.(To be implemented from 1.1.1994)
3. Evaporative emission should not be more than 2.0 g/test. (To be implemented from 1.1.1994)

ii) Two wheelers (For all categories)

CO - 3.75 g/km
HC - 2.40 g/km

Note
The test will be as per Indian driving cycle with cold start.

iii) Three wheelers(For all categories)

CO - 5.6 g/km
HC - 3.6 g/km
Note
The test will be as per Indian driving cycle with cold start.

II CONFORMITY OF PRODUCTION TESTS

i) Passenger Cars (For all categories)
A relaxation of 20% for CO & 25% for combined HC+NO_x for the corresponding values of Type Approval Test given above would be permitted.

ii) Two & Three Wheelers (For all categories)
A relaxation of 20% for CO and 25% for HC for the values of Type Approval Test given above would be permitted.

Annexure II
(Page 1 of 2 Pages)

MASS EMISSION STANDARD FOR DIESEL VEHICLES EFFECTIVE FROM 1.4.1995.

I TYPE APPROVAL TESTS

Vehicle category	HC* (g/KWH)	CO* (g/KWH)	NO_x (g/KWH)	Smoke
Medium & Heavy over 3.5 Ton/GVW	2.4	11.2	14.4	***
Light diesel upto 3.5 Ton GVW	2.4	11.2	14.4	***

OR

Reference mass R(Kg)	CO** g/km	HC + NO_x** g/km
R < 1020	5.0	2.0
1020 < R < 1250	5.7	2.2
1250 < R < 1470	6.4	2.5
1470 < R < 1700	7.0	2.7
1700 < R < 1930	7.7	2.9
1930 < R < 2150	8.2	3.5
R > 2150	9.0	4.0

Note

* The test cycle is as per 13 mode cycle on dynamometer.

**1) The test should be as per Indian driving cycle with cold start.

*** The emissions of visible pollutants(smoke) shall not exceed the limit values to smoke density, when expressed as light absorption coefficient given at Page 2 of Annexure II for various nominal flows when tested at constant speeds over full load.

I CONFORMITY OF PRODUCTION TESTS

A relaxation of 10% for the values of Type Approval Test given above would be permitted .

Annexure II
(Page 2 of 2 Pages)

Nominal Flow G(l/s)	Light Absorption Coefficient (K(m^{-1})
42	2.00
45	1.91
50	1.82
55	1.75
60	1.68
65	1.61
70	1.56
75	1.50
80	1.46
85	1.41
90	1.38
95	1.34
100	1.31
105	1.27
110	1.25
115	1.22
120	1.20
125	1.17
130	1.15
135	1.13
140	1.11
145	1.09
150	1.07
155	1.05
160	1.04
165	1.02
170	1.01
175	1.00
180	0.99
185	0.97
190	0.96
195	0.95
200	0.93

Annexure III

MASS EMISSION STANDARD FOR PETROL DRIVEN VEHICLES EFFECTIVE FROM 1.4.2000

I TYPE APPROVAL TEST

i) Passenger cars(for all categories)

CO - 2.72 g/km
$HC + NO_x$ - 0.97 g/km

Note

1. The test should be as per Indian driving cycle with cold start.

ii) Two wheelers(for all categories)

CO - 2.0 g/km

HC - 1.5 g/km

Note

1. The test should be as per Indian driving cycle with cold start.

iii) Three wheelers(for all categories)

CO - 4.0 g/km

HC - 1.5 g/km.

Note

1. The test should be as per Indian driving cycle with cold start.

II CONFORMITY OF PRODUCTION TESTS

i) Passenger Cars (For all categories)
A relaxation of 16% for CO & combined $HC + NO_x$ for corresponding values of Type Approval Test given above would be permitted.

ii) Two & Three Wheelers (For all categories)
A relaxation of 20% for CO as well as HC for the values of Type Approval Test given above would be permitted.

Annexure IV

MASS EMISSION STANDARD FOR DIESEL VEHICLE EFFECTIVE FROM 1.4.2000

I TYPE APPROVAL TESTS

Vehicle category	HC*	CO* (g/KWH)	NO_x*	PM*	Smoke
Medium & Heavy over 3.5 ton GVW	1.1	4.5	8.0	0.36	***
Light diesel upto 3.5 ton GVW	1.1	4.5	8.0	0.61	***

OR

CO ** g/km	HC + NO_x** g/km	PM**
2.72	0.97	0.14

Note

* The test should be as per 13 mode cycle.

**1) The test should be as per Indian driving cycle with cold start.

*** The emission of visible pollutants (smoke) shall not exceed the limit values of smoke density , when expressed and light absorption coefficient given at Page 2 of Annexure IV for various nominal flows when listed at constant speed, over full load.

I CONFORMITY OF PRODUCTION TESTS

A relaxation of 10% for the values of Type Approval Test given above would be permitted for Conformity Of Production Test for all vehicles.

Annexure IV
(Page 2 of 2 Pages)

Nominal Flow G(l/s)	Light Absorption Coefficient (K(m^{-1})
42	2.00
45	1.91
50	1.82
55	1.75
60	1.68
65	1.61
70	1.56
75	1.50
80	1.46
85	1.41
90	1.38
95	1.34
100	1.31
105	1.27
110	1.25
115	1.22
120	1.20
125	1.17
130	1.15
135	1.13
140	1.11
145	1.09
150	1.07
155	1.05
160	1.04
165	1.02
170	1.01
175	1.00
180	0.99
185	0.97
190	0.96
195	0.95
200	0.93

REQUIREMENTS OF LIQUEFIED PETROLEUM GASES

Sr. No.	Characteristics	Requirements			Method of Test Ref. To (P) of IS-1448
		Commercial Butane	Commercial Butane Propane Mixture	Commercial Propane	
i.	Vapour Pressure @ 65°C, kgf/cm^2. (see note 1)	10 max.	16.87 max. (see note 2)	26 max.	P:71
ii.	Volatility evaporate temperature in °C, for 95% vol. @ 760 mm. pressure, max.	2	2	−38	P:72
iii.	Total volatile sulphur, % by mass, max.	0.02	0.02	0.02	P:34
iv.	Copper strip corrosion @ 38°C for one hour.	——— Not worse than no. 1 ———			P:15
v.	Hydrogen Sulfide	absent	absent	absent	P:73
vi.	Dryness	No free entrained water	No free entrained water	shall pass the test	P:74 (see note 3)
vii.	Odour (See note 4)	Level 2	Level 2	Level 2	P:75

NOTE 1: Vapour pressure may be determined at any temperature and converted to 65°C by means of suitable vapour pressure temperature graph. The same can also be determined by analysing the gas by means of gas chromatograph and then using the composition, the vapour pressure can be calculated @ 65°C from the standard value of vapour pressures at various temperatures.

NOTE 2: Each consignment of commercial butane - propane mixture shall be designated by its maximum vapour pressure in kgf/cm^2. @ 65°C. Further, if desired by the purchaser and subject to prior agreement between the purchaser and the supplier, the minimum vapour pressure of that mixture shall not be lower than 2 kgf/cm^2. gauge compared to the designated maximum vapour pressure and in any case the minimum for the mixture shall not be lower than 10 kgf/cm^2 @ 65°C.

NOTE 3: The presence or absence of free entrained water in commercial butane or commercial butane - propane mixture shall be determined by visual inspection of the sample.

NOTE 4: Subject to agreement between the purchaser and the supplier, odour requirements of LPG may be changed for certain applications where unodourised LPG is required.

CONFORMS TO IS:4576-1978 FOR LPG.

SPECIFICATION OF MOTOR GASOLINE

Sr. No.	Characteristics	Test Method IS:1448	Requirements 87 OCTANE	93 OCTANE
i	Colour, Visual	–	Orange	Red
ii	Copper Strip Corrosion for 3 hours at 50°C	P:15	Not worse than No. 1	Not worse than No. 1
iii	Density at 15°C, g/ml	P:16	To be reported	To be reported
iv	Distillation	P:18		
	a) Initial Boiling Point °C		To be reported	To be reported
	b) Recovery upto 70°C, % v, min.		10	10
	c) Recovery upto 125°C, % v, min		50	50
	d) Recovery upto 180°C, % v, min		90	90
	e) Final Boiling Point °C, max.		215	215
	f) Residue, % v, max.		2	2
v	Octane number (Research Method) min.	P:27	87	93
vi	Oxidation Stability in Minutes, min.	P:28	360	360
vii	Residue on Evaporation, mg/100 ml, max.	P:29 (Air-Jet, Solvent Washed)	4.0	4.0
viii	Sulphur, % wt. max.	P:34	0.25	0.20
ix	Lead content (as Pb), g/l max.	P:38	0.56	0.80
x	Reid Vapour Pressure at 38°C, kgf/cm², max.	P:39	0.70	.0.70

CONFORMS TO IS:2796-1971 SPECIFICATIONS FOR MOTOR GASOLINES

SPECIFICATION OF DIESEL FUELS

Sr. No.	Characteristics	Test Method IS:1448	HSD	LDO
1.	Acidity, inorganic	P:2	Nil	Nil
2.	Acidity, total, mg KOH/g, max.	P:2	0.50	–
3.	Ash, % wt., max.	P:4	0.01	0.02
4.	Carbon residue (Ramsbottom), % wt., max.	P:8	0.20	1.50
5.*	Cetane number, min.	P:9	42	–
6.**	Pour Point, °C, max.	P:10	6	Winter 12*** Summer 18
7.	Copper strip Corrosion for 3 hrs. at 100°C	P:15	Not worse than No. 1	Not worse than No. 2
8.	Distillation, percentage recovery at 366°C, min.	P:18	90	–
9.****	Flash Point			
	a) Abel °C, min.	P:20	32	–
	b) PMCC °C, min.	P:21	–	66
10.	Kinematic Viscosity, cSt at 38°C	P:25	2.0 to 7.5	2.5 to 15.7
11.	Sediment, % wt., max.	P:30	0.05	0.10
12.	Total Sulphur, % wt., max.	P:33 or P:35	1.0	1.8
13.	Water Content, % V., max.	P:40	0.05	0.25
14.	Cold Filter Plugging Point (CFPP) °C, max.	IP 309/76	To be reported	–
15.*****	Total Sediments, mg/100 ml, max.	Appendix 'A' of the Specification	1.0	–

REMARKS

* Cetane Number

Diesel Fuel for Naval applications shall have a cetane number of 45, min. When an engine for determination of cetane number is not available, diesel index determined by IS:1448-1960 'Methods of test for petroleum and it ; products' P:17, Diesel Index may be used as a rough indication of ignition quality. A diesel index of 45 is normally considered sufficient to ensure a minimum cetane number of 42. This approximate correlation holds good only in case of fuels which are of petroleum origin and contain no additives. For arbitration purposes, the direct determination of cetane number by means of the standardized engine test shall be used unless the buyer and the seller agree otherwise.

** Pour Point

Subject to agreement between the purchaser and the supplier a lower or higher maximum pour point may be accepted.
The Ministry of Petroleum & Natural Gas issues instructions periodically to the Refineries to reduce/increase pour point of HSD according to ambient temperature conditions.

*** Winter shall be the period from November to February (both months inclusive) and rest of the months of the year shall be called as summer.

**** Flash Point

Diesel Fuel for Naval applications and for Merchant Navy shall have a flash point of 66°C, min, when tested by the method prescribed in IS:1448 (P:21)-1970 'Methods of test for petroleum and its products', P:21 Flash Point (Closed) by Pensky-Martens apparatus (first revision).

***** Total Sediments

This test shall be carried out only at the refinery or manufacturer's end.

CONFORMS TO IS:1460-1974 SPECIFICATIONS FOR DIESEL FUELS

SPECIFICATION OF DIESEL HIGH POUR POINT-A

Sr. No.	Characteristics	Requirements
1.	Colour, ASTM, max.	3.5
2.	Flash Point, min.	55°C (Navy – min. 65°C)
3.	Cetane No., min.	45
4.	Diesel index, min.	48
5.	Distillation:	
	% recovered upto 357°C, min.	90%
	F.B.P., max.	385°C
	Residue, % vol., max.	2.0
6.	Total sulphur, % wt., max.	0.5
7.	Olefins, % vol., max.	5.0
8.	Aromatics, % vol., max.	20.0
9.	Carbon (Ramsbottom on 10% residue), max.	0.2

OTHER REQUIREMENTS AS PER IS:1460-1974 SPECIFICTIONS FOR HSD

SPECIFICATION OF FURNACE OIL

Sr. No.	Characteristics	Test Method IS:1448	Requirements for Grade LV	Grade MV1	Grade MV2	Grade HV
1.	Acidity, inorganic	P:2	Nil	Nil	Nil	Nil
2.	Ash, % wt., max.	P:4 (Method A)	0.1	0.1	0.1	0.1
3.	Gross, calorific value, cal/g.	P:6 or 7	Not limited, but to be reported (typical-10280)			
4.	*Relative density at 15/15°C.	P:32	Not limited but to be reported (typical-0.950)			
5.	Flash point, (PMCC)°C, min.	P:21	66	66	66	66
6.	Kinematic viscosity in centistokes at 50°C.	P:25	80 Max.	80 – 125	125 – 180	180 – 370
7.	Sediment, % wt., max.	P:30	0.25	0.25	0.25	0.25
8.	** Sulphur, total, % by wt., max.	P:33 or P:35	3.5	4.0	4.0	4.5
9.	Water content, % by vol., max.	P:40	1.0	1.0	1.0	1.0

REMARKS:

* Furnace oil for marine uses in diesel engines shall not exceed a limit of 0.99

** Sulphur Content

Recognising the necessity for low-sulphur fuel oils in some specialized use, a lower limit may be specified by mutual agreement between the purchaser and the supplier.

CONFORMS TO IS:1593-1988 SPECIFICATIONS FOR FUEL OIL

Appendix 4

Emission inventory

Contents

Emission inventory

1. Introduction

Several attempts have been made to establish a comprehensive survey of air pollution emissions for the Bombay area (refs). The most recent survey was worked out by Coopers & Lybrand and AIC, as part of their Study on Environmental Strategy and Action Plan for Bombay Metropolian Region (Government of Maharashtra, 1993).

For the URBAIR project for Bombay, a more through procedure was conducted to work out the best

Most of the data collection and emission calculations was performed by Aditya Environmental Services of Bombay. The production of gridded emission files (emissions distributed in a km^2 grid net) was done using the supporting software programs for the KILDER dispersion modelling program system developed by NILU.

The road traffic activity and emissions distribution was calculated by NILU, based on traffic and road data provided by W.S. Atkins 1993, produced in connection with their Comprehensive Transportation Study for Bombay Metropolitan Region.

The area selected for air quality modelling, and thus for emission inventorying, is shown in Figure 1. It consists of 42x20 km^2 grid squares, covering the area from the tip of Colaba in the South to Bassein Creek in the North, and from the ocean in the West to Thane Creek in the East. It includes the Chembur-Thane industrial area.

In the following, the data sources and methods for distributing the consumption and emissions is described, and then the calculated emissions are presented.

An evaluation of data gaps and short-comings is presented at the end of this Appendix.

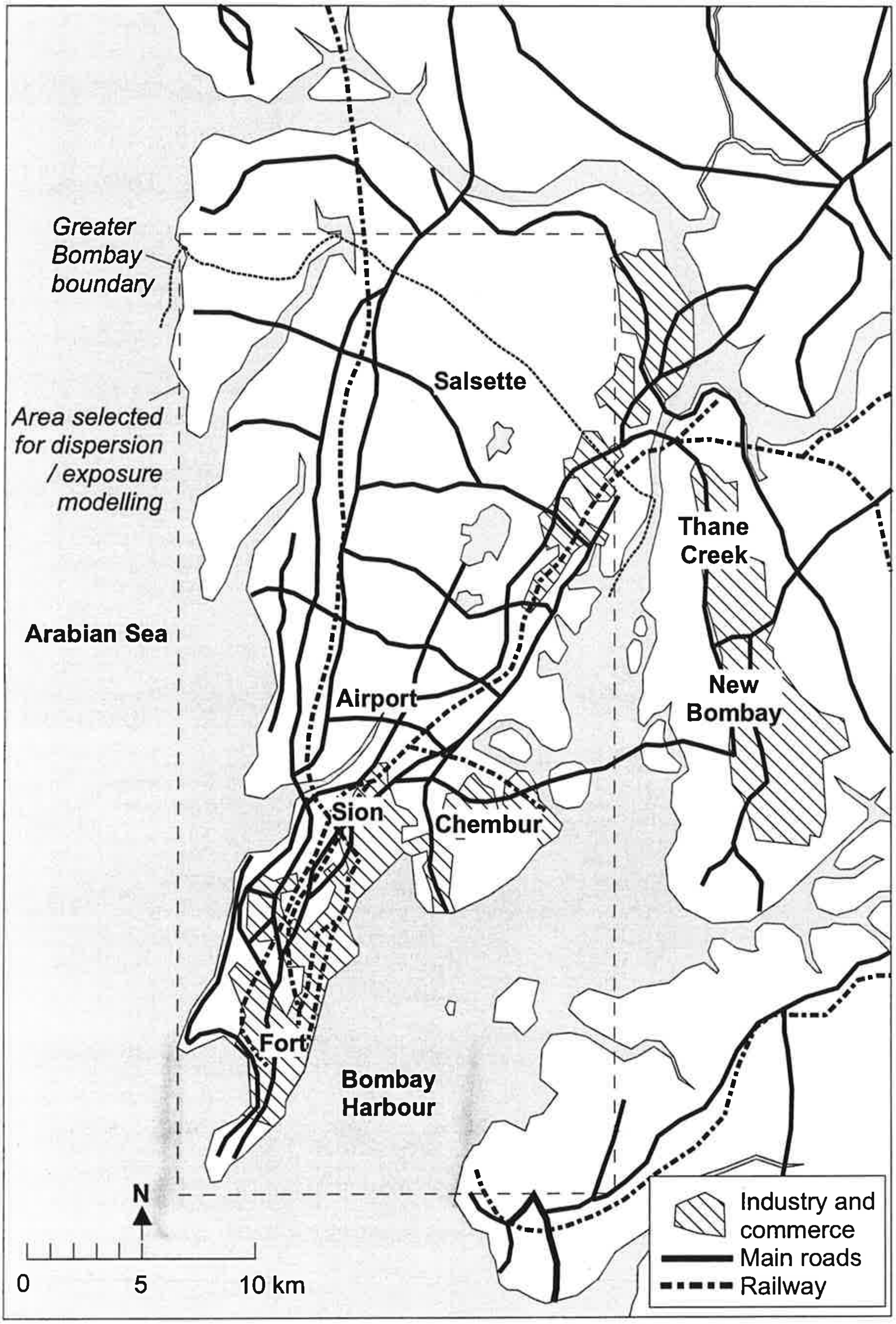


Figure 1: Greater Bombay air quality modelling area.

2. Population distribution

The spatial distribution of the population within the grid system is important information when the fuel consumption, especially domestic fuel consumption, is to be distributed within the grid system.

The fuel consumption practices differ for the non-slum and slum populations. For Bombay, separate spatial distributions has thus been worked out for the two populations.

The total population for the URBAIR modelling area for Bombay is as follows, for the year 1991:

Non slum population	7 056 760
Slum population	2 806 260
Total population	9 863 020

Details of the procedure for distribution of the population is given in Annex 1.

The distribution of the total population is given in Figure 2.

MÅLESTOKK: 1 RUTE ER 1000 METER

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
J=42	2.	5.	5.	.	.	.	.	32.	248.	271.	300.	34.	.	.	.	.	.	.	.	.
J=41	2.	6.	4.	.	.	.	.	152.	264.	156.	106.	106.	.	98.	40.	.	.	.	.	.
J=40	2.	3.	2.	.	.	.	102.	237.	261.	149.	106.	106.	106.	.	.	.	.	.	.	.
J=39	4.	1.	1.	2.	.	.	257.	317.	324.	160.	106.	106.	106.	.	.	.	.	.	.	.
J=38	9.	4.	.	.	.	.	134.	346.	376.	248.	106.	106.	106.	.	.	.	.	.	.	.
J=37	9.	16.	2.	.	38.	99.	190.	318.	274.	222.	134.	133.	44.	2.	1.	17.	.	.	.	.
J=36	4.	2.	45.	128.	209.	264.	303.	161.	146.	146.	146.	146.	44.	12.	30.	28.	.	.	.	.
J=35	5.	8.	67.	137.	183.	.	241.	456.	304.	144.	153.	145.	146.	113.	18.	23.	30.	.	.	.
J=34	.	.	136.	201.	95.	91.	366.	571.	375.	139.	139.	139.	139.	82.	21.	19.	30.	71.	105.	26.
J=33	.	.	79.	158.	.	.	335.	465.	364.	139.	139.	139.	43.	30.	30.	46.	210.	259.	242.	.
J=32	1.	6.	19.	32.	.	.	278.	427.	342.	123.	124.	124.	75.	30.	30.	30.	101.	256.	265.	267.
J=31	.	.	14.	.	.	.	414.	381.	154.	43.	43.	43.	33.	20.	2.	15.	165.	249.	266.	325.
J=30	1.	5.	3.	.	.	.	305.	383.	99.	43.	43.	43.	38.	14.	.	29.	234.	249.	186.	.
J=29	.	30.	10.	379.	27.	.	315.	371.	313.	179.	53.	43.	71.	73.	91.	184.	249.	233.	95.	.
J=28	.	35.	2.	149.	197.	31.	408.	428.	507.	503.	295.	168.	199.	171.	199.	249.	252.	229.	.	.
J=27	.	.	.	.	69.	219.	500.	406.	335.	354.	291.	295.	258.	238.	194.	269.	149.	72.	.	.
J=26	.	.	.	.	14.	265.	495.	367.	291.	291.	291.	295.	305.	302.	276.	272.	272.	85.	.	.
J=25	.	.	.	.	.	127.	168.	220.	238.	286.	288.	297.	305.	330.	400.	287.	269.	20.	.	.
J=24	.	.	.	.	.	89.	161.	220.	237.	224.	220.	284.	305.	421.	444.	329.	204.	.	.	.
J=23	.	.	.	.	.	53.	291.	315.	346.	222.	218.	298.	371.	423.	371.	290.	32.	.	.	.
J=22	.	.	.	.	38.	308.	568.	344.	349.	340.	348.	422.	329.	355.	351.	136.	.	.	.	.
J=21	.	.	.	.	34.	341.	668.	485.	224.	224.	330.	646.	243.	403.	383.	219.	.	.	.	.
J=20	.	.	.	.	28.	265.	542.	803.	113.	40.	499.	303.	428.	223.	24.	291.	188.	.	.	.
J=19	.	.	.	.	57.	259.	510.	344.	98.	287.	608.	359.	421.	421.	403.	260.	166.	.	.	.
J=18	.	.	.	.	98.	39.	171.	627.	836.	632.	353.	149.	286.	322.	320.	260.	260.	195.	.	.
J=17	.	.	.	.	.	.	210.	846.	694.	550.	134.	.	260.	.	.	.	.	195.	.	.
J=16	.	.	.	.	67.	15.	431.	791.	388.	554.	388.	260.	260.	260.	.	.	130.	97.	.	.
J=15	.	.	.	.	312.	430.	546.	477.	438.	343.	249.	.	260.	260.	.	.	.	.	.	.
J=14	.	.	.	34.	507.	544.	572.	550.	390.	140.	.	260.	260.	260.	.	.	.	.	.	.
J=13	.	.	.	84.	454.	542.	574.	412.	211.	.	.	.	.	.	.	.	.	.	.	.
J=12	.	.	.	51.	339.	554.	531.	280.	186.	.	.	.	.	.	.	.	.	.	.	.
J=11	.	.	.	44.	344.	589.	437.	304.	189.	.	.	.	.	.	.	.	.	.	.	.
J=10	.	.	94.	469.	560.	746.	392.	518.	.	.	.	.	.	.	.	.	.	.	.	.
J= 9	.	.	138.	405.	864.	1238.	590.	266.	.	.	.	.	.	.	.	.	.	.	.	.
J= 8	.	36.	291.	139.	543.	971.	406.	232.	.	.	.	.	.	.	.	.	.	.	.	.
J= 7	.	79.	59.	138.	541.	144.	81.	.	.	.	.	.	.	.	.	.	.	.	.	.
J= 6	.	.	.	.	6.	133.	159.	42.	.	.	.	.	.	.	.	.	.	.	.	.
J= 5	.	.	.	.	5.	86.	102.	16.	.	.	.	.	.	.	.	.	.	.	.	.
J= 4	.	.	.	.	115.	227.	26.	2.	.	.	.	.	.	.	.	.	.	.	.	.
J= 3	.	.	9.	109.	93.	48.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
J= 2	.	.	15.	132.	24.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
J= 1	.	.	17.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Figure 2: Distribution of total Bombay population within the km² grids of the modelling area, 1990.

3. Fuel consumption

The consumption of various petroleum fuels by industries is available from four Petroleum Refineries selling their products in Bombay.

Data for LPG and SKO (Kerosene) consumption for domestic purposes is available from the Rationing Office of Bombay.

Consumption of wood was considered for the slum population, and for bakeries and crematoria, according to information and evaluation from various agencies.

The evaluation and considerations made by Aditya E.S. Inc. regarding the calculation and distribution of the fuel consumption for domestic purposes and for industries, are given in Annexes II and V of this Appendix.

The resulting fuel consumption data are given in Table 1. (Fuel consumption for road traffic is considered in Chapter 4 of this Appendix).

Table 1: Fuel consumption data for Greater Bombay, for 1992-93, for industry, domestic purposes, and by ships in Bombay port/bay area.

Category	Fuel type	10^3 Metric tonnes/a	
Tata Power Plant	LSHS	927	
	Coal	298	
	Gas	496	
Industrial	LSHS	499	279 in Petrochem. ind. 164 in large/medium ind. 56 in small scale ind.
	FO	306	183 in large/medium ind. 123 in small scale ind.
	LDO	42	
	Diesel (HSD)	40	
	LPG	7	
Domestic	Wood	289	
	SKO	480	
	LPG	233	
Marine (port/bay)	FO	100	
	LSHS	56	
	Diesel	6	
	LDO	3	

Comments:

Domestic:

LPG	was distributed grid-wise in the non-slum population. Combustion takes place during 10 hours of the day.
SKO	was distributed gridwise in the total population. Combustion takes place during 10 hours of the day.

Wood consumption:

Bakeries:	a total of 440 tonnes/day, in 1100 bakeries, distributed in the total population, 12 hours per day.
Crematoria:	a total of 87.5 tonnes/day in 76 crematoria, distributed in the total population, 24 hours per day.
Combustion in slums:	a total of 276 tonnes/day, distributed in the total population, 10 hours per day.

Industrial:

There are some 40 000 commercial establishments and industries in Bombay. 400-500 of these use fuel for combustion.

A total of 280 large and medium scale industries were identified and located, based on the following criteria:

LSHS consumption	>500 tonnes/a
FO consumption	>200 tonnes/a

The industries were mainly in the categories engineering (10-15 large industries), chemical, pharmaceutical and textile.

For these industries, emission data were given based on reported measurement data, and, where not available, emissions were calculated based on emission factors. Stack data were also given.

This list of industries included the Tata Power Plant, three chemical/ petrochemical plants and a fertilizer plant, all in the Chembur area.

The gridwise distribution of the fuel consumption was done in the following manner:

- The fuel consumed by the identified large/medium sources was assigned to the grids where the industries were located.

- The remainder (balance) fuel was distributed in the grids according to the number of medium/small industries in the grid for which data was not available.

4. Traffic activity, fuel consumption and emissions

The basis for the calculation of vehicle exhaust emissions, and their spatial distribution, is the file with traffic and road data provided by Atkins Inc., produced within their Comprehensive Transportation Study for Metropolitan Bombay Region. This file basically contained:

- the main road network, separated into links (a total of 275 links), with the link endpoint co-ordinates (nodes) fixed in an arbitrary co-ordinate system

- traffic data for each link, for morning rush hour (10-11 A.M.):
  - light duty traffic (cars + MC/TC), in passenger car units (PCU)
  - truck traffic, in PCU (1 truck = 2.4 PCU)
  - bus traffic, in PCU (1 bus = 3.4 PCU)
  - traffic speed.

It was considered that the morning rush hour (10-11 A.M.) accounted for 6% of the annual average daily traffic.

The traffic activity, for each vehicle class, has been calculated separately for the "Island" Area and "Suburb" area (see Figure 1), and distributed in the km^2 grid.

Additional data from the Atkins' report, and from Aditya were used to estimate the overall distribution of traffic activity between the vehicle classes, and the gasoline/diesel mix:

Vehicle classes	Gasoline/diesel	Fuel cons. (l/km)
Passenger cars	80% gasoline/20% diesel	0.1
Motorcycles/tricycles	100% gasoline	0.067*
Trucks	100% diesel	0.3
Buses	100% diesel	0.3

* Based on: Motorcycles: 40% 0.05 l/km
Tricycles: 50% 0.075 l/km

The total fuel consumption for road traffic in Greater Bombay used in this analysis, is, as provided by Aditya:

Gasoline: 248 578 tons/a
Motor diesel: 243 444 tons/a

The calculated traffic activity for separate classes/road systems is given in Table 2.

Table 2: Traffic activity (10^3 vehicle km/day), Greater Bombay 1992, distributed between vehicle classes and the "Island"/"Suburb" areas.

	Cars	MC/TC	Trucks	Buses	Total
Traffic activity					
Main roads (Atkins' data)					
"Island"	1 827	457	306	177	2 767
"Suburbs"	1 353	1 793	833	234	4 213
Sub-total	3 180	2 250	1 139	411	6 980
Additional ("small") roads					
"Island"	2 097	480	148	86	2 811
"Suburbs"	1 771	2 160	177	113	4 221
Sub-total	3 868	2 640	325	199	7 032
Total	**7 048**	**4 890**	**1 464**	**610**	**14 012**

The methodology used was as follows:

1. The traffic activity on the main road (Atkins') network, and the associated fuel consumption was calculated.

2. The traffic activity was distributed in the km^2 grids, according to the location of the road links.

3. The fuel consumption not accounted for by this main road traffic, was calculated by difference (total minus main road fuel consumption).

4. This balance fuel consumption was used to distribute the balance traffic activity, assuming:
   - the same vehicle composition in the traffic as on the main road system.
   - the spatial distribution of this balance traffic activity within the km^2 grid system is as the distribution of the non-slum population.

Using the following emission factors, the calculated emissions of TSP (e.g. exhaust particles) and NO_x from traffic is as given in Table 3.

Emission factors (g/km)	Exhaust particles	NO_x
Cars, gasoline	0.2	2.7
Cars, diesel	0.6	1.4
MC/TC, gasoline	0.5	0.1
Trucks, diesel	2.0	13.0
Buses, diesel	2.0	13.0

Table 3: Exhaust emissions from road traffic, Greater Bombay, 1992 (kg/h, averaged over the year, all hours).

	TSP		NO_x	
	main roads	"small" roads	main roads	"small" roads
Gasoline				
Cars	26.5	29.7	358	401
MC/TC	29.1	55.0	9	11
Diesel				
Cars	79.5	7.7	186	18
Trucks	94.9	46.0	617	299
Buses	34.2	16.6	222	108
Total	**264.2**	**155.0**	**1 392**	**826**

5. Emission factors

The emission factors used in this URBAIR calculation for Bombay were selected based on the following sources of data:

- US EPA emission factors of AP42 publication.
- Emission factors of the WHO publication: "Assessment of Sources of Air, Water and Land Pollution", Part I: Rapid inventory techniques in Environmental Pollution (Geneva, 1993).
- Emission factors worked out by the Bombay Urbair Working Group I (on Air Quality Assessment), shown in Table 5.
- Emission factors for road vehicles described in Appendix 5.
- Emission factors from Indian vehicles (IIP, 1985; Luhar and Patil, 1986).

The selected emission factors for fuel combustion and road vehicles are shown in Table 4.

Table 4: Emission factors used for URBAIR, Bombay, 1992.

	TSP	PM_{10} / TSP	SO_2	NO_x	%S max.
Fuel combustion (kg/t)					
Coal, bituminous, power plant					
- uncontrolled	5A 1)		19.5S 1)	10.5	
- cyclone	1.25A	0.95	19.5S	10.5	
- ESP	0.36A		19.5S	10.5	
Residual oil (FO) ind./comm	1.25S+0.38	0.85	20S	7	4
Distillate oil ind./comm	0.28	0.5	20S	2.84	LSHS: 1
(LSHS, HSD, LDO) residential	0.36 → 1.6 2)	0.5	20S	2.6	HSD: 1 LDO: 1.8
LPG ind./dom.	0.06	1.0	0.007	2.9	0.02
Kerosene dom.	0.06	1.0	17S	2.5	0.25
Natural gas utility	0.061	1.0	20S	11.3	
Natural gas ind./dom.	0.061		20S	2.5	
Wood dom.	15	0.5	0.2	1.4	
Refuse burning, open	37	1	0.5	3	
Road vehicles (g/km)					
Gasoline Cars	0.2	1		2.7	87:0.25
Gasoline Trucks, light duty	0.33	1			83:0.20
Gasoline Buses and trucks, heavy duty	0.68	1			
Gasoline MC/TC	0.5	1		0.1	
Diesel Cars	0.6	1		1.4	1
Diesel Trucks, light duty	0.9	1		13	
Diesel Buses and trucks, heavy duty	2.0				

1) A: Ash content, in %; S: sulfur content, in %
2) Well → poorly maintained furnaces

Table 5: Emission factors as worked out by the Bombay URBAIR Working Group I on Air Quality Assessment.

Type of Source	Fuel Burned	Unit	Particulates (kg/unit)	SO_2 (kg/unit)	NO_x (kg/unit)
Power plants Plants	Coal	t	8(A)	19(S)	9
	Fuel Oil	t	1.04 (controlled)	19.9(S)	13.2
	Natural Gas	10^3m^3	0.24	16.6(S)	9.6
		t	0.29	19.9(S)	11.5
Industrial & Commercial Furnaces	Coal	t	6.5(A)	19(S)	7.5
	Fuel Oil	t	2.87	19(S)	7.5
	Oil, distillate	t	2.13	20.1(S)	7.5
	LPG	m^3	0.21		1.43
		t	0.38	0.01(S)	2.6
	Natural Gas	10^3m^3	0.29		3
		t	0.34	0.02(S)	3.6
				6.6(S)	
				20(S)	
Domestic Furnaces	Coal (hand fired)	t	10	19(S)	1.5
	Wood	t	13.7	0.5	5
	Kerosene	t	3	17(S)	2.3
	LPG	m^3	0.23		1
		t	0.42	0.01(S)	1.8
				0.02(S)	
Solid Waste Dumps	Refuse	t	8	0.5	3
	Wood	t	13	0.1	4
	Rubber Tyres	t	138	-	-
	Municipal Refuse	t	37	2.5	-

NOTE: i) A is % ash content (combustible by wt.)
ii) S is % sulphur content (combustible by wt.)
iii) Coal used in Bombay by Industries and for Domestic purposes is of Bituminous type.

The selected factors for fuel combustion is in some cases somewhat different from those worked out by the Bombay Working Group I. The factors in Table 4 (from EPA AP42) were used because factors from the AP42 reference were used also in the other URBAIR cities (Manila, Jakarta), and because the Bombay factors were worked out a bit late in the process, after dispersion calculations were well under way. The Bombay factors would modify the emission inventory and calculated concentrations somewhat, but would not change the main results from the calculations.

The emission factors for Indian vehicles referenced, include:

- Luhar and Patil (1986): Light duty, gasoline 2.1 g/km at 30 km/h; MC/3-wheelers 0.06 g/km at 30 km/h.

- IIP, 1995 (Tata, 1995)

	NO_x	"TSP"
Buses, suburban	11.1	0.37
urban	8.52	0.28
Trucks	6.65	0.22
Light commercial vehicles	2.5	0.1

For NO_x, these are in fair agreement with the selected factors in Table 4. For "TSP" (presumably exhaust particles) from buses and trucks, they are considerably lower, and seem quite a bit too low compared to all other references.

6. Total emissions

Table 6 gives the total annual emissions of TSP, PM_{10}, SO_2 and NO_x associated with the various source categories, fuels and vehicle types. Those emission figures were calculated by multiplying the fuel consumption with the emission factor. The table also gives the operation hours of the various sources.

Table 6: Total annual emission in Greater Bombay, 1992. (metric tonnes/a).

		TSP	PM_{10}	SO_2	NO_x	Hours of operation
Vehicles						
Gasoline	Cars	492	492	160	6 643	12
	MC/TC	737	737	250	179	12
Diesel	Cars	765	765	395	1 783	12
	Buses	445	445	566	2 891	12
	Trucks	1 234	1 234	2 120	8 024	12
Sum vehicle exhaust		3 673	3 673	3 490	19 520	12
Resuspension from roads		10 200	2 550	-	-	12
Power plant		~1 500	~1 500	~26 000	~11 200	24
Fuel combustion						
Industrial	LSHS	140[1]	84	11 920[1]	1 690	24
	FO	1 652[1]	1 399	24 480[1]	2 140	24
	LDO	12[1]	6	1 510[1]	120	24
	Diesel	12[1]	6	800[1]	115	24
	LPG	0,5	0.5	-	20	24
Sum industrial		1 817	1 496	38 710	4 085	
Domestic	Wood	4 395	2 198	59	410	12 (day)
	Kerosene (SKO)	23	23	1 628	258	10 (day)
	LPG	14	14	0,7	676	10 (day)
Sum domestic		4 432	2 235	1 688	1 344	
Marine (docks)	FO	540	459	8 000	750	24
	LSHS	16	8	1 120	425	24
	Diesel	2	1	120	45	24
	LDO	1	1	110	25	24
Sum marine		560	469	9 350	1 245	
Industrial processes[2]						
Refuse burning	Domestic	3 700	3 700			
	Dumps	408	408	26	153	12 (3 PM-3 AM)
Construction						
Stone crushers		6 053				12 (day)

1 Uncontrolled

2 Emissions from processes in Bombay is considered less important than to the fuel combustion emissions.

Comments to Table:

- There is no specific file of data available regarding industrial process emissions. Based on their survey work in Bombay, Aditya is of the opinion that the process emissions are not significant totally in Bombay, compared to emissions from fuel combustion. Still, process emissions will in many cases give significant exposure in areas near industrial process plants.

- There is a large discrepancy between the calculated emissions of SO_2 and NO_x in Table 6, and those from the emission data file produced by AES Inc. for the input to the KILDER model (see below), regarding industrial emissions. The discrepancy is as follows:

	Emissions in Table 6	Emissions from the AES Point source file
SO_2 (t/a)	66 710	18 290
NO_x (t/a)	15 285	5 590

  Part of the discrepancy may be explained as follows:

  – In the AES point source file, results from actual emission measurements were used, where available. Where not available, a calculation of the emissions was based on fuel consumption and emission factors.

  – Table 5 is based on the maximum S contents of oil, while the average actual S contents may be considerably lower.

- Refuse burning, open burning on dumps.

  AES has estimated the total emissions from the Dumps Deonar, Chincholi + Gorai, and Mulund. The estimation was based on TSP, SO_2 and NO_x measurements carried out by MCGB near Deonar, by means of box model. The details are described in Annex IV to this Appendix.

  NEERI has also estimated total emissions of the same compounds from open burning on dumps in Bombay, based on some measurements of their own.

  Table 7 below summarized the results.

Table 7: Summary of estimates of emissions from open burning on dumps in Bombay.

		TSP	SO_2	NO_x
AES	kg/hr	54.3	3.4	20.4
NEERI	kg/day	950	71	175

There is a fair agreement between these estimates, considering that the burning mainly takes place during 10-15 hour periods evening-nights.

The AES estimates have been used in Table 6.

- ***Refuse burning, domestic***

Several discussions within the URBAIR groups have not led to a conclusion regarding the amount of refuse burnt domestically (street sweepings, vegetation debris, domestic refuse) in Bombay.

It might be estimated that a total of 2 mill households in Bombay each burn 1 kg of refuse per week. Using a SPM emission factor of 37 g/kg, this produces annually some 3 700 tonnes of SPM.

- ***Stone crushers***

The SPM emissions from 47 registered stone crushers in Greater Bombay has been estimated by AES, as described in Annex V to this Appendix.

7. Spatial emission distribution

The total emissions from each source category has been distributed within the km^2 grid system based on

- the actual location of point sources
- the population distribution, separate for non-slum and slum populations
- the traffic activity distribution.

AES and NILU has produced the spatial emission distributions listed below. For each distribution, an average emission rate was calculated for each grid square, in kg/hr, representing the average emission during the operating hours of the source.

Fuel consumption	Operating time hrs/day	Distribution
Road traffic, gasoline	12	According to traffic activity on roads, and non-slum population
Road traffic, diesel	12	According to traffic activity on roads, and non-slum population
LPG, domestic	10 (day)	Non-slum population
SKO, domestic	10 (day)	Total population
Wood, domestic	10 (day)	Slum population
Wood, bakeries	12 (day)	Total population
Wood, crematoria	24	Total population
Refuse burning, dumps	12 (evening-night)	3 dumps
Stone crushers	12	47 units
Balance fuel	24	Non-slum population
Point sources	24	Actual locations

For some further details, se Annex VII of this Appendix

8. References

Luhar, A.K. and Patil, R.S. (1986) Estimation of emission factors for Indian vehicles. *Indian J. Air Pollution Control*, Vol 7, no. 4.

Tata Energy Research Institute (1992) *In: Environmental Effects of Energy Production, Transportation and Consumption in National Capital Region, 1992*. New Delhi.

ANNEXURE - I

DATA ON POPULATION DISTRIBUTION - GRID WISE

TOTAL POPULATION

Data Available :

* Total population and area of each Census District obtained from BMRDA. (There are a total of 88 Census Districts in Bombay).

* Map of Bombay.

Distribution of Population :

* Population Density per sq. km. area was calculated using data obtained from BMRDA. However, it was noticed that area with no possible human habitation (like waterbodies/marshy lands/airport/ industrial area etc.) was also included in many of the census districts. Hence, new population densities were derived after deducting such areas.

* Actual habitable area of each of the census districts in a grid was measured and multiplied by population density to arrive at population per grid.

Data Constraints :

Non-availability of Specific Zoning Maps showing clearly the land use pattern.

SLUM POPULATION

Data Available :

* Wardwise list of slums in Bombay on Private land/Central Govt. lands/State Govt. lands/BHADA (Bombay Housing and Area Development Authority) and M.C.G.B. land giving number of tenements in each slum pocket. List obtained from Slum Improvement Dept., M.C.G.B. and is for the year 1985. (No updated list was available from the Dept.).

........2/-

* Map of Bombay from MHADA (Maharashtra Housing & Area Development Authority) showing positions of these slums.

Slum Population Distribution :

No figures were available on actual population in the slums. Also distribution of slums in each Census District was not available.

Available data on total population and number of households obtained from BMRDA and discussions with faculty of Tata Institute of Social Sciences, Deonar indicates average number of persons per tenement as 5. Hence total slum population was derived as :

5,61,252 x 5 = 28,06260
(no of tenements) x (avg. no. of persons per tenement) = (Total slum population)

The slum population was then distributed in the grids based on number of tenements in each grid.

Data Gaps :

Conflicting reports exist on total population of Bombay residing in slums. Estimates indicate upto 40-45% (of total population) as total slum population.

The Book "Slums Squatter Settlements & Organised Sector Worker Housing in India some Affordable Myths" authored by R.M. Kapoor and M.S. Mitra published by the Times Research Foundation (1987) puts Task Force Estimates on slum population for million plus cities for 1981 (based on 1981 population) as varying from a low of 40% to a high of 45% of total population.

It is suspected that data given by Slum Improvement Dept. gives number of registered slums only and hence total slum population as worked out for URBAIR is only 28.5% of total population. This is a major data gap as this will affect the consumption pattern of SKO/Wood in the grids.

NON-SLUM POPULATION

The slum population in each grid was substracted from total population in that grid to arrive at non-slum population in that grid.

ANNEXURE - II

DATA ON DOMESTIC FUEL CONSUMPTION

DATA AVAILABLE

* LPG Consumption for Domestic purposes) as indicated by Rationing
* SKO Consumption for Domestic purposes) Office.

(Data on LPG/SKO consumption for domestic purposes was not seperately available for one of the Petroleum Companies and hence data from Rationing Inspectorate was used).

* Total Population/Slum Population/Non-slum population gridwise from POPDIST1.WK1 files.

BASIS FOR DISTRIBUTION OF DATA

LPG CONSUMPTION

Total LPG consumption per day for domestic purposes as indicated by Rationing Inspectorate is 639 MT/d. As this is predominantly used in well to do households, the entire LPG consumption was distributed gridwise in the non-slum population. Daily use of LPG is for cooking purposes and hence restricted to 10 hours/day LPG consumption in Kg/hr was calculated for this period.

SKO CONSUMPTION

The total SKO consumption for Domestic purposes and by establishments is 1236 KL/d or 1062.96 T/d. This was distributed in the grids according to total population in that grid. Daily use of SKO is mainly for cooking and to some extent water heating. Total daily period of such use is restricted to 10 hours. Hence, SKO consumption in Kg/hr was calculated for this period.

WOOD CONSUMPTION

Major wood consumers in Bombay were identifid as bakeries, other small establishments, domestic households (slums/pavement dwellers) and crematories.

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Wood Consumption in Bakeries/Small Establishments

Data Available

No figures were available on wood consumption by small establishments. The Indian Bakers Association indicated that there are about 1100 bakeries in the city which are using wood for their fuel needs. The average wood consumption in each bakery was estimated by them as @ 400 kg/day (Large bakeries in the city are not using wood but are using HSD or electricity). Based on these figures the total wood consumption by bakeries works out to be 440 T/day.

Basis for Distribution

The bakeries are more or less evenly spread out in the city and hence wood consumption was distributed based on % of total population in a particular grid.

Wood Consumption in Cremetoria

Data Available

* Wardwise list of Hindu cremetoria.

* Death figures for 1991 from Health Dept., M.C.G.B.

* Wood consumption per dead body 500 Kg (obtained from a visit to cremetoria).

Data Derived

Deaths in Bombay 80,000 (1991).
Hindu Deaths (approx. 80%) = 64,000.
Deaths/day (approx.) = 175.

Hence wood consumption (Kg/day) = 175 x 500
for cremation (deaths/day) (wood reqd./body)

= 87,500 Kg/day
= 87.5 T/day

No. of cremetoria (Pvt. & Municipal) = 76

.........3/-

Hence the total wood consumption was distributed in the wards based on location of cremetoria in the wards. Daily use of wood in cremetoria is for burning purposes for dead bodies. Such use covered whole 24 hours period. Hence use of wood in Kg/hr was based on 24 hours usage period.

Wood Consumption in Slums

Data Available

Discussions with faculty members of Tata Institute of Social Sciences, Deonar showed that wood and not charcoal (as shown by the E.M.S. study) was used as fuel in slums. However, no figures were available to substantiate the total slum population using wood or the per capita wood consumption.

Data Derived

A study on "Energy Consumption in Pune City" conducted by S.P. College, Pune (1989) indicates that 20% of slum dwellers use firewood and average consumption is 180-200 Kg/capita/year. Since Pune city has a colder climate compared to Bombay the lower figures of 180 kg/capita/year was assumed for Bombay city. Based on the above, the total wood consumption by this source per day works out as given below :

Total Slum Population	= 28 lakhs
Assuming 20% population using wood	= 5.6 lakhs
Total wood consumption per year	= 5,60,000 x 180 (persons) x (kf/cap/day)
	= 1,00,800 T/year
	= 276 T/day.

This was distributed in the grids based on slum population in the grid. Daily use of wood in slum is extended over 10 hours period. Hence, to calculate the load in kg/hr this period was considered.

Total wood consumption

Since, bakeries and crematoria are situated in predominantly domestic areas the total wood consumption by these sources was added to wood consumption by slum population for estimating total wood consumption for Bombay city.

Total wood consumption = (Wood) cemetries + (Wood) bakeries + (Wood) slums

= 87.5 + 440 + 276
= 803.5 T/d.

Gridwise distribution of wood was added to arrive at total wood consumption per grid.

Data Gaps

* From the available data no energy consumption pattern could be derived for the urban population of Bombay. Attempts to derive energy consumption pattern gave rise to very conflicting results.

The S.P. College, Pune showed the fuel consumption pattern in slums is as below :

Energy requirements in slums :

SKO	70%
Wood	20%
Others (LPG/others)	10%

The per capita consumption of SKO is indicated by the study as 50 L/capacity/year. This works out to a average figure of 135 ML/capita/day. Assuming a higher value of 150 ML/capita/day the consumption pattern of SKO works out as under :

Slum Population (28 lakhs)==> Population using SKO (20 lakhs)(@ 70%)
SKO used in slums = 300 KL/day
(@ 150 ML/capita/day)

Available data indicates total domestic consumption for SKO as 1198 KL/day. Balance SKO of 898 KL/day when distributed on the basis of 150 ML/Capita/Day shows a total of 59.86 lakhs people using SKO. This means about 85% of non-slum population uses SKO which is a unreasonably high figure.

Even assuming 45% of total population as slum population (i.e. including the non-registered slums) the total SKO consumed by slums works out as under :

..........5/-

98 lakhs=======> 44.1 lakhs=========> 30 lakhs========> 463 KL/d
(Total Population) (Slum Population) (SKO users) (SKO consumed based on 150 ML/cap/day)

The balance 735 KL/day when distributed @ 150 ML/cap/day shows 49 lakh non-slum population using SKO which also works out to a high figure of 70%.

The LPG consumption for domestic purposes has been indicated by Rationing Inspectorate as 233235 MT/year (1,64,25000 cylinders/ year). Assuming requirement of each household as 1 cylinder/month or 12 cylinders/year.

No. of households using LPG works out to $= \frac{1,64,25000}{12}$

$= 13.69$ lakhs.

Assuming average size of each household as 5; total population using LPG works out to @ 68 lakhs which is @ 70% of Bombay's total population which is a very high figure.

The SKO consumption by establishments (Hotels/Restaurants) has been shown as 38 MT/day which is a very low figure considering numerous such establishments in the city.

Available data for Pune indicates that charcoal is used in slums by a very small amount of population (<5%). However, no quantification exists for Bombay.

Considering the above, it is very much apparent that data on fuel distribution by domestic sector is very much rudimentary and there is a urgent need to study the pattern of usage in these sectors and consider cost effective alternatives to reduce pollution from this sector.

ANNEXURE III

EMISSION FROM DOMESTIC SOURCES

Data Available

Fuel consumption by Domestic Sources for Total SKO/LPG and Wood consumption (inclusive of usage by establishments)

Emission Factors used :

Type of Source	Fuel burned	Unit	Particulates (Kg/unit)	SO_2 (Kg/unit)	NO_x (Kg/unit)
Domestic	Wood	t	13.7	0.5	5
	Kerosene	t	3	17(s)	2.3
Furnaces	LPG	t	0.42	0.02(s)	1.8

SOURCE : Rapid Assessment of sources of Air/Water and Land Pollution WHO Offset Publication No. 62.

ANNEXURE - IV

EMISSIONS FROM REFUSE BURNING

disposed - 4000 T/day.

	Quantity (T/day)	Available Area
	2526.5	200 acres
ka)	631.5	50 acres
	421.0	60 acres
vali)	421.0	20 acres

: Mr. D.K. Dhokale Astt. Engineer)
nagement, M.C.G.B.

d Waste has the following composition :

- 40% (by wt.)
- 22% (by wt.)
- 38% (by wt.)

100%

ition

- 10% (by wt.)
- 0.2% (by wt.)
- 0.2% (by wt.)
- 2% (by wt.)
- 3.6% (by wt.)
- 20% (by wt.)
- 38% (by wt.)
- 26% (by wt.)

100%

Although municipal officials claim that no refuse burning takes place (or is very negligible), a number of complaints are received and the fact that refuse burning does take place is definitely established.

The Air Quality Monitoring laboratory of the M.C.G.B. (Environmental Sanitation & Projects Dept.) has carried out air monitoring near the solid waste dump site at the time of refuse burning. The reports are as given below :

Parameters		Concentration	Sampling Period
TSP	2011	ug/m^3	16:30 to 22:15 hrs.
SO_2	702	ug/m^3	19:00 to 22:15 hrs.
No_2	164	ug/m^3	19:00 to 22:15 hrs.
NH_3	1014	ug/m^3	19:00 to 22:15 hrs.

There is no documented data on rate of burning; area of dump which is burnt or the emission factors.

To find out the rate of burning of the Solid Wastes it was decided to develop a Box Model and back calculate from the ambient monitoring data.

To find out total emissions from refuse burning discussions were held with residents in the neighbourhood, N.G.O.'s and factory owners near the Deonar dump. The findings from this discussions are as given below :

1) Refuse burning is an unauthorised activity of rag pickers operating at the dumps. Objective is to recover metallic scrap, glass and other valuables.

2) Fresh refuse is high in moisture content and is left to dry for 10-15 days. Generally the dry refuse is lighted at 4-5 p.m. and burns till late night 2-3 a.m.

3) The nuisance of the smoke is felt upto 3rd/4th floors and hence height of smoke plume can be guessed as 10-15 mt. Nuisance is felt upto a downwind distance of 3-4 km.

..........3/-

Box Model Calculations

From the above the emission from refuse burning (from Deonar site) were back calculated as below :

$$Cj = \frac{Qj}{u.W.D.}$$

It is assumed in the development of the box model that :

1) Air is transported through the volume with a face velocity of u and

2) the pollutants are assumed to be instantaneously and uniformly mixed throughout the volume of the box.

From the available data the following values were assigned to various variables :

u = Avg. wind velocity = 1 m/sec.
(Observed for night time from Santacruz data)

W = Width of box normal to wind direction = 500 m.

D = Depth of box normal to wind direction = 15m
(Elevation of 4 storeyed building)

Cj = Concentration recorded = 2011 ug/m^3.

= 2011×10^{-6} gm/m^3.

$$\text{Therefore } 2011 \times 10^{-6} = \frac{Qj}{1 \times 500 \times 15}$$

Qj = 15.0825 gm/sec.
= 54.297 Kg/hr.

Assuming WHO emission factor 8 Kg/T for SPM from Refuse burning, Quantity of Refuse burnt was calculated.

........4/-

Quantity burnt/hour $= \frac{54.297}{8} = 6.787$ T/hr.

Further calculations were carried out by applying WHO Emission Factors for SO_2/NO_x (by assuming above rate of burning). Thus emissions at Deonar for SO_2 and NO_x are estimated as :

SO_2 = 3.393 Kg/hr.

NO_x = 20.361 Kg/hr.

As no details regarding other sites are available it is assumed that refuse burning is proportional to daily quantity of waste dumped. Applying WHO emission factors the emission from these dumps are calculated as below :

Grid No.	Site	Wastes Dumped/day	SPM	SO_2 (kg/hour)	No_x
16-17	Deonar	2056	54.29	3.39	20.36
6-36	Chincholi + Gorai	842	22.22	1.39	8.34
17-30	Mulund	631.5	16.66	1.04	6.25

Data Gaps

No specific studies have been carried out as burning of refuse and the air pollution impact of these.

NEERI is currently carrying out a study under M.E.I.P. on this aspect. Results of this study will be shortly available.

ANNEXURE - V

STONE CRUSHER EMISSION

Data Available

Data on capacity of stone crushers was obtained from M.P.C.B. records.

The data collected shows that there are 19 registered stone crushers in Kandivali (Ward 'R'/North); 21 registered crushers in Dahisar (Ward R/North) and 7 in Andheri (Ward K/W) area.

No data is available of any air monitoring carried out close to these sites.

Emissions from Crushers

Emissions from stone crushers were calculated by using EPA emission factors as outlined below :

Type of Process Dry Crushing Operation	Suspended Dust Emission (Kg/MT)
Primary Crushing	0.05
Secondary Crushing/Screening	0.30
Tertiory Crushing/Screening	1.80
Recrushing & Screening	1.25
Fines Mill	2.25

The capacity of each crusher and the emission from them work out to very high loads as indicated in enclosed sheets. Hence, seperate box file has been prepared for this source.

Preparation of Box File

While preparing box file the following assumption were made :

1) The exact locations of the crushers on map were not known but as it is well known that these crushers are very close to each other they have been clubbed together and total emission has been shown from one particular grid only.

..............2/-

2) Micro level details of each crusher like the types of control measures existing, the method of transfer of rock, the moisture content of rock etc. are not known and it is assumed in preparation of the box file that all crushers have no installed control systems.

3) *It has been assumed that crusher operates for 24 hours and suspended particulate emissions reported as Kg/hour accordingly. However, normal period of operation of crushers is between 8:00 hrs. and 19:30 hrs. and emissions should be corrected for further accuracy in the box file.*

ANNEXURE -VI

BALANCE FUEL EMISSION FILE

Data available :

The consumption of various Petroleum fuels by industries in Bombay is available from four Petroleum Refineries selling their products in Bombay.The data on fuel consumption obtained from emission inventory carried out for URBAIR was compiled and used to prepare box file (area files) for industries for which adequate data was not available and for small scale industries.

Emission Inventory :

Data available thus far from emission inventory indicates the following :

1) There are about 40,000 odd commercial establishments and industries in Bombay. About 500-600 of these use fuel for combustion. (Very small scale and tiny units are not considered in preparing this estimate).

2) The data indicates the following pattern of fuel use :

Industry Type	Estimated Nos./Area Where Present	Fuel
Large (Chemical/Petrochemical)	3 (Chembur)	LSHS/Gas
Large (Engineering)	10-15 (Western/Central Suburbs)	LDO/LPG & small quantity LSHS.
Medium (Chemical/Pharmaceutical/ Textile)	250-275 (Western/Central Suburbs) (Textile Industires:Bombay Island)	FO/LSHS & small quantity LDO.
Medium (Dyeing/Printing/ Bleaching works)	50-75 (Western/Central Suburbs)	FO
Small Scale	100-150 (Western/Central Suburbs)	FO/LDO

.........2/-

In general, usage of LPG and SKO is restricted to Engineering industries. Usage of HSD is generally in Diesel generators/compressors and in large bakeries.

Fuel Usage :

Furnace Oil

About 839 T/d of Furnace Oil was sold in Bombay city in 1992-93. F.O. is used by industries in boilers for steam generation; of this 500 T/day was accounted for in the emissions inventory data gathered for preparation of POISOURC.DAT file. The balance 339 T/d was distributed in the grids based on number of industries in each grid for which adequate data is not available.

LSHS

The two Petroleum Refineries, Fertilizer Plant and the Power Plant together account for more that 3/4th of the LSHS consumption in the city.

These units are not allowed to burn Furnace Oil and use Associated Gas (available through pipeline from GAIL/ONGC) alongwith LSHS. For some part of the year, the Associated Gas supply from ONGC was affected and consequently LSHS consumption in the city has increased considerably.

LSHS Consumption by Tata Thernal

Tata Thermal has 6 units for power generation at Chembur. Unit Nos. 1,2,4 are normally on stand by and used for peaking the supply. Unit 3 has been decommissioned and is not in use. Unit 5 & 6 are of 500 MW capacity each. All units have multi-fuel capabilities. Unit 5 can fire LSHS/Coal/Gas whereas unit 6 can fire LSHS and Gas. The total daily heat requirement at Tata Thermal is estimated at 5.25×10^{10} Kcal/d and the fuels burnt for this consumption for 1992-93 work out as an average daily basis as (please refer enclosed sheets) :

2710 T	Oil (LSHS)	)	based on annualised sales figures of
1448 T	Gas	)	these products.
870 T	Coal	)	

........3/-

The higher LSHS requirement may be due to reduced supply of gas during the year form ONGC.

LSHS Consumption by Refineries

The Refineries (BPCL & HPCL) have daily usage of LSHS as 230 T and 534 T respectively (baed on MPCB Consent figures).

Fertilizer Factory (RCF)

RCF uses associated gas for steam generation and as feedstock for their plants. They have no consented LSHS usage.

Emission Inventory for URBAIR

The emission inventory could account for additional 450 T of LSHS usage by other Large/Medium Industries.

LSHS Consumption from Refinery Sales Figures

The total average per day sale for LSHS is put at 3312 T/day. The difference between the consumption figures (indicated above) and average sale per day comes out as :

{ 3312 } - { 2710 } - { 450 }
{Estimated Avg. Supply} {Tata Thermal} {Emission Inventory}

= 152 T/day

The total average daily usage of LSHS is estimated at

3312 + 534 + 230 = 4076 T/day
(Estimated Avg. Supply) (Refineries Own Consumption)

...........4/-

is highly variable, the daily consumption large factories in Chembur.

iated Gas changes the entire consumption units. This makes it very difficuilt to aily consumption figure based on yearly Considering the above, the balance LSHS of istributed in the grids while preparing files (*FUE.DAT).

plied per day in 1992-93. Of this about d for in the Emission Inventory. The buted in the grids based on number of r which adequate data is not available).

applied on an average basis in 1992-93. accounted for in the Emission Inventory. ributed in grids based on number of which adequate data is not available.

CALCULATION FOR TATA THERMAL

2 units 500 MW each

Each 500 MW requires 5000 T/d Coal OR 2500 T/d Oil.

Therefore Total requirement of fuels works out as 10000 T Coal or 5000 T Oil.

Therefore requirement works out to :

5000	x	10500	x	1000	=	5.25×10^{10} Kcal/d
Qty. in Tons	x	Kcal/kg	x	convert to Kg.	=	Tot. Heat Requirement

Tata have reported annual purchase of fuels as follows :

9,26,886 T LSHS
4,95,082 T Gas
2,97,556 T Coal

Corresponding Heat load/year works out as :

9.73×10^{12} Kcal/yr.
6.67×10^{12} Kcal/yr.
1.56×10^{10} Kcal/yr.

TOTAL **1.796×10^{13} Kcal**

For a total of 342 working days this gives a heat load/day as 5.25×10^{10}.

Therefore Total Oil required/day = 2710 T/d.
Total Gas supply/day = 1448 T/d.
Total Coal supply/day = 870 T/d.

Comments :

This has been worked out considering tat total fuel purchased by the plant in the year has been utilized. Quantities in stock have not been considered and daily average consumption may vary to that extent.

ANNEXURE - VII

BASIS OF PREPARATION OF POISOURC.DAT

Data Available

Data on emissions from industries was gathered from the applications made by them to obtain MPCB consents. Data was gathered for about 210 industries belonging primarily to large and medium sector. Data was collected on the basis of following criteria :-

F.O. consumption > 200 T/year
LSHS consumption > 500 T/year

Data collected included, physical details of stacks and data on type of emisions, velocity, flow rate and monitoring data wherever available.

Preparation of Poisourc.dat File

This is on following basis :

1) Wherever possible monitoring data (as submitted by Industries) has been used to calculate emission load. Only where monitoring data was entirely absent, emissions were calculated from fuel quantity.

2) No data is required to be submitted by Industries on total NO_x emission and hence this data was entirely computed from emission factors.

3) Emission Factors used for calculations are as given below :

Type Of Fuel	Unit	Particulates	SO_2	NO_x
Bituminous Coal	t	6.5 (A)	19(s)	7.5
Fuel Oil	t	2.87	19(s)	7.5
LPG	t	0.38	0.02(s)	2.6
Natural Gas	t	0.34	20(s)	3.6

........2/-

where A = % Ash
S = % Sulphur by wt.

There is only one power plant in Bombay and emissions were directly taken from actual monitored levels at the plant.

Process emissions in Bombay are unimportant compared to the large number of stacks connected to fuel sources. Wherever available data from such sources is collected and complied in Poisour.dat file.

4) Building heights and widths were not available for buildings nearest to the chimney and hence default width and heights of 30m and 10m were given in the file.

Data Gaps

* A wide variation is observed in the monitored data and data calculated from emission factors. This maybe because of any of the following reasons :

  a) Low amount of sulphur in fuels compared to those available in standard specifications. For example : BPCL specifications for FO shows Sulphur content between 3.5 - 4% whereas actual observed level is between 2.5-3%. Similarly for LSHS actual % observed is between 0.5-0.7% whereas specifications shows sulphur content of 1%.

  b) Greater amount of excess air used by the industries.

  c) Inaccurate monitoring practices adopted.

* The type of data in MPCB files is not up-to-date and should be improved.

* NO_X monitoring is not required by MPCB, even when there is a ambient air standard prescribed for the same.

ANNEX - VIII

BASIS FOR DATA FILES

Sr. No.	File Name	Basis	Source	Additional Details
	WORKSHEET FILES			
1.	POPDIST1.WK1	Census districtwise popu--lation distribution for year 1991. Distribution into grids based on actual area of census districts in each grid.	BMRDA	Annexure-I
2.	FUELCOND.WK1	-	-	Annexure-II
	LPG (Domestic)	Total Usage : 639 TPD. Period of Use: 10 hrs/day. User : Non-slum population.	Rationing Office.	-
	SKO (Domestic)	Total Usage: 1236 KL/day. Period of Use:10 hrs/day. User : Slum/Non-slum population.	Rationing Office.	-
	Wood (Domestic)	Total Usage : 276 TPD. Period of Use: 10 hrs/day. User: 20% slum population.	S.P. College Pune study.	-
	Wood (Bakeries)	Total Usage : 440 TPD. Period of Use: 12 hrs/day. User : Bakeries.	Bakeries Association.	-
	Wood (Crematoria)	Total Usage : 87.5 TPD. Period of Use: 24 hrs/day. User : Crematoria.	Health Dept./ BMC & visits to crematoria.	-

Sr. No.	File Name	Basis	Source	Additional Details
	Total Wood	Gridwise addition of wood consumption by domestic source + bakeries + crematoria.	-	-
3.	EMISNDOM.WK1	Emissions from Domestic fuel usage. Emission Factors-W.H.O.	Fuel Data from FUELCOND.WK1.	Annexure-III
	BOX FILES			
4.	POPDIST.DAT	Population distribution in box.	Data from POPDIST1.WK1 file.	Annexure-I
5.	SLUMDIST.DAT	Slum population distri--bution in box.	Data from POPDIST1.WK1 file.	Annexure-I
6.	BLDG-HT.DAT	Average building height in grid.	Own observations.	-
7.	**DOMESTIC DATA FILES**			
7.1	SPMARDOM.DAT	Area source SPM from LPG /SKO/Total Wood.	Data from FUELCOND.WK1 & EMISNDOM.WK1.	-

.........3/-

Sr. No.	File Name	Basis	Source	Additional Details
7.2	SO2ARDOM.DAT	Area source SO_2 from LPG/SKO/Total Wood.	Data from FUELCOND.WK1 & EMISNDOM.WK1.	-
7.3	NOXARDOM.DAT	Area source NOx from LPG/SKO/Total Wood.	Data from FUELCOND.WK1 & EMISNDOM.WK1.	-
8.	REFUSE BURNING			
8.1	SPMARSW.DAT	Area source SPM from Solid Waste (Refuse burning). E.F. - W.H.O. & moni--toring data from M.C.G.B.	Box Model calculations.	Annexure-IV
8.2	SO2ARSW.DAT	Area source SO_2 from Solid Waste (Refuse burning). E.F. - W.H.O.	Box Model calculations.	Annexure-IV
8.3	NOXARSW.DAT	Area source NOx from Solid Waste (Refuse burning). E.F. - W.H.O.	Box Model calculations.	Annexure-IV
9.	STONE CRUSHERS			
9.0	SPMARCRU.DAT	Area source SPM from Stone crushers.	E.F. - EPA Capacity of crushers MPCB files.	Annexure-V

.........4/-

Sr. No.	File Name	Basis	Source	Additional Details
10.	<u>BALANCE FUEL DISTRIBUTION</u>			
10.1	SPMARFUE.DAT	Area source SPM from from Balance Fuel consumption.	Total fuel consumption from POISOURC.DAT and Sale Figures from Petroleum Companies.	Annexure-VI
10.2	SO2ARFUE.DAT	Area source SO_2 from from Balance Fuel consumption.	Total fuel consumption from POISOURC.DAT and Sale Figures from Petroleum Companies.	Annexure-VI
10.3	NOXARFUE.DAT	Area source NO_x from from Balance Fuel consumption.	Total fuel consumption from POISOURC.DAT and Sale Figures from Petroleum Companies.	Annexure-VI
11.	<u>POINT SOURCE DATA FILES</u>			
11.0	POISOURC.DAT	Emission from industries.	MPCB files (Monitoring data submit- -ted by industries) + E.F. - WHO.	Annexure-VII

Appendix 5

Emission factors, particles

Emission factors, particles

1 Introduction

Emission factors (emitted amount of pollutant per quantity of combusted fuel, or per km driven, or per produced unit of product) are important input data to emission inventories, which again are essential input to dispersion modelling.

The knowledge of emission factors representative for the present technology level of Asian cities is limited. For the purpose of selecting emission factors for the URBAIR study, references on emission factors were collected from the open literature and from studies and reports from cities in Asia.

This appendix gives a brief background for the selection of emission factors for particles used in the air quality assessment part of URBAIR.

2 Motor vehicles

The selection of emission factors for motor vehicles for use in the URBAIR project to produce emission inventories for South-East Asian cities, was based on the following references:

- WHO (1993)
- US EPA (EPA AP42 report series) (1985)
- Vehicles Emission Control Project (VECP), Manila (Baker, 1993)
- Indonesia (Bosch, 1991)
- Williams et al. (1989)
- Motorcycle emission standard and emission control technology (Weaver and Chan, 1993)

Table 1 gives a summary of emission factors from these references for various vehicle classes. From these, the emission factors given in Table 2 were selected, for use as a basis for URBAIR cities.

Taking account of the typical vehicle/traffic activity composition, the following vehicle classes give the largest contributions to the total exhaust particle emissions from traffic:

- Heavy duty diesel trucks
- Diesel buses
- Utility trucks, diesel
- 2-stroke 2- and 3-wheelers.

Thus, the emission factors for these vehicle classes are the most important ones.

Table 1: Emission factors (g/km) for particle emissions from motor vehicles, relevant as a basis for selection of factors to be used in South-East Asian cities.

Fuel and Vehicle	Particles g/km	Reference
Gasoline		
Passenger cars	0.33	USEPA/WHO
	0.10	VECP, Manila
	0.16	Indonesia (Bosch)
	0.07	Williams
Trucks, utility	0.12	VECP, Manila
	0.33	USEPA
		USEPA
Trucks, heavy duty	0.33	USEPA
3-wheelers, 2 stroke	0.21	USEPA/WHO
MC 2/4 stroke	0.21/	USEPA/WHO
	2.00/	VECP, Manila
	0.21/0.029	Indonesia VWS
	0.28/0.08	Weaver and Chan
Diesel		
Car, taxi	0.6	VECP, Manila
	0.45	USEPA/WHO
	0.37	Williams
Trucks, utility	0.9	VECP, Manila
	0.93	EPA
Trucks, heavy/bus	0.75	WHO
	1.5	VECP, Manila
	0.93	USEPA
	1.2	Bosch
	2.1	Williams

Table 2: Selected emission factors (g/km) for particles from road vehicles used in URBAIR.

Vehicles class	Gasoline	Diesel
Passenger cars/taxies	0.2	0.6
Utility vehicles/light trucks	0.33	0.9
Motorcycles/tricycles	0.5	
Trucks/buses		2.0

Comments

It is clear that there is not a very solid basis in actual measurements on which to estimate particle emission factors for vehicles in South-East Asian cities. The given references represent the best available basis. Comments are given below for each of the vehicle classes.

Gasoline:

Passenger cars:	Fairly new, normally well maintained cars, engine size less than 2.5 l, without 3-way catalyst, running on leaded gasoline (0.2-0.3 g Pb/l), have an emission factor of the order of 0.1 g/km. Older, poorly maintained vehicles may have much larger emissions. The US EPA/WHO factor of 0.33 g/km can be used as an estimate for such vehicles.
Utility trucks:	Although the VECP study (Manila) uses 0.12 g/km, we select the EPA factor of 0.33 g/km was selected for such vehicles, taking account of generally poor maintenance in South-East Asian cities.
Heavy duty trucks:	Only the USEPA have given an estimate for such vehicles, 0.33 g/km, the same as for passenger cars and utility trucks.
3-wheelers, 2 stroke:	The USEPA and WHO suggest 0.2 g/km for such vehicles.
Motorcycles, 2 stroke:	The Weaver report supports the 0.21 g/km emission factor suggested by USEPA/WHO. In the VECP Manila study a factor of 2 g/km is suggested. This is the same factor as for heavy duty diesel trucks, which seems much too high. Visible smoke emissions from 2-stroke 2- and 3-wheelers is normal in South-East Asian cities. Low-quality oil as well as worn and poorly maintained engines probably both contribute to the large emissions. The data base for selecting a representative emission factor is small. In the data of Weaver and Chan (1993), the highest emissions factor is about 0.55 g/km. For URBAIR, we choose a factor of 0.5 g/km. Realizing that this is considerably higher than the factor suggested by US EPA, we also have a view to the factor 2 g/km used in the VECP study in Manila, which indicates evidence for very large emissions from such vehicles.
Motorcycles, 4-stroke:	The emission factor is much less than for 2-stroke engines. The Weaver report gives 0.08 g/km, while 0.029 g/km is given by the VWS study in Indonesia (Bosch, 1991).

Diesel:

Passenger cars, taxis: The factor of 0,6 g/km given by the VECP Manila is chosen, since it is based on measurements of smoke emission from vehicles in traffic in Manila. The 0,45 g/km of USEPA/WHO was taken to represent typically maintained vehicles in Western Europe and USA, as also measured by Larssen and Heintzenberg (1983) on Norwegian vehicles. This is supported by the Williams' factor of 0,37 g/km for Australian vehicles.

Utility trucks: The USEPA and the VECP Manila study give similar emission factors, about 0,9 g/km.

Heavy duty trucks/ buses: The factors given range from 0,75 g/km to 2,1 g/km.

It is clear that "smoking" diesel trucks and buses may have emission factors even much larger than 2 g/km. In the COPERT emission data base of the European Union (   ), factors as large as 3-5 g/km are used for "dirty" city buses. Likewise, based on relationships between smoke meter reading (e.g. Hartridge smoke units, HSU) and mass emissions, it can be estimated that a diesel truck with a smoke meter reading of 85 HSU, as measured typically on Kathmandu trucks and buses (Rajbahak and Joshi, 1993), corresponds to an emission factor of roughly 8 g/km!

As opposed to this, well maintained heavy duty diesel trucks and buses have an emission factor of 0,7-1 g/km.

As a basis for emission calculations for South-East Asian cities we choose an emission factor of 2 g/km. This corresponds to some 20% of the diesel trucks and buses being "smoke belchers". A larger fraction of "smoke belchers", such as in Kathmandu, will result in a larger emission factor.

3 Fuel combustion

Oil

The particle emission factors suggested by USEPA (AP 42) is taken as a basis for calculating emissions from combustion of oil in South-East Asian cities. The factors are given in Table 3.

Table 3: Emission factors for oil combustion (Ref.: US EPA, AP 42). (kg/m³)

	Emission factor	
	Uncontrolled	Controlled
Utility boilers		
Residual oil[a)]		
Grade 6	1.25(S)+0.38	×0.008 (ESP)
Grade 5	1.25	×0.06 (scrubber)
Grade 4	0,88	×0.2 (multicyclone)
Industrial/commercial boilers		
Residual oil	(as above)	×0.2 (multicyclone)
Distillate oil	0.24	
Residential furnaces		
Distillate oil	0.3	

S: Sulphur content in % by weight

a): Another algorithm for calculating the emission factors is as follows: 7,3xA kg/m^3, where A is the ash content of the oil.

4 References

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Appendix 6

Population exposure calculations

Population exposure calculations

The basis for the calculations of the exposure of the Bombay population to TSP is the following:

1. The population distribution, calculated per km^2 as described in Appendix 2, Chapter 2, and shown in Figure 2 in that appendix.

2. The TSP distribution in Bombay, calculated by dispersion modelling as annual average concentration in km^2 grids (city background) described and shown in Chapter 2.3.2 in the main report.

These two distributions are combined, and give an estimate of the residential exposure frequency distribution shown in Table 1 of this Appendix, 1. and 2. columns.

This residential exposure is modified to account for additional roadside exposure experienced by drivers, commuters and roadside workers. This modification is done in the following way:

- 300,000 drivers are given fairly high annual exposures:
  100,000 at 195 $\mu g/m^3$
  100,000 at 205 $\mu g/m^3$
  100,000 at 215 $\mu g/m^3$

- 1,500,000 commuters are given a moderately high annual exposure (see 3rd column, Table 1)
  500,000 at 125 $\mu g/m^3$
  500,000 at 155 $\mu g/m^3$
  500,000 at 175 $\mu g/m^3$

  which is thought to correspond to commuting on intermediate, high and very high traffic density roads.

These 1.8 million people are then subtracted from the residence distribution, somewhat arbitrarily at equal rate from exposure classes between 95 $\mu g/m^3$ and 185 $\mu g/m^3$ (see 4th column, Table 1), i.e. the residents of the commuters and drivers are thought to be in moderately-to-fairly highly exposed areas.

This modification gives the total exposure frequency distribution of Table 2, column 5.

Columns 6 and 7 of Table 1 give the resulting cumulative distributions.

Figure 1 shows the calculated exposure distributions.

The residential distribution show that most people are exposed to annual concentrations between 110-140 $\mu g/m^3$ (annual average TSP). Small fractions of the population are exposed to higher concentrations near specific particle sources, which are stone quarries. The roadside exposure causes a considerably increased exposure for a considerable part of the population.

Table 1: Calculated distributions (%) of population exposure to tSP (annual average, µg/m³) in Bombay, 1993.

Exposure class TSP, µg/m³	Residential exposure, freq. distr.	Traffic exposure modification		Total exposure freq.distr.	Cumulative distr.	
		Add.	Subtr.		Residential	Total
55	0			0	99.843	99.873
65	0			0	99.843	99.873
75	1.085			1.085	99.843	99.873
85	6.007			6.007	98.758	98.788
95	8.405		1.83	6.575	92.751	92.781
105	10.800		1.83	8.970	84.346	86.206
115	19.008		1.83	17.178	73.546	77.236
125	22.662	5.09	1.83	25.922	54.538	60.058
135	19.600		1.83	17.770	31.876	34.136
145	3.900		1.83	2.070	12.276	16.366
155	1.100	5.09	1.83	4.360	8.376	14.296
165	1.400		1.83	-0.430	7.276	9.936
175	0.846	5.09	1.83	4.106	5.876	10.366
185	1.868		1.83	0.038	5.03	6.260
195	0.143	1.02		1.163	3.162	6.222
205	0.218	1.02		1.238	3.019	5.059
215	0.466	1.02		1.486	2.801	3.821
225	0.302			0.302	2.335	2.335
235	0.606			0.606	2.033	2.033
245	0.093			0.093	1.427	1.427
255	0.518			0.518	1.334	1.334
265	0.108			0.108	0.816	0.816
275	0			0	0.708	0.708
285	0.020			0.020	0.708	0.708
295	0.270			0.270	0.688	0.688
305	0.152			0.152	0.418	0.418
315	0.266			0.266	0.266	0.266
325	0			0	0	0
335	0			0	0	0

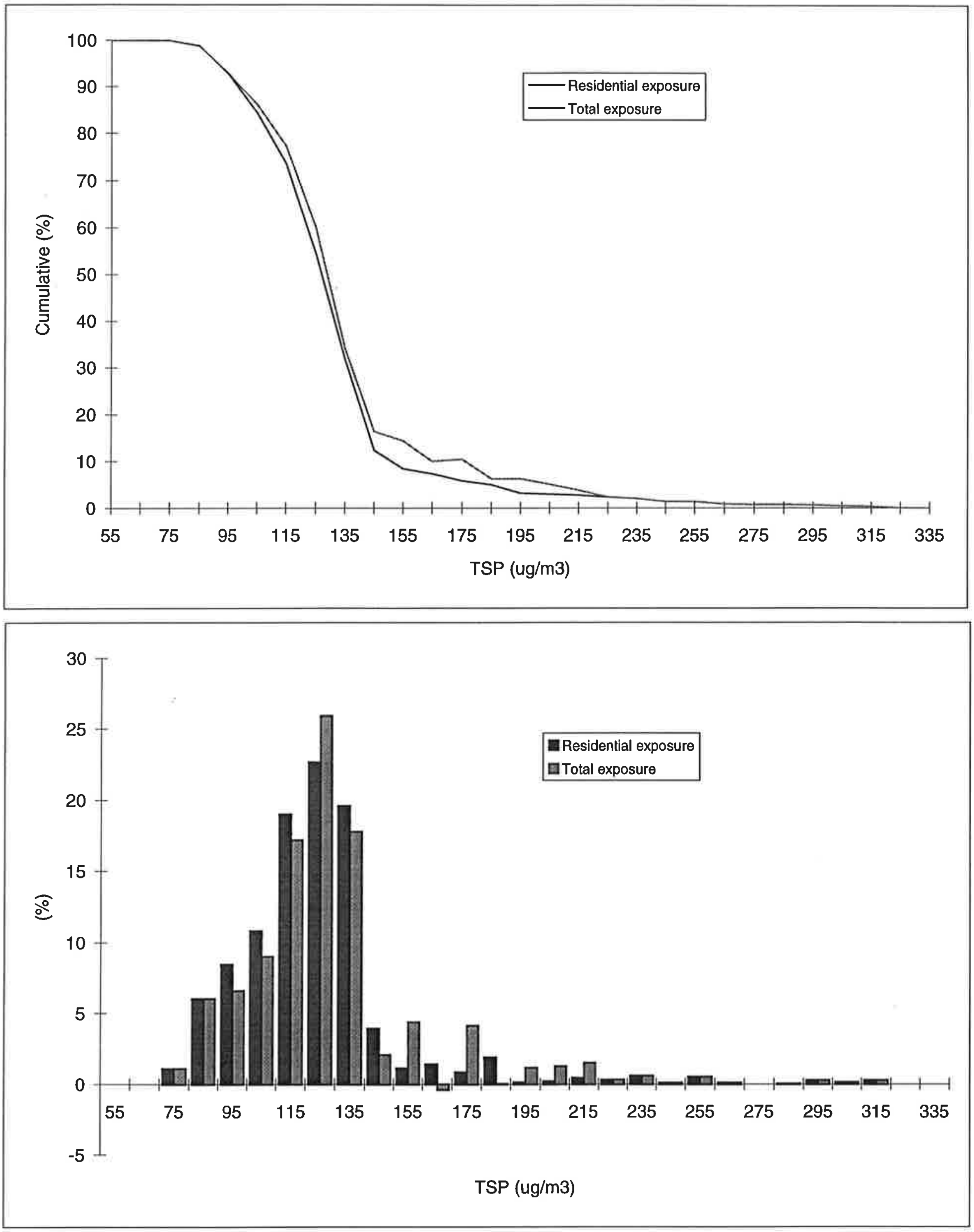

Figure 1: Calculated distributions of population exposure to TSP (annual average) in Bombay, 1993.

Appendix 7

Spreadsheet for calculating effects of control measures on emissions

Spreadsheet for calculating effects of control measures on emissions

1 Emissions spreadsheet

The spreadsheet is shown in Figure 1. (Example: TSP emissions, Greater Bombay, Base Case Scenario, 1992.) Figure 2 shows emission contributions in absolute and relative terms.

The purpose of the spreadsheet is to calculate modified emission contributions, due to control measures, such as:

- new vehicle technology
- improved emission characteristics, through measures on existing technology
- reduced traffic activity/fuel consumption
- other.

The emissions are calculated separately for large point sources (with tall stacks) and for area sources and smaller distributed point sources. The reason is that air pollution concentrations and population exposures are calculated differently for these two types of source categories.

The colums and rows of the worksheet are as follows:

Columns

a)	q	Emission factor, g/km for vehicles, kg/m^3 or kg/ton for fuel combustion and process emissions. For vehicles, emission factors are given for "existing" and "new" technology.
b)	F,T	Amount of "activity" T (vehicle km) for traffic activity F (m^3 or ton) for fuel consumption in industrial production.
c)	qT,qF	Base case emissions, tons, calculated as product of columns a) and b).
d)	fq, fF, fT, f-	Control measures. Relative reduction of emission factor (fq), amount (fF, fT) or other (f-) resulting from control measures.

Emissions spreadsheet, Greater Bombay
TSP, Base case, 1992

		Emission factor	Amount	Base-case Emissions	Control measures			Modified emissions	Relative emissions per category	Relative emissions total
LARGE POINT SOURCES										
		q (kg/t)	F (10E3 t/a)	qF (tonnes)	fq	fF	f-	qF fq fF f (10E3 tonnes)	(dqF fq fFf) (percent)	(dqF fq fFf)tot (percent)
Power plant	LSHS	0.10	927	93	1.00	1.00	1.00	93		6.7
	Coal	0.50	298	149	1.00	1.00	1.00	149		10.8
	Gas	0.06	496	30	1.00	1.00	1.00	30		2.2
Petrochem. ind.	LSHS	0.28	279	78	1.00	1.00	1.00	78		5.6
Large/med. ind.	LSHS	0.28	164	46	1.00	1.00	1.00	46		3.3
	FO	5.40	183	988	1.00	1.00	1.00	988		71.4
Sum large point sources				**1384**				**1384**		**100.0**
Modified emissions/emissions, point sourc.								1		
DISCRETE AREA SOURCES										
Waste dumps					1.00	1.00	1.00			
Stone crushers					1.00	1.00	1.00			
Sum discrete area sources				0.00				0		
Modified emissions/emissions, discr. area sourc.										
DISTRIBUTED AREA SOURCES										
Vehicles		q (g/km)	T (10E9 vehkm/a)	qT (tonnes)	fq	fT	f-	qT fq fTf (10E3 tonnes)	(dqT fq fTf) (percent)	(dqT fq fTf) (percent)
Gasoline exhaust										
Cars, taxis		0.20	2.46	492	1	1	1	492	13.4	2.0
MC/TC		0.50	1.47	735	1	1	1	735	20.0	3.0
Sum gasoline				1227				1227		5.0
Modified emissions/emissions, gasoline								1		
Diesel exhaust										
Cars, taxis		0.6	1.27	762	1	1	1	762	20.8	3.1
Trucks		2.0	0.62	1240	1	1	1	1240	33.8	5.0
Buses		2.0	0.22	440	1	1	1	440	12.0	1.8
Sum diesel				2442				2442	100.0	9.9
Modified emissions/emissions, diesel								1		
Sum total vehicle exhaust				3669				3669		14.8
Modified emissions/emissions, total vehicle exhaust								1.00		
Resuspension		2.0	6.04	12080	1	1	1	12080		48.8
Sum total vehicles (exh.+resusp.)				**15749**				**15749**		**63.7**
Modified emissions/emissions, total vehicles (exh.+resusp.)								1.00		
Fuel combustion		q (kg/t)	F (10E3 t/a)	qF (tonnes)	fq	fF	f-	qF fq fF f (10E3 t/a)	(dqF fq fFf)fuel (percent)	(dqF fq fFf)tot (percent)
Industrial										
LHSH		0.28	56	15.68	1.00	1.00	1.00	15.68	0.2	0.1
FO		5.40	123	664.20	1.00	1.00	1.00	664.20	7.4	2.7
LDO		0.28	42	11.76	1.00	1.00	1.00	11.76	0.1	0.0
Diesel (HSD)		0.28	40	11.20	1.00	1.00	1.00	11.20	0.1	0.0
LPG		0.06	7	0.42	1.00	1.00	1.00	0.42	0.0	0.0
Sum industrial				703.26				703.26		2.8
Modified emissions/emissions, industrial								1.00		
Domestic										
Wood		15.00	293	4395.00	1.00	1.00	1.00	4395.00	48.9	17.8
SKO		0.06	480	28.80	1.00	1.00	1.00	28.80	0.3	0.1
LPG		0.06	233	13.98	1.00	1.00	1.00	13.98	0.2	0.1
Coal		10.00		0.00	1.00	1.00	1.00	0.00	0.0	0.0
Dung		10.00		0.00	1.00	1.00	1.00	0.00	0.0	0.0
Refuse		37.00	104	3848.00	1.00	1.00	1.00	3848.00	42.8	15.6
Sum domestic				8285.78				8285.78		33.5
Modified emissions/emissions, domestic								1.00		
Sum fuel combustion				**8989.04**				**8989.04**	100.0	**36.3**
Modified emissions/emissions, fuel								1.00		
Miscellaneous		q	M	qM	fq	fM	f-	qM fq fM f	(dqM fq fMf)misc (percent)	(dqM fq fMf)tot (percent)
Construction										
Sum miscellaneous				0	1	1	1	**0**	0.0	**0.0**
Modified emissions/emissions, misc.								#DIV/0!		
Sum total distributed area sources				**24738.04**				**24738.04**		**100.00**
Modified emissions/emissions, distr. area sources								1.00		

Figure 1: URBAIR spreadsheet for emissions calculations.

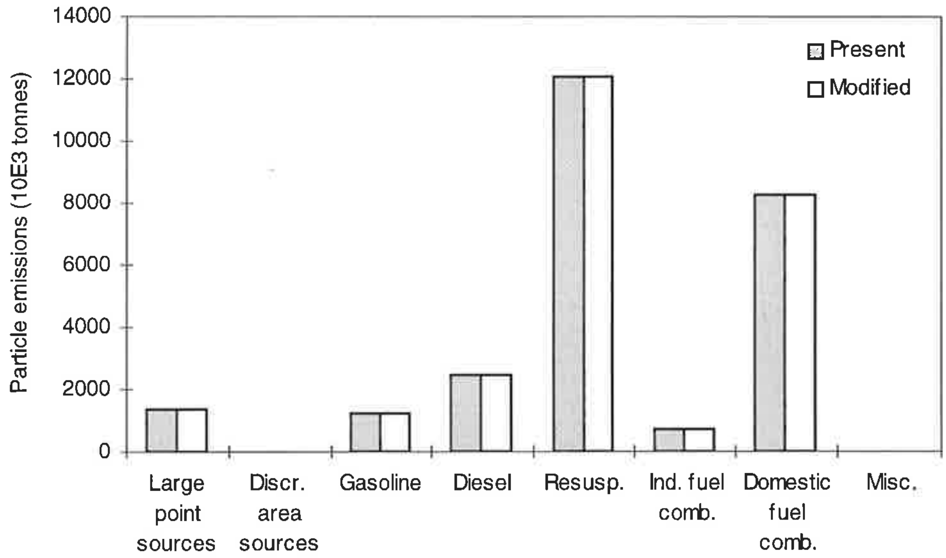

Figure 2: Emissions contributions from various source categories.

e)	qFfqfFf-	Modified emissions, due to control measures.
f)	d(qFfqfFf-)	Relative emission contributions from each source, per source category: - vehicles - fuel combustion - industrial processes - miscellaneous
g)	d(qFfqfFf)	Relative emissions contributions, all categories summed.

Rows

a) Separate rows for each source type and category, "existing" and "new" technology.

b)	"Background"	:	Fictitions emissions, corresponding to an extra-urban background concentration.
c)	Modified emission/emissions	:	Ratio between modified and base case emissions.

Appendix 8

Project Descriptions, Local consultants

Project description regarding Air Quality Assessment

18 May 1993

ANNEX 2

Project Description

This Project Description describes the work to be carried out under the Contract of 18 May 1993 between Norwegian Institute for Air Research (NILU) and Aditya Environmental Services, Bombay.

Information shall be collected regarding the items described below. The information to be collected shall go beyond the information contained in the material referenced in the Draft Report from NILU and Institute of Environmental Studies (IES) of the Free University of Amsterdam prepared for the Workshop, and summarized in that report.

Available information shall be collected regarding the following items, and other items of interest for Air Quality Management Strategy Development in Bombay:

- Meteorological measurements in and near the city
- Activities/population data for Bombay:

Fuel consumption data:	Total fuel consumption - per type (high/low sulphur oil, coal, gas, firewood and other biomass fuels, other) - per sector (industry, commercial, domestic)
Industrial plants:	- Location (on map), type/process, emissions, stack data (height, diameter, effluent velocity and temp.)
Vehicle statistics:	- No. of vehicles in each class (passenger cars, trucks (small, med., large), buses, MC (2 and 3-wheels, 2 and 4 stroke - Age distribution - Average annual driving distance per vehicle class
Traffic data:	Definition of the main road network marked on map. Traffic data for the main roads: - annual average daily traffic (vehicles/day) - traffic speed (average, and in rush hours) - vehicle composition (pass.cars, MCs, trucks/buses)
Population data:	Per city district (as small districts as possible) - total population - age distribution

- Air pollution emissions — Emission inventory data (annual emissions)
  - per compound (SO_2, NO_X, particles (in size fractions: <2 µm, 2-10 µm, >10 µm), (VOC, lead)
  - emissions per sector (industry, transport, domestic, etc.)

- Air pollution data:
  - concentration statistics per monitoring station: annual average, 98-percentile, maximum concentrations (24 hr, 1 hr)
  - trend information
  - methods description, and quality control information on methods

- Dispersion modelling: Reports describing studies and results

- Air pollution laws and regulations: Summary of existing laws and regulations

- Institutions: Description of existing institutions working in, and with responsibilities within, the air pollution sector, regarding:
  - monitoring
  - emission inventories
  - law making
  - enforcement

  The information shall include:
  - the responsibilities and tasks of the institutions
  - authority
  - manpower
  - expertise
  - equipment (monitoring, analysis, data hard/software)
  - funds

It is important that the gathering of information is as complete as possible regarding each of the items, so that we have a basis of data which is as updated and complete as possible. Remember that this updated completed information data base is to form the basis for an action plan regarding Air Quality Management in Jakarta. Such an action plan will also include the need to collect more data. In that respect, it is very important that the gathering of existing data is complete.

Project description regarding Damage Assessement and Economic Valuation

Project Description

URBAIR

Topics for research

A. Physical Impacts

1. Describe available studies on relations between air pollution and health.

2. Decide on the acceptability of dose - effect relationships from USA (tables 5.7 - 5.9).
   a. Mortality: 10 $\mu g/m^3$ TSP leads to 0.682 (range: 0.48-0.89) percentage change in mortality.
   b. Work loss days (WLD): 1 $\mu g/m^3$ TSP leads to 0.00145 percentage change in WLD.
   c. Restricted activity days (RAD): 1 $\mu g/m^3$ TSP leads to 0.0028 percentage change in RAD per year.
   d. Respiratory hospital diseases (RHD): 1 µg TSP leads to 5.59 (range: 3.44-7.71) cases of RHD per 100,000 persons per year.
   e. Emergency room visits (ERV): 1 $\mu g/m^3$ TSP leads to 12.95 (range: 7.1-18.8) cases of ERV per 100,000 persons per year.
   f. Bronchitis (children): 1 $\mu g/m^3$ TSP leads to 0.00086 (range: 0.00043-0.00129) change in bronchitis.
   g. Asthma attacks: 1 $\mu g/m^3$ TSP leads to 0.0053 (range: 0.0027-0.0079) change in daily asthma attacks per asthmatic person.
   h. Respiratory symptoms days (RSD): 1 $\mu g/m^3$ TSP leads to 1.13 (range: 0.90-1.41) RSD per person per year.
   i. Diastolic blood pressure (DBP): change in DBP = 2.74 ($[Pb \text{ in blood}]_{new}$ - $[Pb \text{ in blood}]_{old}$) with [Pb in blood] is blood lead level (µg/dl).
   j. Coronary heart disease (CHD): change in probability of a CHD event in the following ten years is $[1 + \exp - \{ - 4.996 + 0.030365(DBP_1)\}]^{-1}$ –

$$\{ 1 + \exp - \{ - 4.996 + 0.0030365 \, (DBP_0) \} \}^{-1}$$

   k. Decrement IQ points: IQ decrement = 0.975* change in air lead ($\mu g/m^3$).

Calculation example.

Let population be 10 million people.
Let threshold value of TSP be 75 μg/m³ (the WHO standard).
Let the concentration TSP be 317 μg/m³.
--> Concentration - threshold = 317 - 75 = 242 = 24.2 10 μg/m³.
--> Change in mortality = 24.2 * 0.682 = 16.5%.
Let crude mortality be 1% per year.
--> Crude mortality = 100,000 people per year.
--> Change in mortality due to TSP = 16.5% of 100,000 people = 16,500 people per year.

3. For those close -effect relationships that are acceptable, base value must be gathered, e.g.:
   a. crude mortality
   b. present work days lost
   etc.

B. Valuation

1. Mortality.
   a. Willingness to pay.
   In USA research has been carried out on the relation between risks of jobs and wages. It appeared that 1 promille of change in risk of mortality leads to a wage difference of ca. $1000. If this figure is applicable to all persons of a large population (say 10 million), the whole population values 1 promille change in risk of mortality at $1000 * 10 * 10^6 = $ 10 billion. An increase in risk of 1 promille will lead to ca. 10,000 death cases, so per death case the valuation is $ 1 million. It should be decided if in other countries, e.q. cities, this valuation should be corrected for wage differences (e.g. if the average wage is 40 times lower than in USA, the valuation of 1 death case is $25,000). If this approach is acceptable, the only information needed is average wage.
   b. Production loss.
   If the approach of willingness to pay is not acceptable, the alternative is valuing human life through production loss, i.e. foregone income of the deceased. Again,

the information needed is average wage. Moreover, information is needed on the average number of years that people have a job. However, those without a job should also be assigned a value. An estimate of the income from informal activities can be an indication. Otherwise a value derived from the wages (e.g. half the average wage) can be a (somewhat arbitrary) estimation.

2. Morbidity.
Estimates are needed, for all cases of morbidity, of the duration of the illness, so as to derive an estimation of foregone production due to illness. Just as in the case of mortality (B. 1.b.) wages can be used for valuation of a lost working day. Moreover, the hospital costs and other medical costs are to be estimated. These costs still do not yet include the subjective costs of illness, which can be estimated using the willingness to pay to prevent a day of illness.

3. Willingness to pay to prevent a day of illness.
Valuation in USA, based on surveys among respondents, indicate that the willingness to pay to prevent a day of illness is ca. $15. This amount could, just like the amount of willingness to pay for risk to human health, be corrected for wage differences. The acceptability of such a procedure is, perhaps, somewhat lower.

4. IQ points.
Loss of IQ of children may lead to a lower earning capacity. A USA estimate is ca. $4600 per child, per IQ point, summed over the child's lifetime. If this is acceptable, the figure could be corrected for wage differences between USA and the city.

C. Other impacts

1. Buildings.
An estimate by Jackson et al, (see URBAIR report table 5.18) is that prevented cleaning costs per household per year are $42 for a reduction in TSP concentration: from 235 $\mu g/m^3$ to 115 $\mu g/m^3$. This would imply a benefit of $0.35 per household per $\mu g/m^3$ reduction. This figure could be corrected for wage differences between USA and the city. If that is acceptable, the information needed is the number of households in the city.

2. Monuments.

It is difficult to say which value is attached to monuments, as they are often unique and their value is of a subjective character. Nevertheless, the restoration and cleaning costs of monuments could be an indication of the order of magnitude of damage to monuments. Revenue of tourism might also give a certain indication of the valuation of future damage to monuments.

D. Remark

In most cases, the valuation of damage is not very precise, and certainly not more than an indication of the order of magnitude.

E. Technological Reduction Options

To give a reliable estimate of the costs of technological reduction options, one needs a reliable emission inventory in which is included the currently used technologies and the age and replacement period of the installed equipment. In the absence of this, the study by the city team might wish to concentrate on a case study (e.g. traffic, fertilizer industry, large combustion sources).

The first step is to identify options. Cooperation with IES is possible, once a case study is identified.

The second step is to estimate the costs, i.e. investment costs and O&M (operation and maintenance) costs. Based on the economic lifetime of the invested equipment, the investment costs can be transformed to annual costs, using writing-off procedures. Costs will often depend to a large extent on local conditions. Corrections of the costs are described in chapter 6 of the URBAIR report.

The third step is to estimate the emission reductions of the various reduction options.

The fourth step is to rank the options according to cost-effectiveness. For this purpose the various types of pollution have to be brought under a common denominator. A suggestion could be to calculate a weighed sum of the pollutants, using as weights the amount by which ambient standards are exceeded on average.

The calculation of the cost-effectiveness consists then of the calculation of the ratio of reduction over annual cost (R/C). The options with the highest ration R/C are the most cost-effective ones.

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TITLE

URBAIR

Urban Air Quality Management Strategy in Asia

GREATER BOMBAY

Appendices

PROJECT LEADER

Steinar Larssen

NILU PROJECT NO.

O-92117

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CLASSIFICATION *

A

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ABSTRACT

The main report describes the development of an action plan for air quality improvement in Greater Bombay, based upon the assessment of emissions and air quality in the metropolitan area, population exposure and health effects (damage), the assessment of costs related to the damage and to a number of proposed abatement measures, and a cost-benefit analysis.

This report contains appendices on air quality measurements, emission factors and inventory, exposure calculations, etc.

NORWEGIAN TITLE

KEYWORDS		
Air Pollution	Management	Greater Bombay

ABSTRACT (in Norwegian)

** Classification*	*A*	*Unclassified (can be ordered from NILU)*
	B	*Restricted distribution*
	C	*Classified (not to be distributed)*