Health and Environment: Action-based Learning

(HEAL)

Results and Trends: 2004-2005

Programme co-ordinator:
Bakhtaver S. Mahajan

Research assistants:
Kulwanti M. Bellara
Suma Nair

Homi Bhabha Centre for Science Education
Tata Institute of Fundamental Research
V. N. Purav Marg, Mumbai 400 088

Technical Report:
Health and Environment: Action-based Learning (HEAL)
Results and Trends: 2004-2005

Cover design by:
Manoj Nair

(bsm@hbcse.tifr.res.in)
Homi Bhabha Centre for Science Education
(www.hbcse.tifr.res.in)
Tata Institute of Fundamental Research
V. N. Purav Marg, Mumbai 400 088

Homi Bhabha Centre for Science Education
Tata Institute of Fundamental Research
V. N. Purav Marg, Mumbai 400 088

CONTENTS

ACKNOWLEDGEMENTS

This program is dedicated to the student community of Navi Mumbai who worked hard in collecting data about the quality of air, water and other allied aspects, along with health status of residents as related to environment. We are thankful to them for their efforts. These students were associated with the National Service Scheme (NSS) of the University of Mumbai and were drawn from five colleges in Navi Mumbai. Principals, participating teachers and NSS college co-ordinators from these colleges played an important role in marshalling their students and gave us continuous co-operation, despite examinations, holidays and other myriad activities of the colleges (Appendix 1).

We would sincerely like to thank Dr. Anil Patil of NSS, who was enthusiastic about HEAL and incorporated it as a compulsory NSS programme in Navi Mumbai. Subsequently, Dr. P.N. Pabrekar and others from NSS gave us good co-operation.

We got excellent support from the Navi Mumbai Municipal Corporation (NMMC), who provided maps, NMMC Environmental Reports and access to health data of Navi Mumbai. Our special thanks to Drs. L. Dethe, L. Murlidhar and S. Pattivar, all from the NMMC health department, Mr. Mohan Dagaonkar, Chief Engineer and Mr. Bhalchandra Desle, Education Officer, NMMC. All of them and many others were always ready to guide and help us.

Dr. V. Murlidhar of L. T. Medical College, Sion, gave valuable inputs on different health aspects of the project. More importantly, he and his team of 10 student-doctors took active part in health surveys. Mr. V. Kanhere from the Occupational Health and Safety Centre, Mumbai, gave a new dimension to the program by carrying out lung function tests. We thank all our partners in HEAL.

Dr. T. N. Mahadevan, former Head, Environmental Assessment Division, Bhabha Atomic Research Centre, Mumbai, gave us invaluable guidance at every stage of the programme. He was always there to solve our many problems; his critical appraisal and reading of this report has given us added confidence to take this programme forward. We are highly grateful to him for all his efforts.

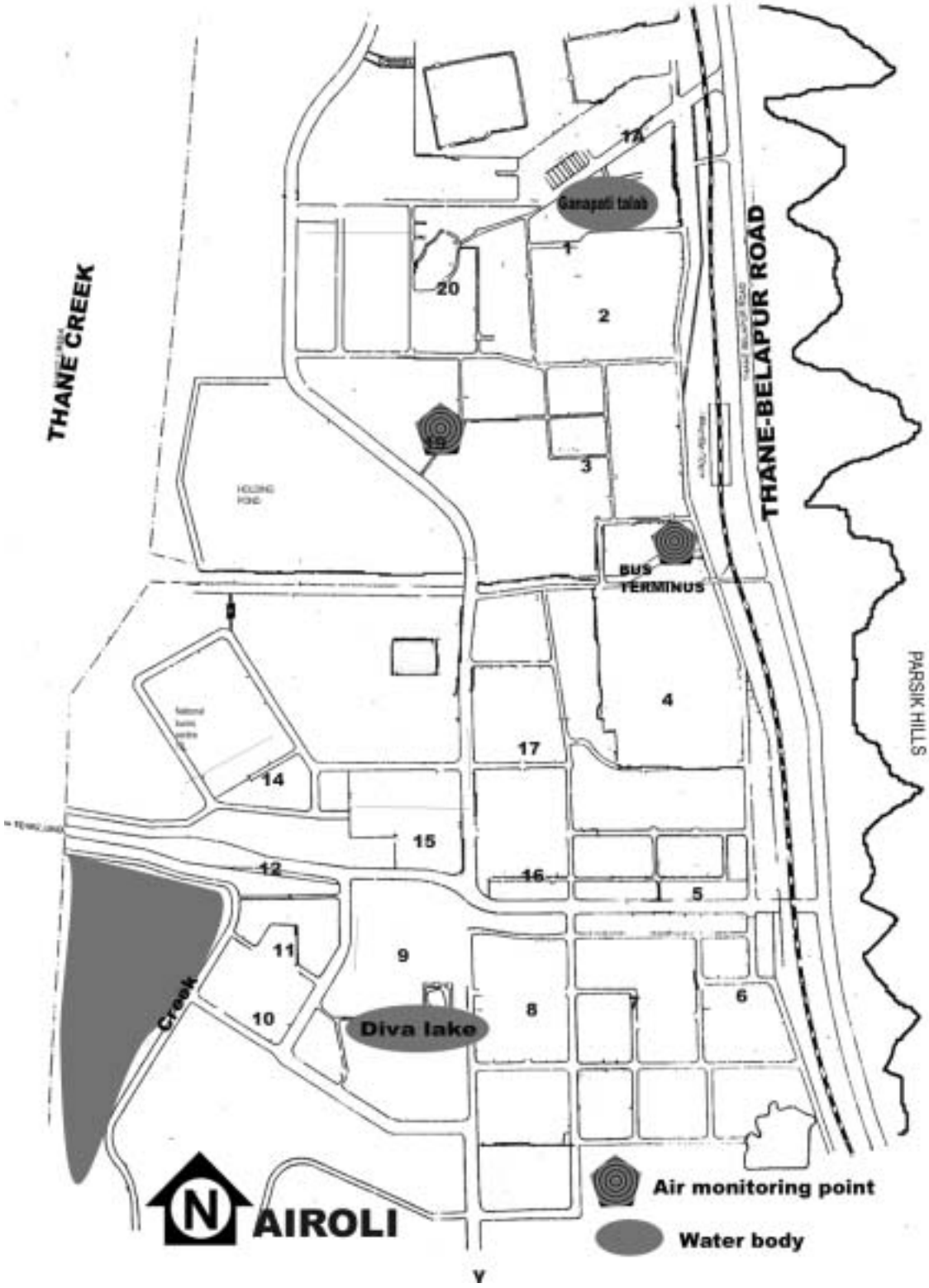
We would also like to thank Mahabal Enviro Engineers Pvt. Ltd., and thousands of volunteers of Navi Mumbai, including police, shop keepers and residents who agreed to be interviewed, and co-operated wholeheartedly in this programme.

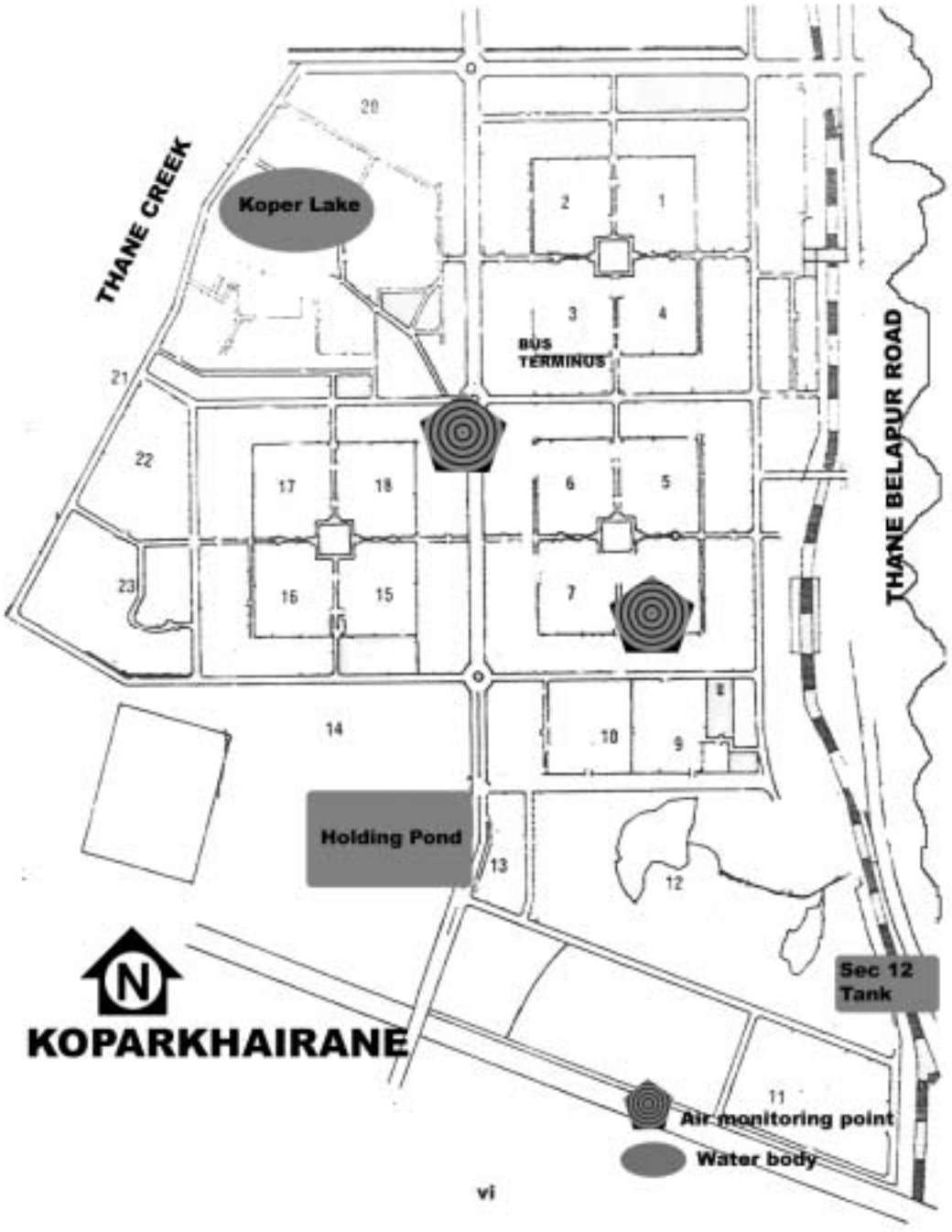
The Centre Director, the Dean, the Head, Administration, and our colleagues have all encouraged us in this new venture.

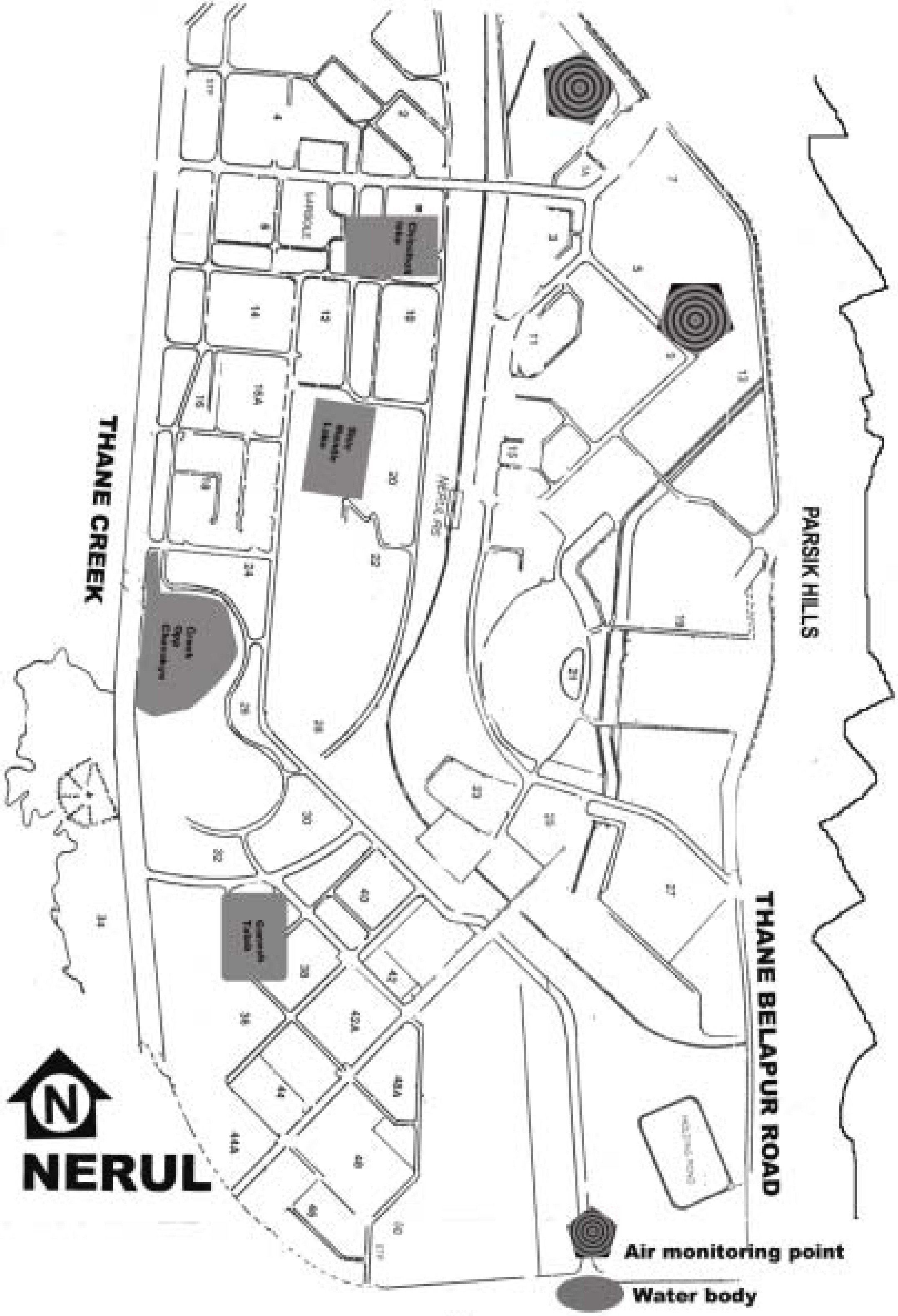
We are thankful to them all.

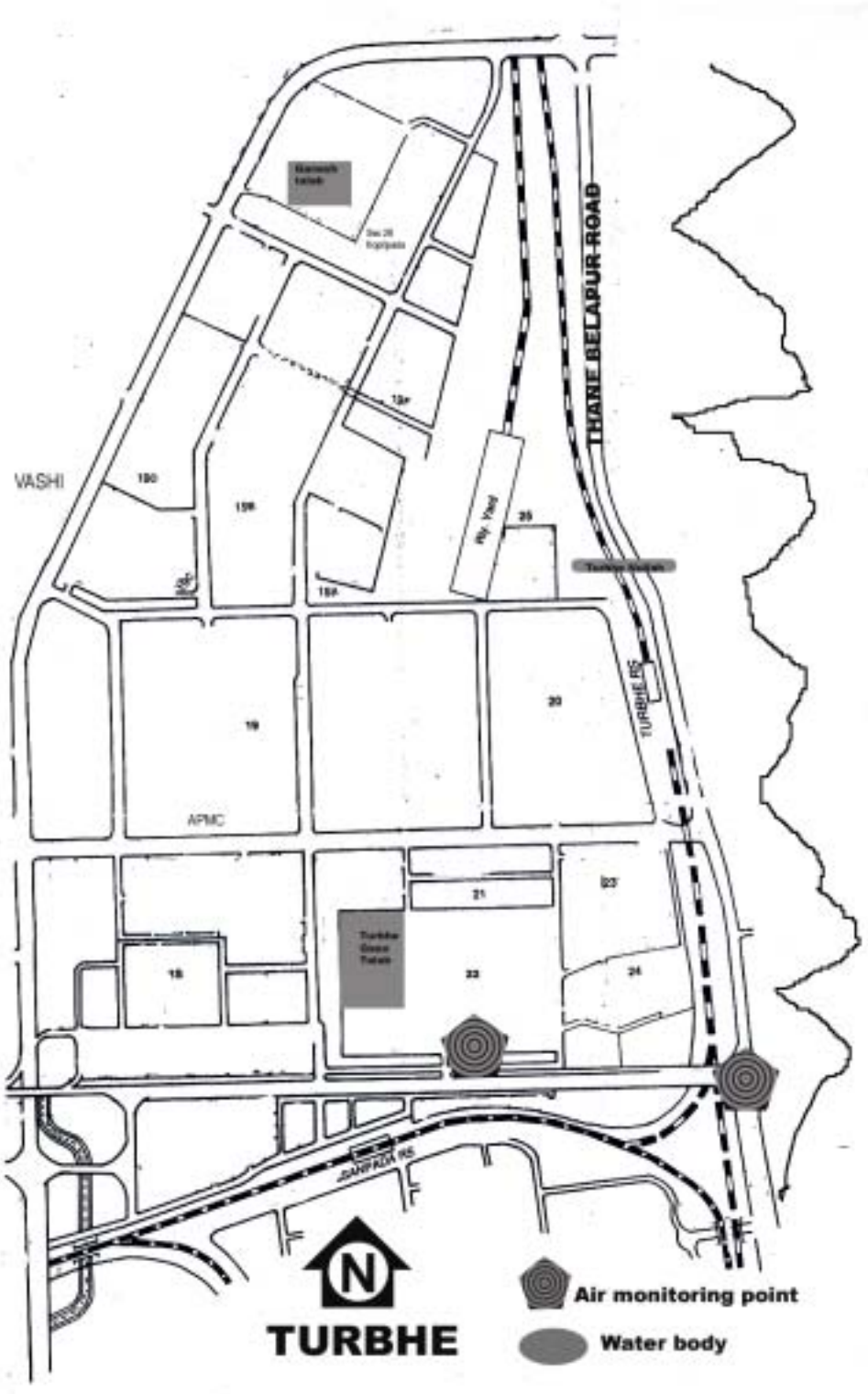
BSM
KB
SN

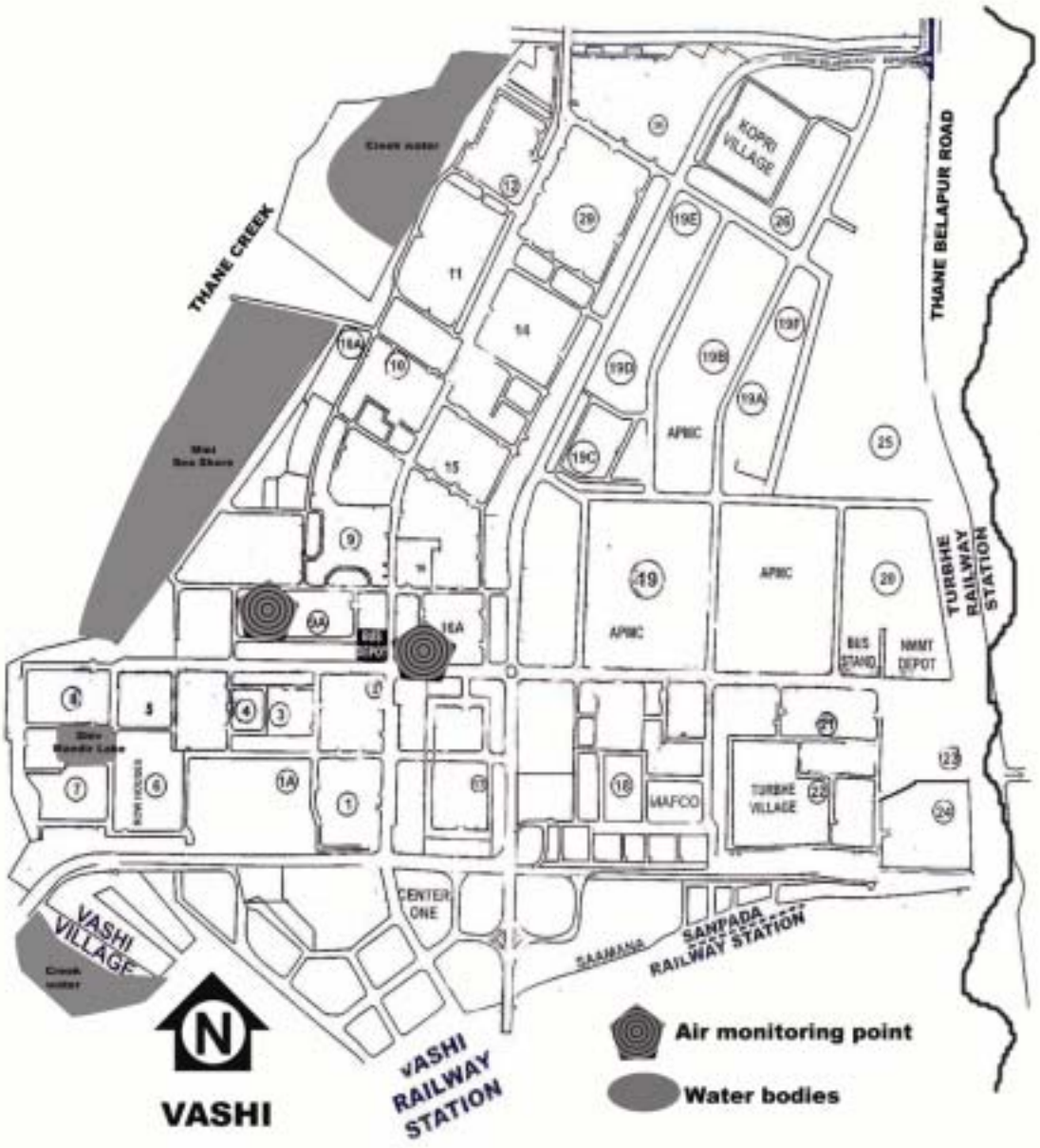

MAHARASHTRA
LANDMASS
AIROLI
DIVE
RABALE
GHANSOLI
KOPAR
KHAIRANE
MHAPE
MUMBAI
LANDMASS
PAWNE
VASHI TURBHE
SANPADA
KHARGHAR
NERUL
BELAPUR
KALAMBOLI
THANE
CREEK
PANVEL
N
NAVI MUMBAI
URAN
NAGAON


THANE CREEK
THANE-BELAPUR ROAD
PARSIK HILLS
Ganapati talab
Diva lake
Creek
BUS TERMINUS
1
2
3
4
5
6
7
8
9
10
11
12
14
15
16
17
20
N
AIROLI
Air monitoring point
Water body


THANE CREEK
Koper Lake
BUS TERMINUS
THANE BELAPUR ROAD
Holding Pond
Sec 12 Tank
N
KOPARKHAIRANE
Air monitoring point
Water body


THANE CREEK
PARSIK HILLS
THANE BELAPUR ROAD
NERUL
Air monitoring point
Water body

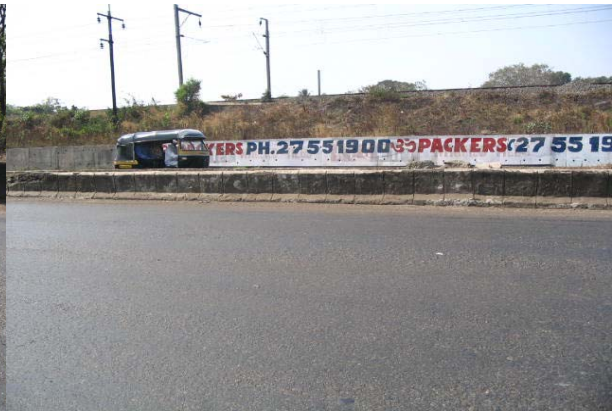

THANE BELAPUR ROAD
VASHI
APMC
TURBHE RS
JUINFADA RS
N
TURBHE
Air monitoring point
Water body


THANE CREEK
THANE BELAPUR ROAD
KOPRI VILLAGE
APMC
TURBHE RAILWAY STATION
BUS STAND
NMMT DEPOT
MAFCO
TURBHE VILLAGE
CENTER ONE
VASHI VILLAGE
SANPADA RAILWAY STATION
VASHI RAILWAY STATION
VASHI
N
Air monitoring point
Water bodies

College students and teacher-coordinators associated with the National Service Scheme (NSS) of the University of Mumbai in Navi Mumbai took up the challenge of working with HBCSE for HEAL. They monitored the quality of air and water in the open water bodies, and partially surveyed the green cover and management of domestic solid waste in the study zones. This was done over three seasons in 2004-2005.

In brief, the quality of air and water was poor; on the positive side, the open garbage bins for domestic solid waste observed in Sept. 2004 were removed in Jan. 2005, and garbage was collected in special vans. However, these vans are ill designed, posing health risks for the workers.

Door-to-door health surveys based on symptom-based provisional diagnosis revealed the widespread presence of upper respiratory tract problems among residents of the study zones in 2004-05. These problems were aggravated in Turbhe stores and Hanuman Nagar, Turbhe, where residents were exposed to air pollutants from factories, including those from Sulphur Mills Ltd., and from nearby hill quarrying. The surface industrial *nullah* in Turbhe carried large volumes of polluted liquid waste. The much needed green cover in the industrial area was being systematically reduced, even on the road dividers.



GENERAL INTRODUCTION

Homi Bhabha Centre for Science Education (HBCSE) with its goals of excellence and equity in science education carries out a variety of programmes. These include training of students and teachers, curriculum development, science popularization activities and organizing Indian science olympiads.

The Health and Environment: Action-based Learning (HEAL) programme was initiated in 2003. The major objectives of the study was to bring about awareness about the strong interface between health and environment and to inculcate a culture of data-collection among students and their teachers. In this programme, nearly one thousand students associated with the National Service Scheme (NSS) of the University of Mumbai, and their teachers, participated in collecting and analyzing data about different environmental issues. In addition, the students collected data on the health status of residents –as impacted by environment--of the study sites in Navi Mumbai, the satellite city of Mumbai.

India's status on both health and environment is dismal. Our environment is fast deteriorating and our health records over the years show high disability adjusted life year (DALY) losses, especially contributed by diseases linked to the dirty environment. According to *The World Development Report* on "Investing in Health –1993", the total DALY loss in India in 1990 was 292 million days per year (mdy), as compared to 201, 58 and 94 mdy respectively, for China, former socialist countries and developed countries. The disease burden due to deteriorating environment is further aggravated by poverty, malnutrition and illiteracy, still widespread in several segments of our population.

Together, all these and several other factors put India in an unenviable position of bearing about 20 per cent of the world's burden of diseases. In such a scenario, the 'traditional' communicable diseases, like pneumonia, tuberculosis, asthma, gastro-intestinal diseases and malaria, that can be prevented by public health interventions and a clean hygienic environment, still continue to contribute to heavy DALY losses. These diseases are however nearly absent in the developed countries.

HEAL attempted to highlight the many issues under environment and health by adopting different modes of action-based research, which would facilitate good systematic understanding of how we are using (rather abusing) air, water and soil. Besides furthering scientific knowledge about different aspects of health and environment, the program encouraged students to ask questions (often the answers and solutions were neither simple nor straightforward), sharpened their understanding of different scientific concepts, along with creating a realization of the realities and complexities of health and environmental issues at the actual ground root level.

HEAL was initiated with a pilot study in December 2003, and next extended to a larger area in Navi Mumbai during 2004-2005. As students continued to collect and analyse the data during the course of the year, a genuine progression of knowledge among students was witnessed, as some of them wanted to try out different research methodologies, say, devise chemical tests for different air pollutants to be conducted at the college / school levels, rather then depend on regulatory authorities to indicate the quality of air. Others will soon be making geographical information maps (GIS) of Navi Mumbai using the HEAL data.

Indeed, HEAL (or such action-research projects) could serve as an educational model to be replicated in other parts of the country. The Protocol Guide of HEAL could serve as a guide book for teachers and students, and even for the newly introduced subject of environmental studies in the school curriculum. It forges links between public policy, human behaviour and the prevalent socio-political norms. Over time, this activity-based science education programme could sensitize our young student community to the importance of a clean environment and how it is inextricably linked to good health of a population.

Topography of Navi Mumbai

HEAL was confined to Navi Mumbai, covering a total area of 344 sq. kms. This city lies across the Thane creek, north east of Mumbai. It is flanked by the Thane creek waters on its west, south-west and north-west contours. Parsik hills (in varying stages of natural and anthropogenic erosion like extensive quarrying) run

north-south across the Navi Mumbai landmass. The efforts of TBIA to green the hills over the last decade are only partially successful. Trans Thane Creek Industrial Area (TTCIA, largest in India), Thane Belapur Road and other arterial roads also run in the north-south direction. Residential zones are situated between the creek and the hills. Towards the north and east, the city leads to the main landmass of Maharashtra state. These, among several other important topological and siting features are to be considered while studying the environment and health of Navi Mumbai (please see the map of the city).

The complex terrain of Navi Mumbai, consisting of Thane creek and Parsik hills, and the siting of The TTCIA nearly on the foot hills, with the residential zones juxta-positioned in between, is a cause of concern for the health of residents of the area, especially in the context of air pollution. The hills (80 to 200 m high) are fast decreasing in height and also disappearing due to heavy quarrying, settlement of slums on the hill slopes (especially, near Turbhe, Ghansoli and Rabale) and unchecked deforestation. Thane Belapur Road (TBR), the major arterial road, while it serves the industrial belt, also effectively separates the industrial zone from other areas of Navi Mumbai. Another major road parallel to TBR and interconnected by smaller roads connects the industrial zone with the residential zones of Navi Mumbai.

Further, several residential zones have been located on this landmass. Hence several nodes of Navi Mumbai are situated on a land mass exposed to industrial/traffic pollution, or to hill quarrying which goes on incessantly, both towards the east. Though the creek waters act as a sink for air pollutants emitted at lower levels, this is not true for pollutants from elevated point sources. Long range dispersal of air pollutants from elevated sources could be blocked by the hills in Ghatkopar and Trombay regions, depending on the wind direction. The same is true of non dispersion of air pollutants on the east, due to their blockage by the Parsik hills.

In several zones, the city has fresh water lakes (ponds). In addition, the Navi Mumbai Municipal Corporation (NMMC) and the City & Industrial Development

Corporation of Maharashtra (CIDCO) have also impounded creek water based on tidal movements along the coast line, creating a series of water holding ponds. This topography made Navi Mumbai an ideal place for our programme.

Approach and Execution:

For the execution of HEAL, HBCSE collaborated with the National Service Scheme (NSS) unit of the University of Mumbai. One of the unique features of HEAL was the involvement of a large number of college students (~1000) from varied disciplines with their teachers in five zones –Airoli, Kopar Khairane, Nerul, Turbhe and Vashi of Navi Mumbai. Students collected and partially analysed the data for various environmental parameters, followed by health surveys. This study was carried out seasonally (pre-monsoon, post-monsoon and winter) in Navi Mumbai.

The programme was executed as follows:

- First a Protocol Guide, which contained the relevant theory and worksheets about different aspects of environment and health, was prepared.
- A pilot study in one zone of Navi Mumbai was conducted in December 2003. The enthusiasm of teachers and students led us to extend HEAL over a larger area.
- HBCSE scientists and other resource persons trained NSS teacher coordinators from five colleges in Navi Mumbai (Appendix).
- These trained teachers facilitated the participating NSS students to carry out the experiments / surveys at their allotted study sites under the supervision of HEAL co-ordinators.
- The different environmental factors as outlined in the HEAL Protocol Guide were air, water, soil, green cover, domestic solid waste and noise levels. However, due to time constraints, students collected data only on air and water and partially on green cover and solid waste in their allotted zones.

- Air monitoring work was outsourced to Mahabal Enviro Engineers Pvt. Ltd., Thane, because of constraints on equipment and other infrastructure needs.
- Chemical analysis of water samples was carried out at HBCSE laboratories, under the supervision of programme coordinators (please see sections on air and water for details).
- To find out the health status of residents of selected zones, participating students carried out detailed health surveys (symptom-based provisional diagnosis), as in Protocol Guide.
- Health surveys were carried out under the direct supervision of third year MBBS students of Lokmanya Tilak Medical College, Sion, Mumbai.
- Students carried out experiments, surveys and preliminary analysis of the observed results, over three seasons in the academic year 2004-2005.
- The results were checked at all levels by programme co-ordinators; health data were further verified from internal health records of the NMMC. [Refs: Environmental Status Reports, NMMC: 2001-2002, 2002-2003 and 2003-2004 //www.nmmconline.com and Maharashtra Pollution Control Board (MPCB) website: information [http://mpcb.mah.nic.in].
- For partial validation of health data, lung function tests were carried out in summer of 2005, under the expertise of Mr. Vijay Kanhere of Occupational Health and Safety Centre, Mumbai.
- In April 2005, the water samples were analysed for bacterial contamination (faecal coliforms) as MPN (most probable number) test.
- In this report, attempts have been made to critically analyze and report the results as collected by participating students under the guidance of their teachers.

Being an exercise in creating awareness about the importance of a clean environment and its effects on health, the data produced by students under HEAL is preliminary. Nonetheless, the data indicate certain trends about the quality of the environment and health. Some of these trends indicate the quality of air [air quality in the studied zones of Navi Mumbai ranged from bad to dangerous in the three seasons of 2004-2005] and the quality of water in the recreational water

bodies [poor water quality mainly in terms of dissolved oxygen (DO) and chemical oxygen demand (COD)]. With reference to health status of residents, prominently the upper respiratory tract (URT) symptoms seemed to be prevalent throughout the year among large percentage of people in the studied zones, along with other vector-borne diseases like rabies and malaria.

These and several other results of HEAL exposed students to the close relationships between health and environment. Students were actively learning about different environmental and health issues by performing hands-on activities, which included different methods of science, such as observations, measurements, planning experiments, varied methods in chemical analysis, data collection and their analysis, graphical representation, map reading, surveys, and statistics.

It is hoped that HEAL and many more such programmes get actively integrated in our formal education system to lead to a sustainable and healthy India.

AIR QUALITY

Introduction

The air quality at any given site or area is closely linked to several factors that govern the given air shed. These include: siting criteria for different industries and residential areas, road traffic flow pattern, resuspension of road dust, management of municipal solid waste, including waste burning at land fill sites, etc. Micro-meterological factors like wind speed, wind direction, atmospheric stability and other prevalent climatic conditions greatly influence the dispersal and/or accumulation of air pollutants. Local topography or surface roughness and other characteristics also play their role in determining the air quality.

This study covered the Trans Thane Creek (TTC) region, with Airoli, Kopar Khairane, Turbhe, Nerul and Vashi as the study (assessment) zones in Navi Mumbai. Under the HEAL project, air quality monitoring was carried out as follows:

- Two locations were selected in each zone to represent traffic junctions (kerbside) and residential areas.
- Air quality monitoring was entrusted to Mahabal Enviro Consultants Ltd., under the supervision of the project co-ordinators.
    - Air samples were collected using a high volume air sampler fitted with cyclone inlet as cut off for assessment of Suspended Particulate matter (SPM) and Respirable Suspended Particulate Matter (RSPM) fractions separately.
    - The same unit was also used for sampling sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) by wet chemical method using impingers connected to the bypass suction tubes.
    - Carbon monoxide (CO) was analysed by grab sampling in a football bladder followed by infrared spectroscopy.
- Two pumps were kept at two different locations (traffic—12 hrs and (residential areas-- 24 hours) in each zone.
- The sampling consisted of one 24 hour and two 12 hour average period sampling on two consecutive days.

- The 24 hour sampling was carried out at an interval of four hours, with an exception of one timeslot being of eight hours (late night-early morning). Thus there were four 4hr samples- and one 8hr sample duration.
- The 12 hour sampling was carried out at a regular interval of four hours, giving three samples of 4 hr duration.
- Sample collection period was kept identical for the three seasons [September 2004 (monsoon), January 2005 (winter) and April/May 2005 (summer)].
- Monitoring was carried out on two consequent days in all three seasons, at each zone to minimize source profile variations (Table 1).
- Attempts were made to keep sampling durations and the timings during the day constant in the three seasons.
- For RSPM, SPM, SO_2 and NO_2, the 24 hour standards were considered. For CO, one hour standard was considered.
- **NOTE:** In this report, particulates monitored are: RSPM (also termed as PM_{10} , i.e., particulates less than 10 micron size, collected on a fine filter paper fitted to the high volume sampler) and SPM {**total** particulates, i.e., RSPM **+** particulates larger than 10 microns (collected in the cyclone hopper)}. Confusion often arises due to casual /interchangeable use of the terms—TSPM and SPM, which essentially refer to the same category of particulates.
- **These results do NOT represent the true long term air quality status, but indicate trends of pollution levels in the monitored zones based on the 24 hr averages. There were heavy rains on several days in September 2004 when the sampling was on, especially in Airoli and Turbhe.**

Two sets of results are given for each zone:

(a) 24 hours in residential area for one day (NAAQS for residential areas);

(b) 12 hours at traffic junction for two days (NAAQS for industrial areas).

Table: Details of air quality monitoring sites

Sr. no.	Sites	Location	Monitoring duration	Activity at site	Sampling height (mts)
1.	Airoli	Jnan Vikas Mandal, Sector 19	24 hours at 4 hour intervals; **for 1 day**	Residential area, with sparse traffic; opposite Thane creek; ongoing construction activity; TBR[1] + TTCIA[2] located on the eastern side.	13
		Opposite Airoli bus depot	12 hours at 4 hour intervals; **for 2 days**	Commercial area, with reasonable traffic of LMV[3]s and buses.	1.5
2.	Kopar-Khairane (KK)	F. G. Naik College, Sector 8	24 hours at 4 hour intervals; **for 1 day**	Residential area, with light traffic; TBR and TTCIA located on the eastern side.	13
		KK. Police *chowky*	12 hours at 4 hour intervals; **for 2 days**	Traffic junction with KK bus depot on the opposite side; flow of buses and LMVs.	1.5
3.	Nerul	SIES College, Sector 5	24 hours at 4 hour intervals; **for 1 day**	Mixed (commercial and residential) area; reasonable traffic of LMVs; TBR + TTCIA located close by (eastern side).	15
		Opposite London Pilsner	12 hours at 4 hour intervals; **for 2 days**	Traffic junction on the TBR, with heavy traffic of buses, trucks and LMVs.	1.5
4.	Turbhe	Turbhe village municipal school no. 19, sector 22	24 hours at 4 hour intervals; **for 1 day**	Residential area with light traffic; TBR + TTCIA located close by (eastern side).	12
		Turbhe *nullah* (industrial)	12 hours at 4 hour intervals; **for 2 days**	Traffic junction on TBR at intersection of several major roads; heavy vehicle traffic (trucks) and LMVs.	1.5
5.	Vashi	ICLES' College, Sec. 9A	24 hours at 4 hour intervals; **for 1 day**	Residential area, with Thane creek nearby in the west; LMVs during college hours only.	12
		Vishnudas Bhave Natyagraha	12 hours at 4 hour intervals; **for 2 days**	Traffic junction, opposite Vashi bus depot; heavy traffic flow of LMVs and buses throughout the day.	1.5

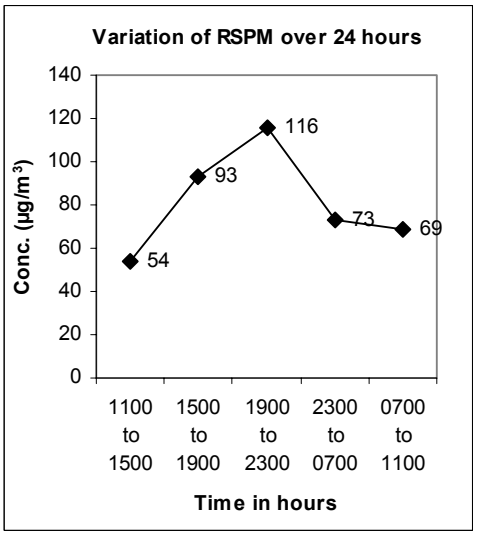
TBR[1] → Thane Belapur Road; TTCIA[2] → Trans Thane Creek Industrial Area; LMV[3]: Light motor vehicle

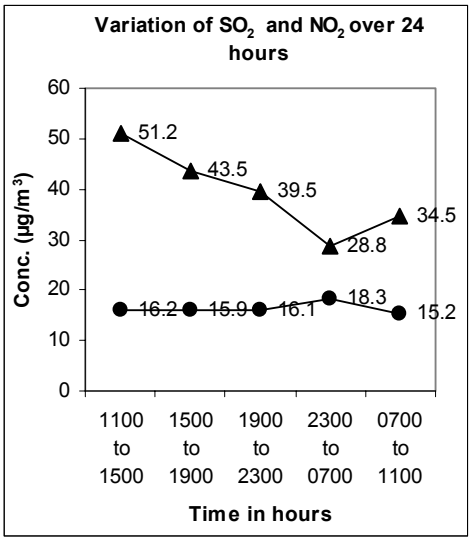
SAMPLING ZONE: AIROLI

MONSOON (SEPTEMBER 2004) :

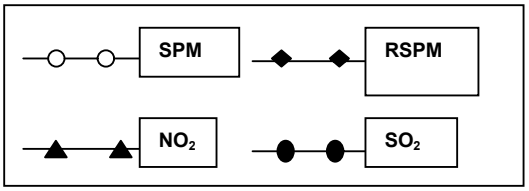
VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 24 HOURS

Date: 6 Sept. 2004; Residential area (Terrace--at about 13m height--of J.V.Mandal College, Sector 19)





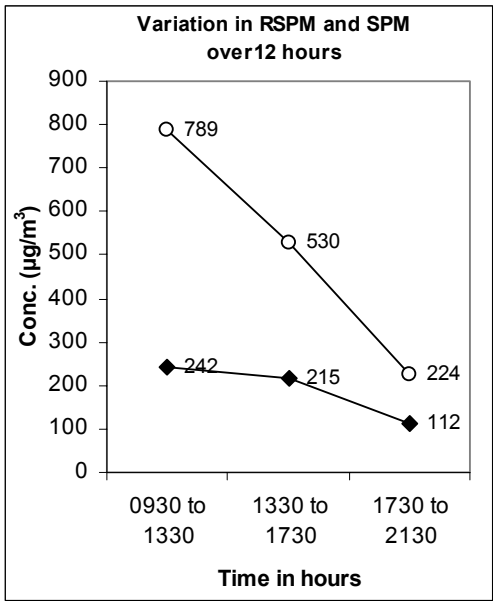
Pollutant	Conc. (µg/m^3) (weighted averages over 24 hrs)	Standards – Residential over 24 hours (in µg/m^3)*
RSPM (PM_{10})	80	100
SPM	NA	200
SO_2	17	80
NO_2	38	80
CO	1220	4000 (1 hr average)

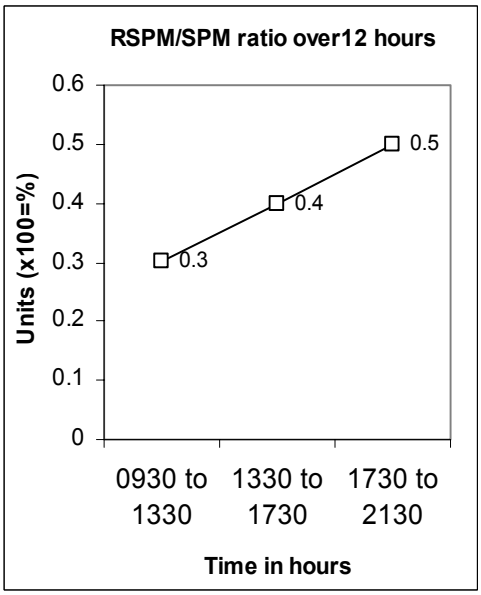


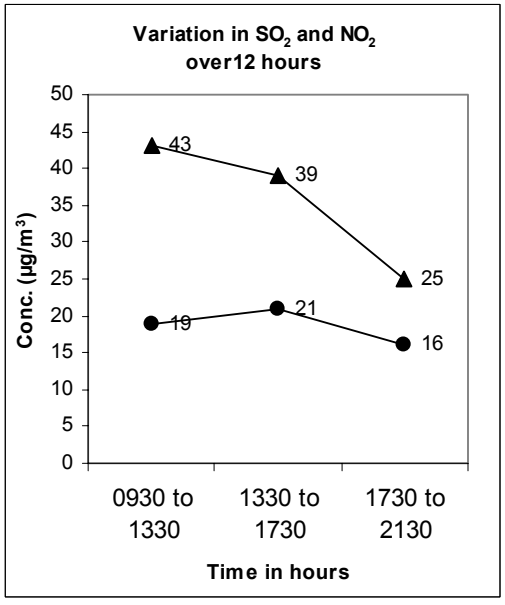
(SPM levels were unavailable in this season at this zone.)

VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 12 HOURS

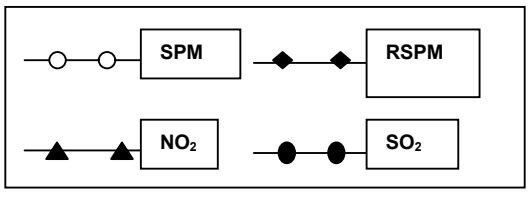
Date: 6 Sept. 2004; Traffic junction (1.5 m off ground level, opp. Airoli bus depot)



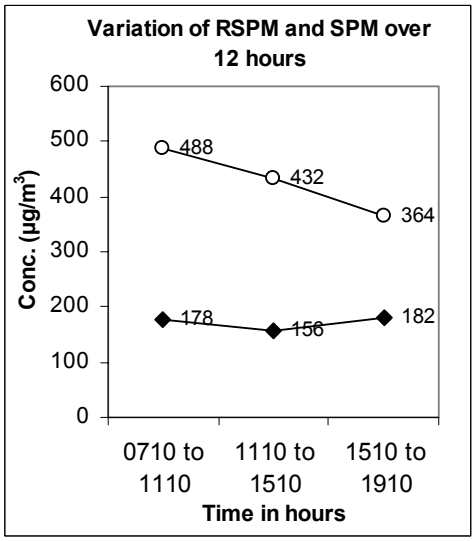


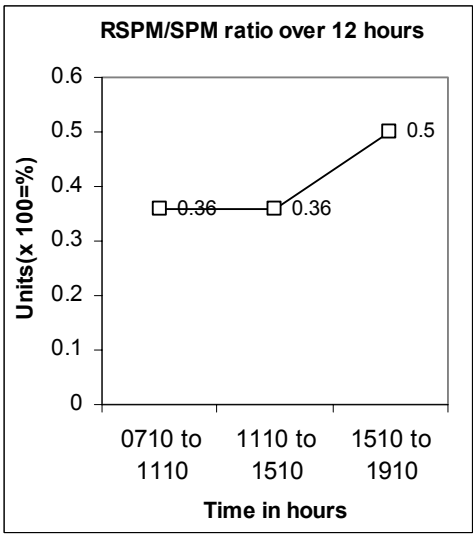


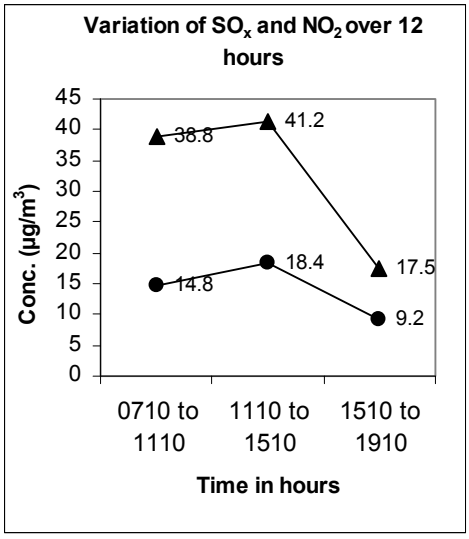
Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	190	100	150
SPM	514	200	500
SO_2	19	80	120
NO_2	36	80	120
CO	2700	4000 (1 hr average)	10,000 (1 hr. average)



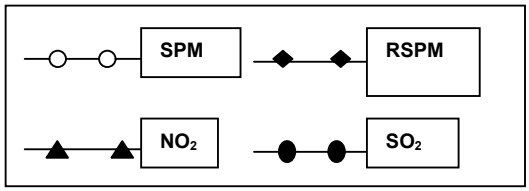
Date: 7 Sept. 2004; Traffic junction (1.5 m off ground level, opp. Airoli bus depot)







Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	172	100	150
SPM	428	200	500
SO_2	14	80	120
NO_2	33	80	120
CO	3200	4000 (1 hr average)	10,000 (1 hr. average)



Airoli: Monsoon (September 2004)

(a) 24 hours monitoring in a residential area for one day:

1. The high volume air sampler was installed on the terrace of the Jnan Vikas Mandal's College, Airoli, Sector 19, at an approximate height of 13 meters.
2. The College is situated in a residential area, with creek in the front (west), the Thane Belapur Highway in the east and surrounded by relatively an open area [please refer to the map of the region].
3. Heavy rains occurred on the day of air monitoring.
4. RSPM levels were largely within the NAAQS (National Ambient Air Quality Standards) stipulated for the residential area, with the weighted average of 80 $\mu g/m^3$.
5. In the 19.00 to 23 hours time period, RSPM was observed to be at its highest (116 $\mu g/m^3$).
6. Results of SPM (24 hours) could not be recorded due to sample loss at the cyclone hopper.
7. Both SO_2 and NO_2 concentrations were very low and within the NAAQS. This could be due to the gases being washed down by the showers as the source vector remains the same in spite of rains.
8. CO levels were within NAAQS.

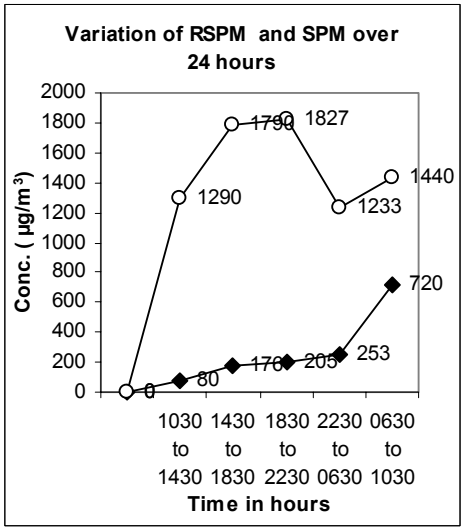
(b) 12 hours monitoring at the traffic junction for two days:

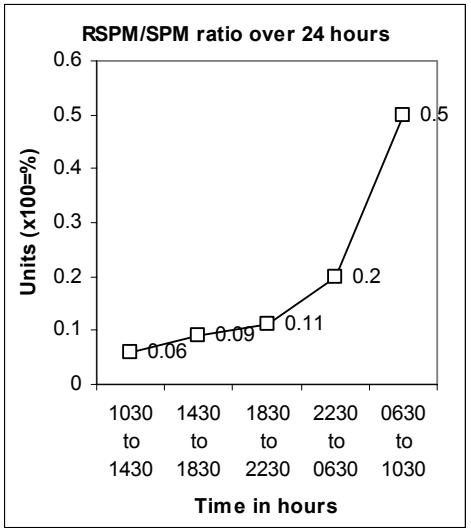
1. The traffic junction at Airoli was located in a residential area, but right across the Thane Belapur road and opposite the Airoli bus depot. Hence the standards for both industrial and residential areas have been used for comparison.
2. On the two days of monitoring at the traffic junction, the weighted average concentrations of RSPM were above the NAAQS even for industrial areas.
3. SPM levels varied during the day, with the weighted averages above/approaching the industrial NAAQS. This also could be due to both traffic blown dust from the Thane Belapur Road and movement of buses at the Airoli Bus Depot.
4. The contribution of RSPM to the total air particulates (SPM) ranged from 30 to 50%. This indicates that the big and small air particulate matter are contributed by the various sources, primarily traffic.
5. The three gaseous pollutants, SO_2, NO_2 and CO, were within the NAAQS on both days. This could be due to washing of gases by heavy rains. With the changeover to cleaner fuels and adherence to EURO –II standards with lower emission rates the NO_2 and SO_2 emissions themselves could have been reduced even if the number/density of vehicles have increased.

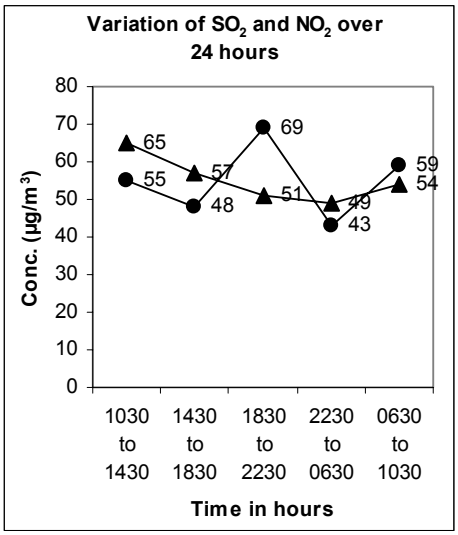
AIROLI
WINTER (JANUARY 2005) :

VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 24 HOURS

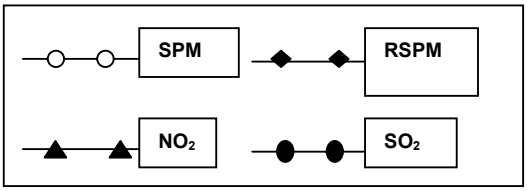
Date: 20 January, 2005; Residential area (Terrace of J.V.Mandal, Sector 19)





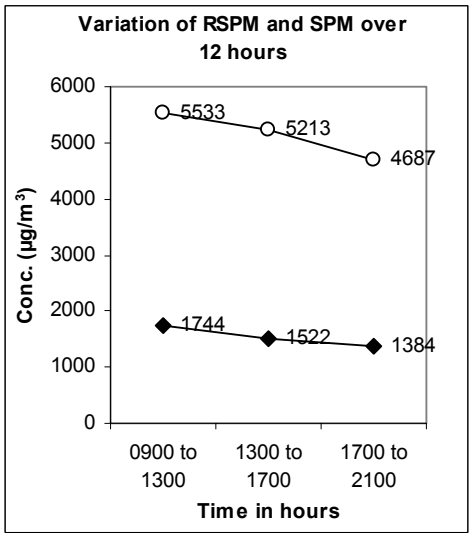


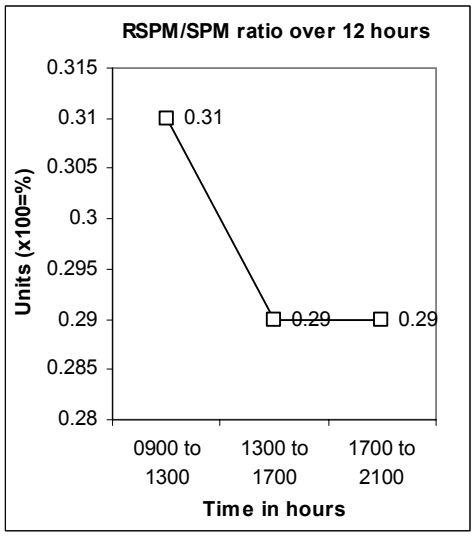
Pollutant	Conc. ($\mu g/m^3$) (weighted averages over 24 hrs)	Standards – Residential over 24 hours (in $\mu g/m^3$)*
RSPM (PM_{10})	280	100
SPM	1470	200
SO_2	53	80
NO_2	54	80
CO	3350	4000 (1 hr average)

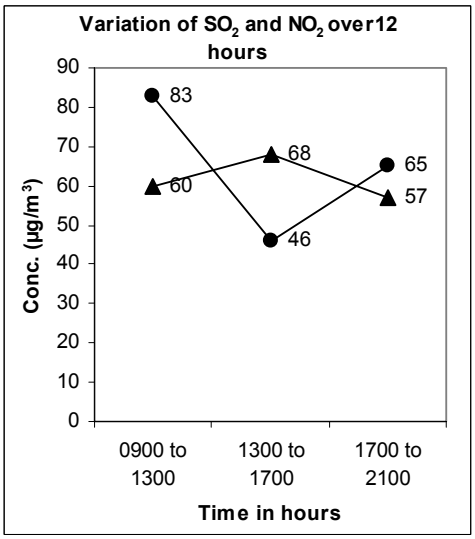


VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 12 HOURS

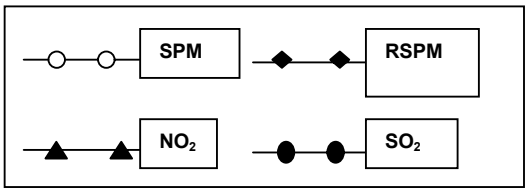
Date: 20 January, 2005; Traffic junction (1.5 m off ground level, opp. Airoli bus depot)



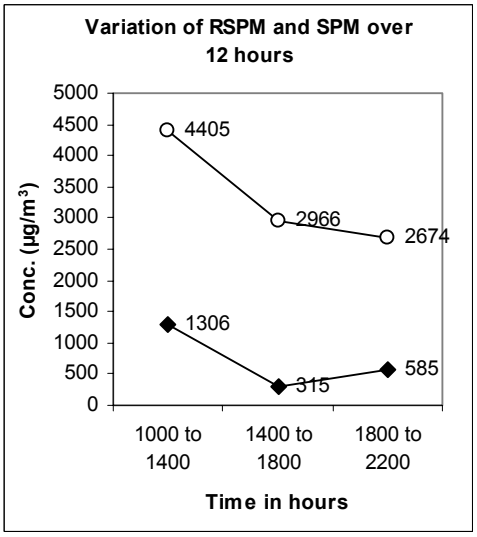


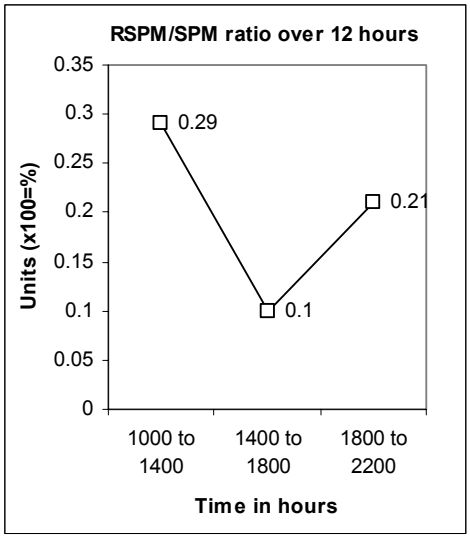


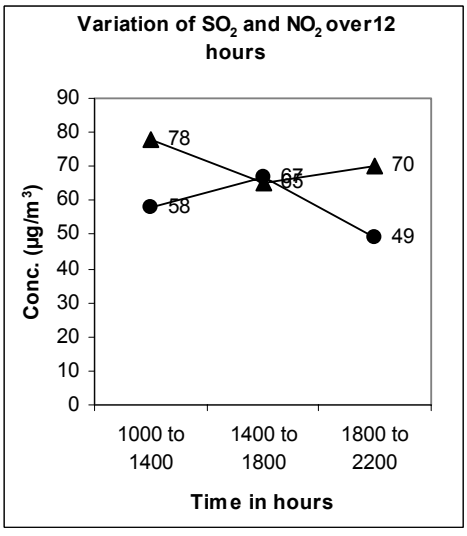
Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	1550	100	150
SPM	5144	200	500
SO_2	65	80	120
NO_2	62	80	120
CO	4750	4000 (1 hr average)	10,000 (1 hr. average)



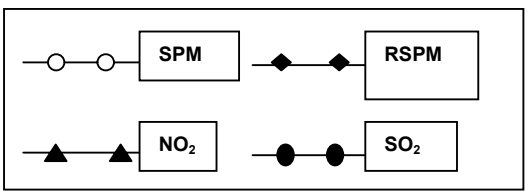
Date: 21 January, 2005; Traffic junction (1.5 m off ground level, opp. Airoli bus depot)







Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	735	100	150
SPM	3348	200	500
SO_2	58	80	120
NO_2	71	80	120
CO	6570	4000 (1 hr average)	10,000 (1 hr. average)



Airoli: Winter (January 2005)

(a) 24 hours monitoring in a residential area for one day:

1. In this season, the day temperatures had dipped to 26º C, with smog conditions prevalent in the whole region due to subsidence and weak dispersion.
2. RSPM levels were largely above the NAAQS, with the weighted average of 280 $\mu g/m^3$.
3. High RSPM (720 $\mu g/m^3$) concentration was observed for the 6.30 to 10.30 am sample with 4 h averaging period.
4. SPM levels were well above the NAAQS for the residential area.
5. High SPM levels were observed in 24 hours (1290, 1798, 1827, 1233 and 1440 $\mu g/m^3$), with the weighted average of 1470 $\mu g/m^3$.
6. There is a perceptible dip in the particulate concentrations (RSPM and SPM) in the 10.30 to 14.30 h sampling period. The reason for this is not clear excepting the impact of monsoon showers.
7. The high levels of SPM and RSPM in this season could be attributed to the low ambient temperatures, prevalent of calm conditions with temperature inversion resulting in poor dispersion of ground based sources.
8. Though the overall RSPM concentrations are high, its contribution to the total particulate load is generally low (varying from 6, 9, 11, 20 and 50 per cent). In the 6.30 to 10.30 hrs time slot, RSPM contribution is 50% of the total particulate load.
9. Both SO_2 and NO_2 were within NAAQS. In 18.30 to 22.30 period, one observed a sudden peak in both SO_2 and SPM. This could be due to some abnormal point source emissions from the nearby industrial area causing elevated concentration in the downward wind direction represented by the sampling site. This observation is very interesting even with a single value limitation as it confirms accidental emissions from point sources. CO levels were within NAAQS.
10. These observations need to be further investigated to pin point the emission sources.

(b) 12 hours monitoring at the traffic junction for two days:

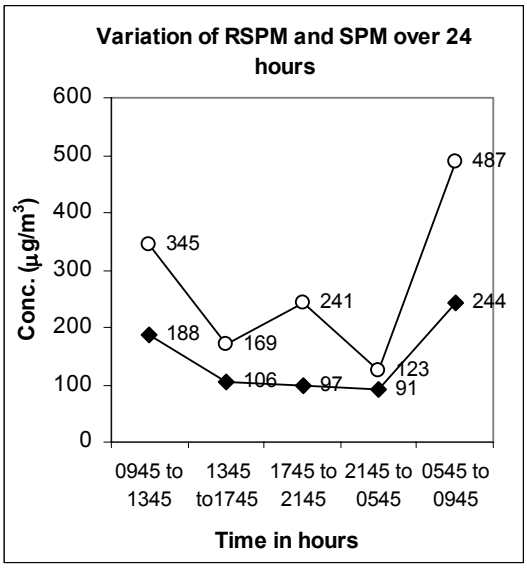
1. Air monitoring was carried out at the Airoli traffic junction from 9 to 21 hrs on day 1 (20 January) and from 10 to 22 hrs on day 2 (21 January, 2005).
2. High concentrations of RSPM, well above the NAAQS, with weighted averages of 1550 and 735 $\mu g/m^3$ were observed on the two days. This indicates the possibility of large variability status in the values which could be due to change in source profile and prevalent micro-meteorological conditions which can be further confirmed by extended sampling schedules.
3. Perceptibly high levels of RSPM (1306 $\mu g/m^3$) were observed in the 10-14 h sampling period on day 2.
4. High concentrations of SPM, well above the NAAQS for industrial areas, on the two days were observed, with the weighted averages being 5144 $\mu g/m^3$ on day 1 and 3348 $\mu g/m^3$ on day 2.
5. Here too, though the overall RSPM concentrations are high, its contribution to the total particulate load is generally low (31, 29, 29% on day 1 and 29, 10, 21% on day 2 respectively). This could be due to presence of large particulates (> 10 μ) released from vehicular exhaust, in addition to industrial emissions.
6. SO_2 and NO_2 concentrations were within the NAAQS on both days.
7. CO was recorded below NAAQS.

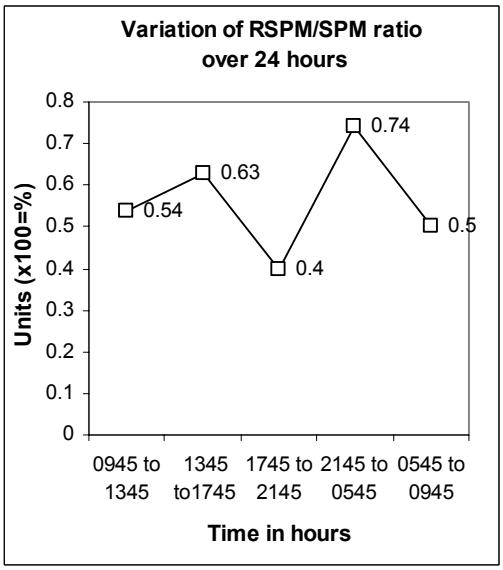
AIROLI

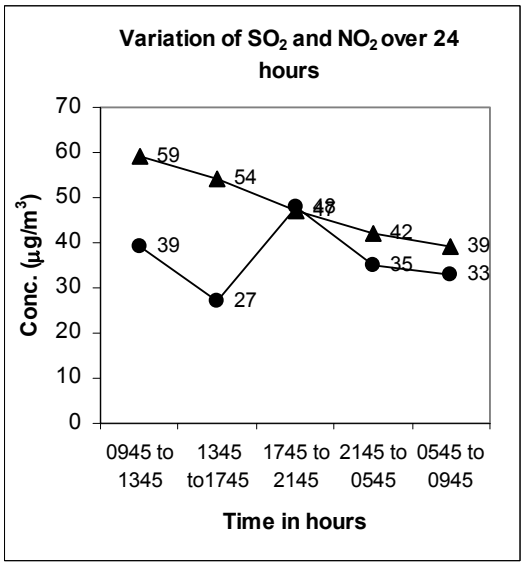
SUMMER (APRIL 2005) :

VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 24 HOURS

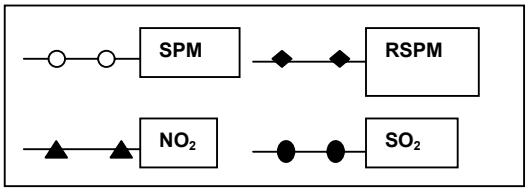
Date: 1 April, 2005 ; Residential area (Terrace of J.V.Mandal, Sector 19)





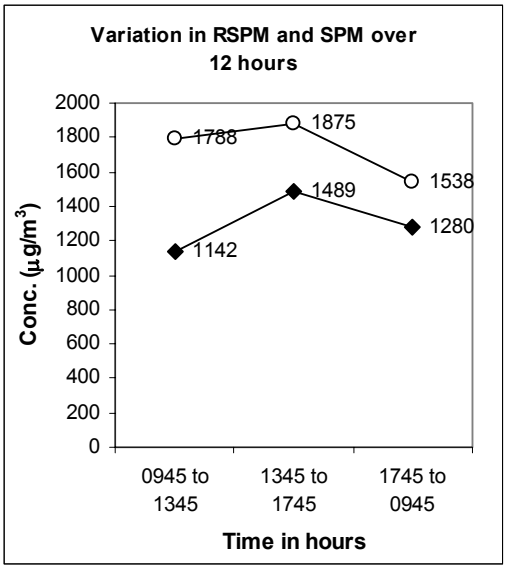


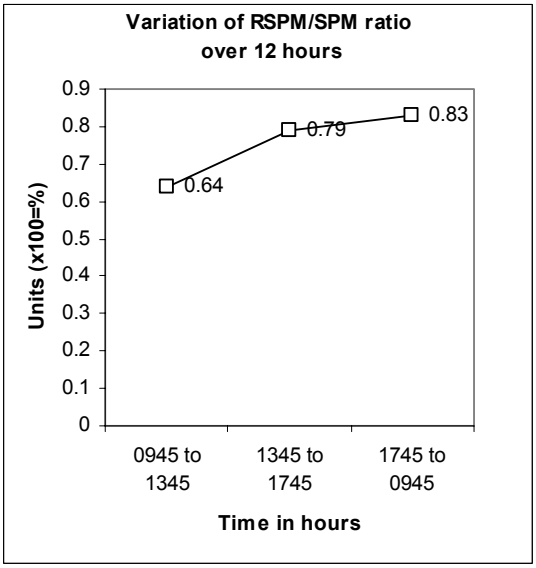
Pollutant	Conc. ($\mu g/m^3$) (weighted averages over 24 hrs)	Standards – Residential over 24 hours (in $\mu g/m^3$)*
RSPM (PM_{10})	136	100
SPM	248	200
SO_2	36	80
NO_2	47	80
CO	3405	4000 (1 hr average)

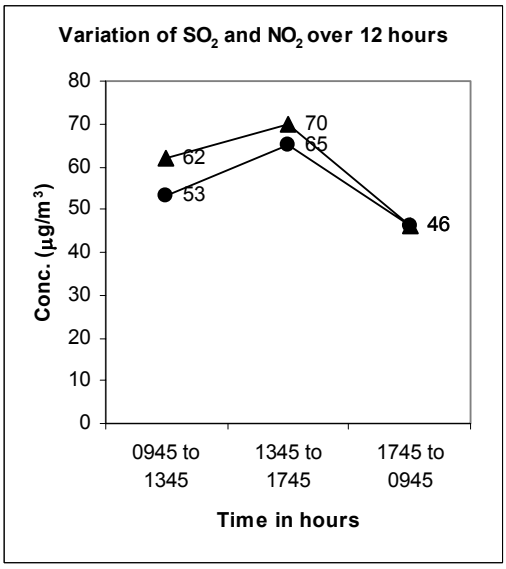


VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 12 HOURS

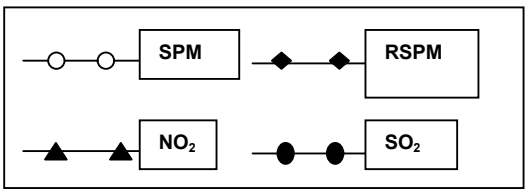
Date: 1 April, 2005; Traffic junction (1.5 m off ground level, opp. Airoli bus depot)



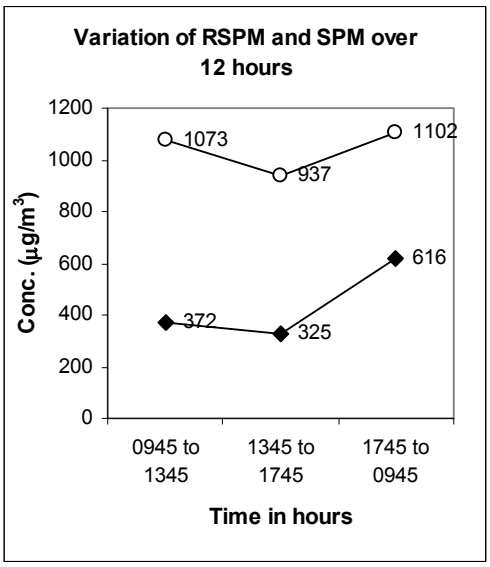


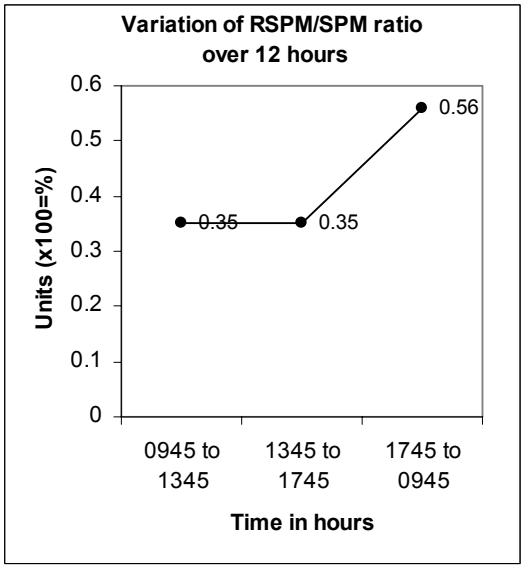


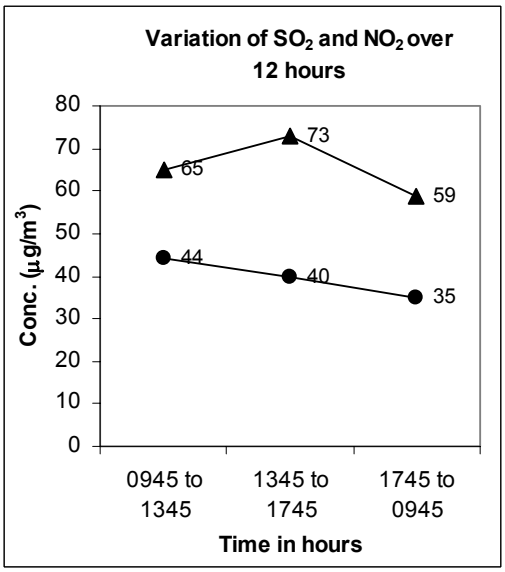
Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	1304	100	150
SPM	1734	200	500
SO_2	55	80	120
NO_2	60	80	120
CO	3430	4000 (1 hr average)	10,000 (1 hr. average)



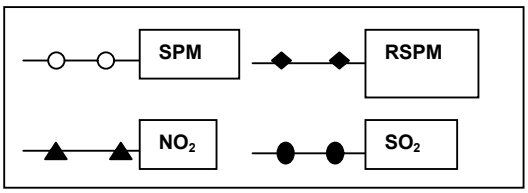
Date: 2 April 2005; Traffic junction (1.5 m off ground level, opp. Airoli bus depot)







Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	438	100	150
SPM	1037	200	500
SO_2	40	80	120
NO_2	66	80	120
CO	5140	4000 (1 hr average)	10,000 (1 hr. average)



Airoli: Summer (April 2005)

(a) 24 hours monitoring in a residential area for one day:

1. In this season, the day temperatures had risen to 30º C. and above.
2. RSPM levels were largely above the NAAQS, with the weighted average of 136 µg/m^3.
3. SPM levels varied during the 24 hours, with the weighted average (248 µg/m^3), which was above NAAQS for the residential area.
4. In this season, the contribution of RSPM to the total particulate load was high (varying from 40, 50, 54, 63 and 74 per cent). In the 21.45 to 5.45 time slot, RSPM contributed more than 70% of the total particulate load.
5. Both SO_2 and NO_2 were within NAAQS.
6. CO levels were within NAAQS.
7. Of all the air pollutants monitored, RSPM appeared to be the major pollutant in Airoli in this season.

(b) 12 hours monitoring at the traffic junction for two days:

Air monitoring was carried out at the Airoli traffic junction from 9.45 am to 9.45 pm on day 1 and day 2.

1. High concentrations of RSPM, well above the NAAQS, with weighted averages of 1304 and 438 µg/m^3, were observed on the two days.
2. High concentrations of SPM, well above the NAAQS for industrial areas, on the two days were observed, with the weighted averages being 1734 µg/m^3 on day 1 and 1037 µg/m^3 on day 2.
3. In this season, the overall RSPM concentrations were high on day 1; this was reflected in overall high contribution of RSPM in the total particulate load (64, 79 and 83%).
4. On day 2, though the RSPM concentrations were above NAAQS, its contribution to the total particulate low was generally low (35 to 56%).
5. SO_2 and NO_2 were within the NAAQS on both days.

6. CO was recorded below NAAQS.
7. It is interesting to note that there is a drop in the concentration levels of gases and the particulates in the 13.45 to 17.45 hrs time period on day 2. Being summer and prevalent afternoon temperatures at the peak, the density of traffic movement could have been low with people preferring to remain indoors.

AIR MONITORING BY THE STUDENTS OF J.V.MANDAL'S COLLEGE, AIROLI

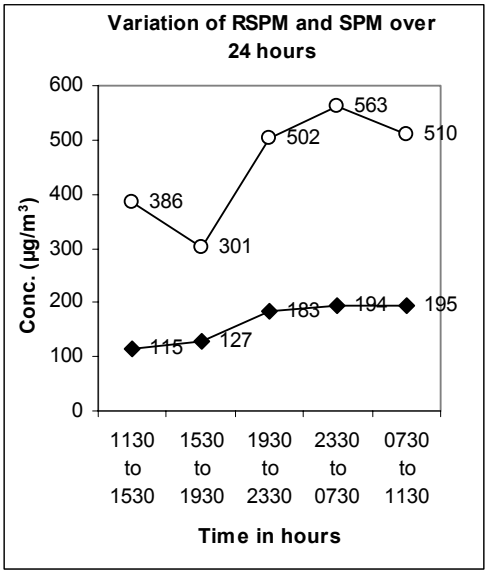
Air monitoring with a high volume air sampler on the terrace of J.V.Mandal College, Airoli

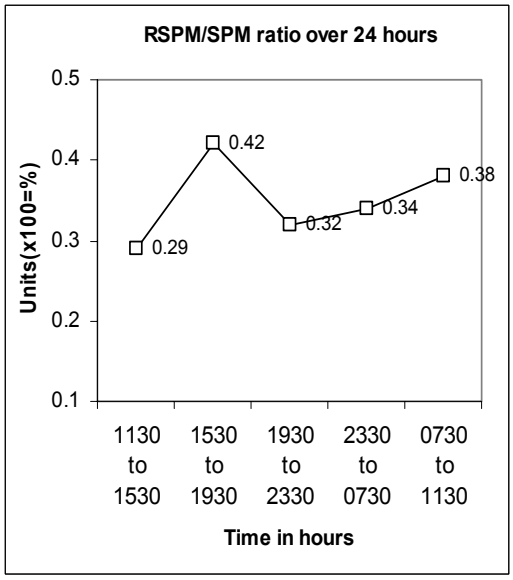
KOPAR KHAIRANE

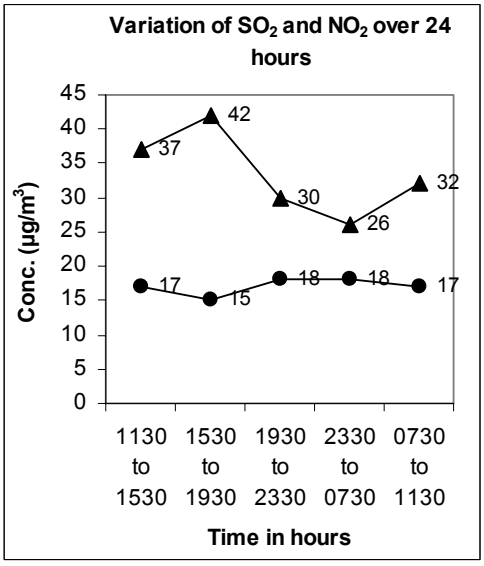
MONSOON (SEPTEMBER 2004) :

VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 24 HOURS

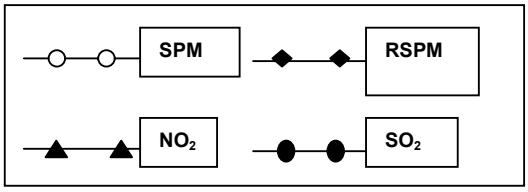
Date: 1 Sept. 2004; Residential area (Terrace -- at about 13 m height -- of F. G. Naik College--, Sector 8)





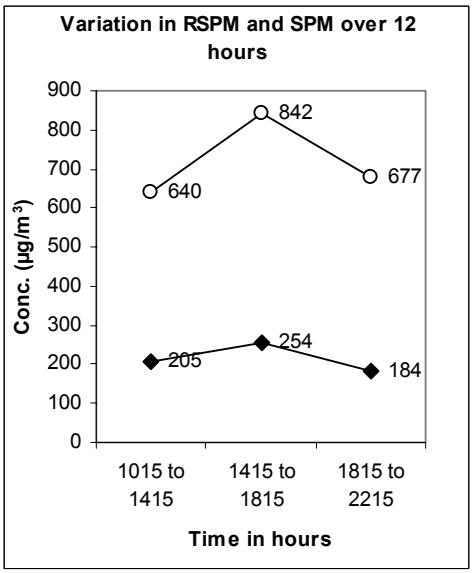


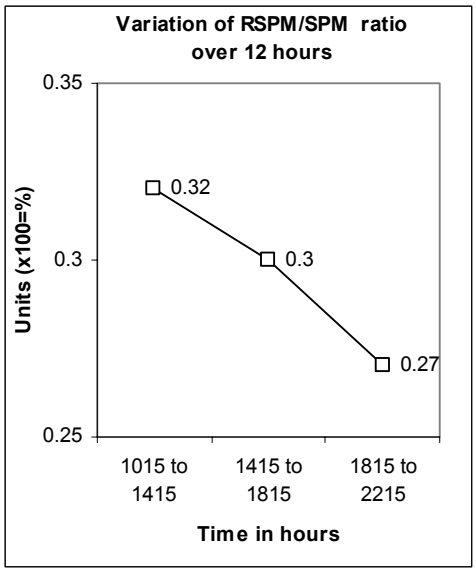
Pollutant	Conc. ($\mu g/m^3$) (weighted averages over 24 hrs)	Standards – Residential over 24 hours (in $\mu g/m^3$)*
RSPM (PM_{10})	168	100
SPM	471	200
SO_2	17	80
NO_2	32	80
CO	1280	4000 (1 hr average)

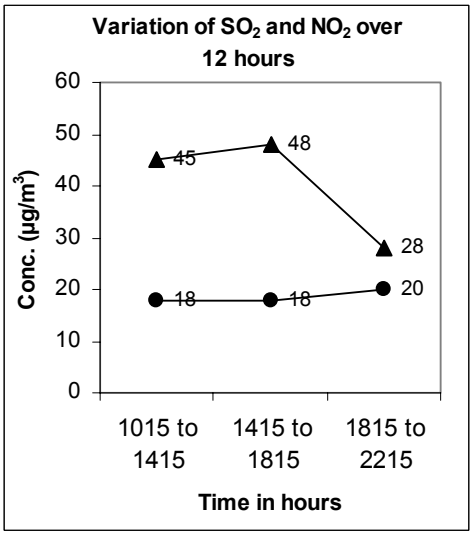


VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 12 HOURS

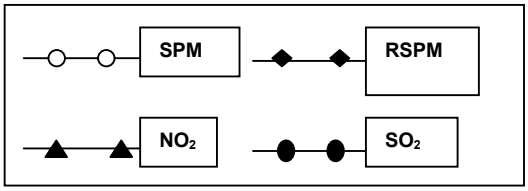
Date: 1 Sept. 2004; Traffic junction (1.5 m off ground level near KK Police *chowky*)



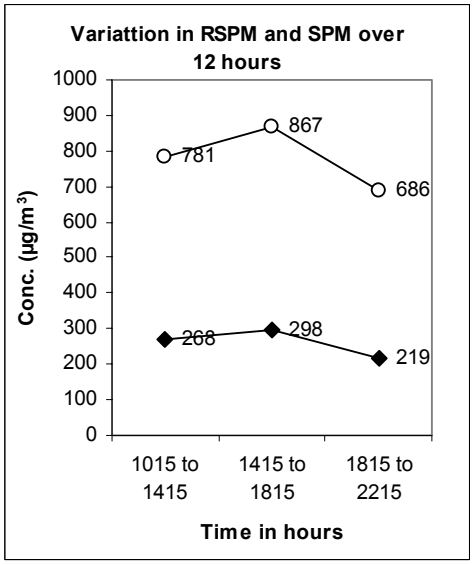


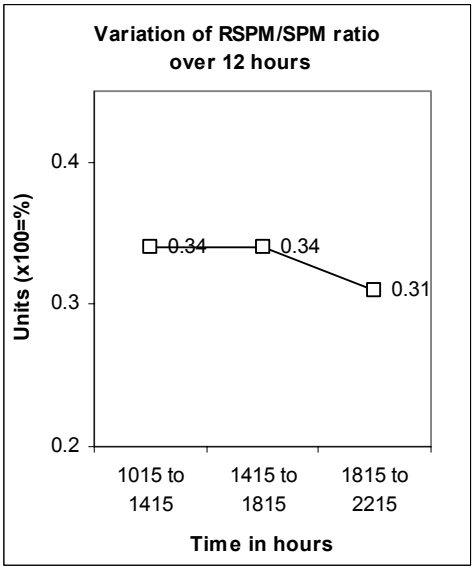


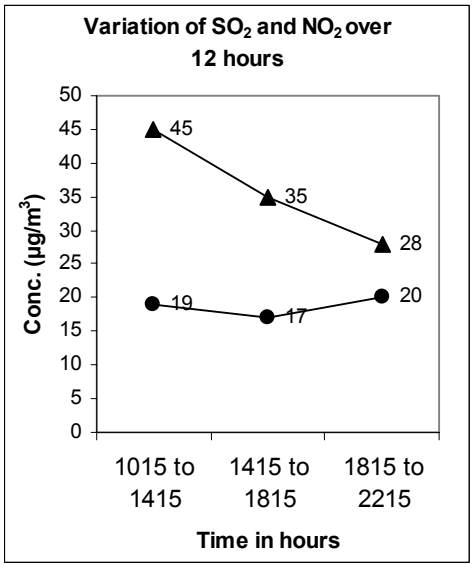
Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	214	100	150
SPM	720	200	500
SO_2	19	80	120
NO_2	40	80	120
CO	3090	4000 (1 hr average)	10,000 (1 hr. average)



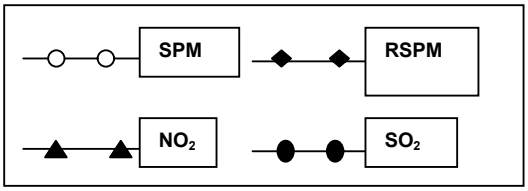
Date: 2 Sept. 2004; Traffic junction (1.5 m off ground level near KK Police *chowky*)







Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	262	100	150
SPM	778	200	500
SO_2	19	80	120
NO_2	36	80	120
CO	3360	4000 (1 hr average)	10,000 (1 hr. average)



Kopar Khairane: Monsoon (September 2004)

(a) 24 hours monitoring in residential area for one day:

1. The high volume air sampler was installed on the terrace of F.G. Naik College, Sector 8, Kopar Khairane, at an approximate height of 13 metres.
2. The College is situated in a residential area, with some shopping complexes in the west and the Thane Belapur Highway in the east. It is surrounded by buildings and an open plot of land.
3. It was not raining on the day of air monitoring.
4. RSPM levels were above the NAAQS, with the weighted average of 168 $\mu g/m^3$.
5. SPM levels were also above the NAAQS, with the weighted average of 471 $\mu g/m^3$.
6. In the 15.30 -19.30 time slot, SPM was observed to decrease to 301 $\mu g/m^3$. This could be due to the reduction in the road traffic at this site as the schools and colleges in the locality closed down in this time slot.
7. The contribution of RSPM to the total air particulate load ranged from 29 to 42%. This indicated that the particulate load was being contributed more by the larger size (>10μ) particulates. The source of this could be the heavy traffic on the Thane Belapur highway, which lies in the vicinity, and the reentrainment and lift up of dust from unpaved area by the draft. This could be the reason for high load of particulates >PM_{10}.
8. Both SO_2 and NO_2 were within NAAQS for 24 hr period, with the weighted averages of 15 and 32 $\mu g/m^3$ respectively.
9. CO levels were also within the NAAQS.

(b) 12 hours monitoring at the traffic junction for two days:

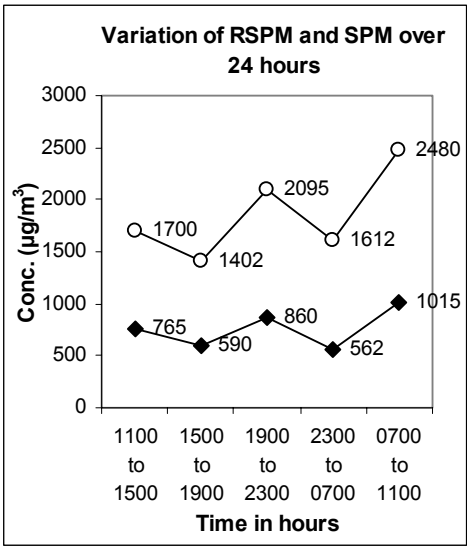
1. The high volume air sampler was positioned at the ground level at the traffic junction, located on the main Vashi-Kopar Khairane road, near the police *chowky*. This road is a main thorough fare with shops, bus depot, etc., in close vicinity.
2. On the two days of monitoring at the traffic junction, the weighted average concentrations of RSPM (214 and 262 $\mu g/m^3$) were above the NAAQS even for industrial areas.
3. SPM levels were above NAAQS, with the weighted averages being 720 and 778 $\mu g/m^3$ resp. on the two days. These are high SPM levels in the monsoon season, and could be due to road and traffic dust in this region.
4. In the time slot of 14.15-18-15, both RSPM and SPM were observed to rise markedly on the two days of air monitoring.
5. The contribution of RSPM to the total air particulate load (SPM) ranged from 27 to 32% on day 1, and 31 to 34% on day 2. This implies that the bigger particulates (>10μ) form the major constituent of the particulate pollution.
6. The three gaseous pollutants, SO_2, NO_2 and CO, were within the NAAQS on both days. This could be due to use of cleaner vehicular fuels in addition to washout of gases by heavy rains.

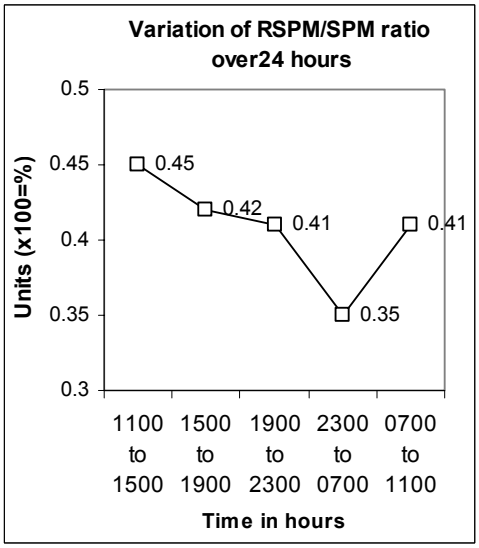
KOPAR KHAIRANE

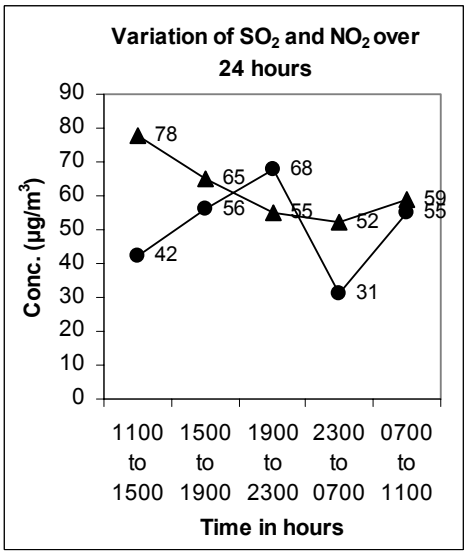
WINTER (JANUARY 2005) :

VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 24 HOURS

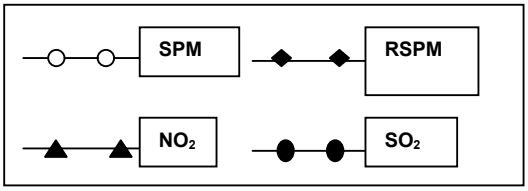
Date:10 January, 2005; Residential area (Terrace of F. G. Naik College, Sec. 8)





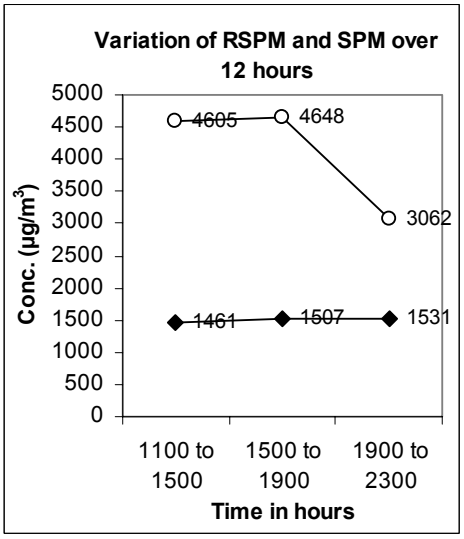


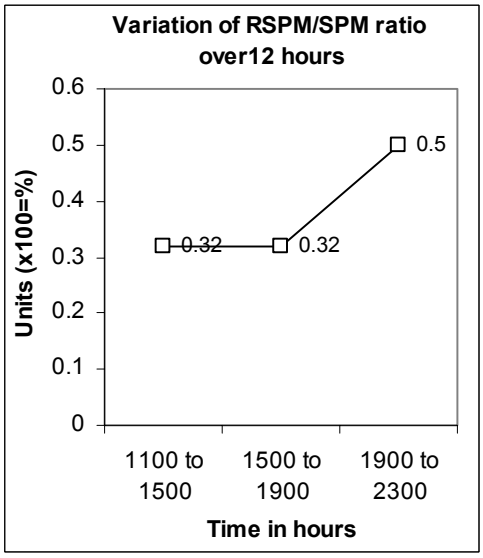
Pollutant	Conc. ($\mu g/m^3$) (weighted averages over 24 hrs)	Standards – Residential over 24 hours (in $\mu g/m^3$)*
RSPM (PM_{10})	726	100
SPM	1817	200
SO_2	47	80
NO_2	60	80
CO	3380	4000 (1 hr average)

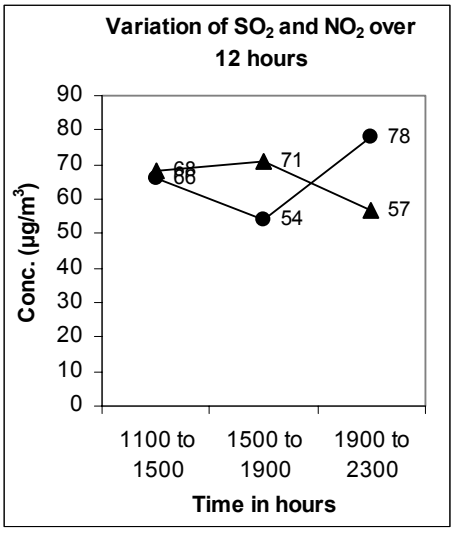


VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 12 HOURS

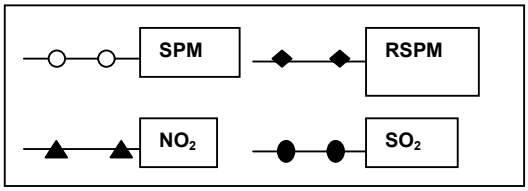
Date: 10 January 2005 Traffic junction (1.5 m off ground level near KK Police *chowky*)



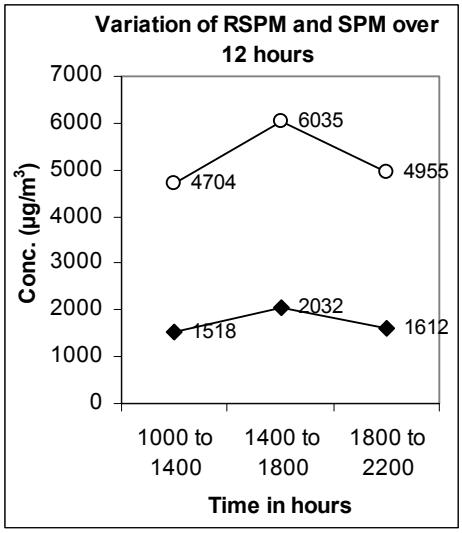


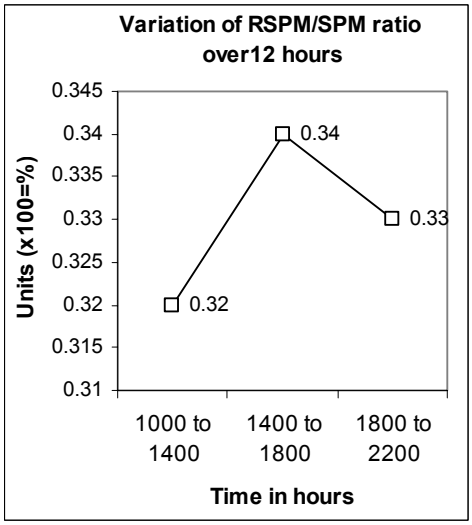


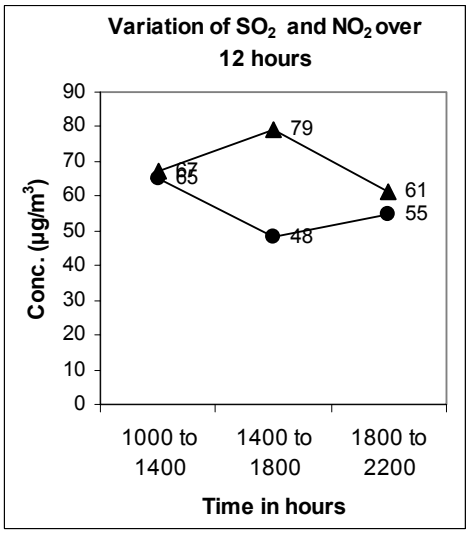
Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	1500	100	150
SPM	4105	200	500
SO_2	66	80	120
NO_2	66	80	120
CO	6890	4000 (1 hr average)	10,000 (1 hr. average)



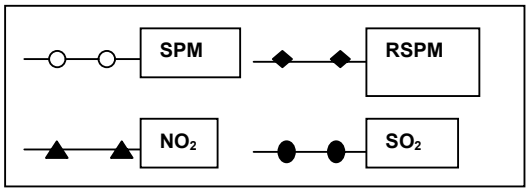
Date: 11 January 2005; Traffic junction (1.5 m off ground level near KK Police *chowky*)







Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	1721	100	150
SPM	5231	200	500
SO_2	56	80	120
NO_2	69	80	120
CO	5790	4000 (1 hr average)	10,000 (1 hr. average)



Kopar Khairane: Winter (January 2005)

(a) 24 hours monitoring in a residential area for one day:

1. In this season, the day temperatures had lowered slightly (27 to 28 º C), with thick smog like conditions.
2. All RSPM concentrations were very high (562 to 1015 µg/m^3), with the weighted average of 726 µg/m^3.
3. High RSPM (1015 µg/m^3) concentration was observed in the 7.00 to 11.00 am time slot.
4. SPM levels were well above the NAAQS for the residential area.
5. High SPM levels were observed in 24 hours (1700, 1402, 2095, 1612, and 2480 µg/m^3), with the weighted average of 1817 µg/m^3.
6. Both SPM and RSPM were observed to rise and fall simultaneously throughout the monitoring period.
7. The overall RSPM concentrations were very high, its contribution to the total particulate load was also moderately high (varying from 35 to 45% per cent).
8. Both SO_2 and NO_2 were within NAAQS. However, the weighted averages in winter (47 and 60 µg/m^3) were greater than those observed in monsoon (17 and 32 µg/m^3).
9. CO levels were within NAAQS.
10. The high levels of air pollutants in this season could be ascribed to subsidence in climate due to low-based temperature inversion and weak dispersal of pollutants resulting in trapping and stagnation of these pollutants.

(b) 12 hours monitoring at the traffic junction for two days:

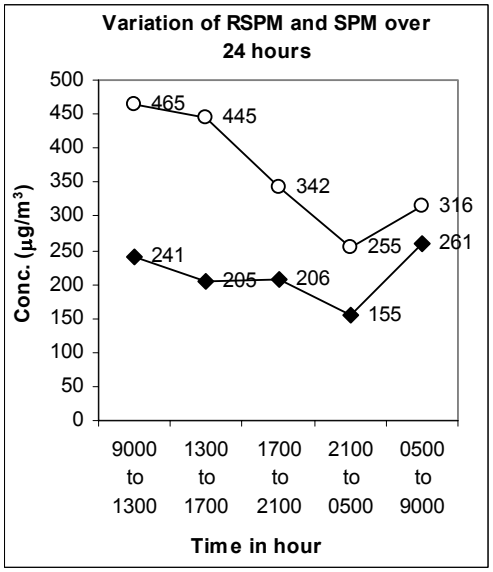
1. Air monitoring was carried out at the Kopar Khairane traffic junction near the police *chowky* from 11.00 to 23.00 on day 1 and from 10.00 to 22.00 hrs on day 2.
2. High concentrations of RSPM, well above the NAAQS, with weighted averages of 1500 and 1721 $\mu g/m^3$ were observed on the two days.
3. Perceptibly high levels of RSPM (2032 $\mu g/m^3$) were observed in the 14 -18 hour time slot on day 2.
4. High concentrations of SPM, well above the NAAQS for industrial areas, on the two days were observed, with the weighted averages being 4105 $\mu g/m^3$ on day 1 and 5231 $\mu g/m^3$ on day 2.
5. Here too, the overall RSPM concentrations were alarmingly high; its contribution to the total particulate load was moderately high (32 to 50% on day 1 and 32 to 34% on day 2 respectively).
6. SO_2 and NO_2 were within the NAAQS on both days; with the weighted averages of 66 $\mu g/m^3$ for both the gases on day 1 and 56 and 69 $\mu g/m^3$ on day 2.
7. The higher NO_2 and SO_2 is closely related to inversion and weak dispersal of pollutants in spite of the heat island effect by the large number of building structures in the area
8. CO level was recorded below NAAQS.

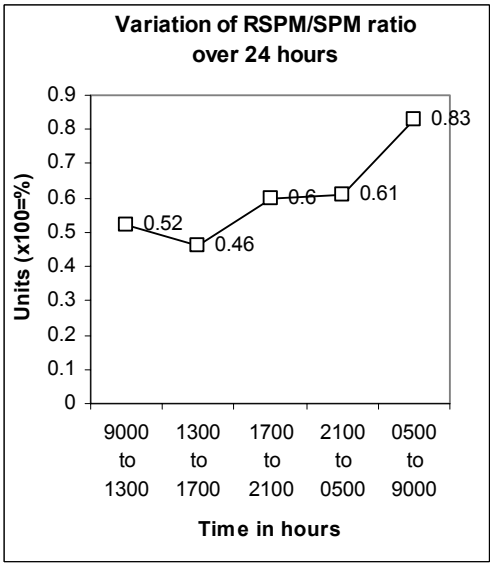
KOPAR KHAIRANE

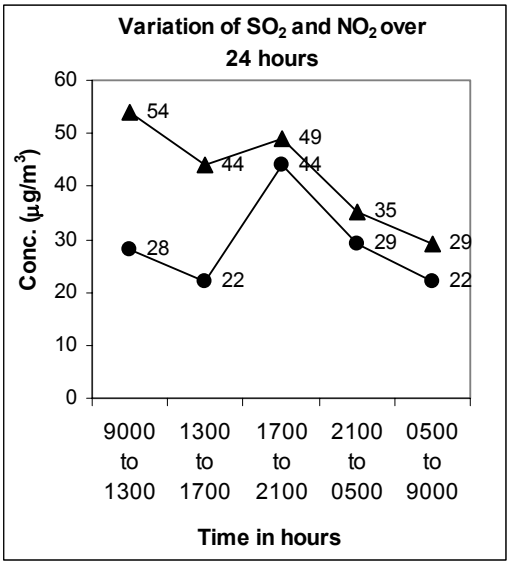
SUMMER (MARCH 2005) :

VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 24 HOURS

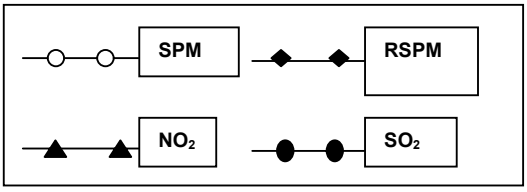
Date: 21 March 2005; Residential area (Terrace of F. G. Naik College, Sector 8)





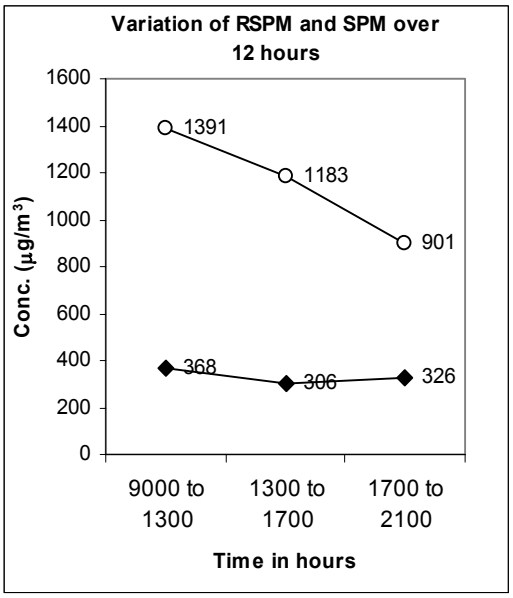


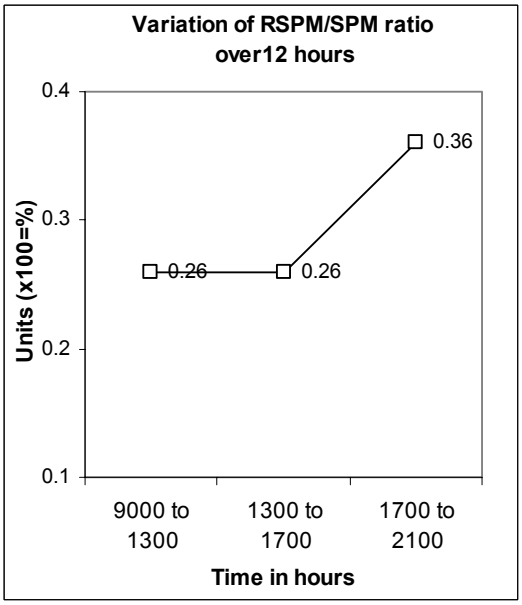
Pollutant	Conc. ($\mu g/m^3$) (weighted averages over 24 hrs)	Standards – Residential over 24 hours (in $\mu g/m^3$)*
RSPM (PM_{10})	204	100
SPM	346	200
SO_2	29	80
NO_2	41	80
CO	2975	4000 (1 hr average)

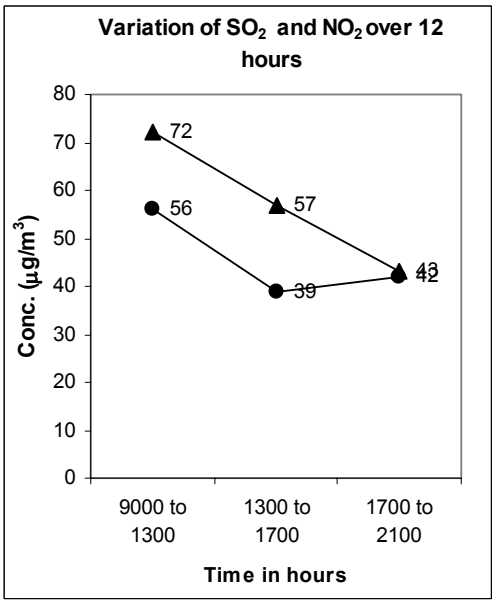


VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 12 HOURS

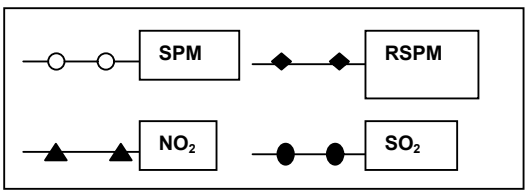
Date: 21 March 2005; Traffic junction (1.5 m off ground level near KK Police *chowky*)



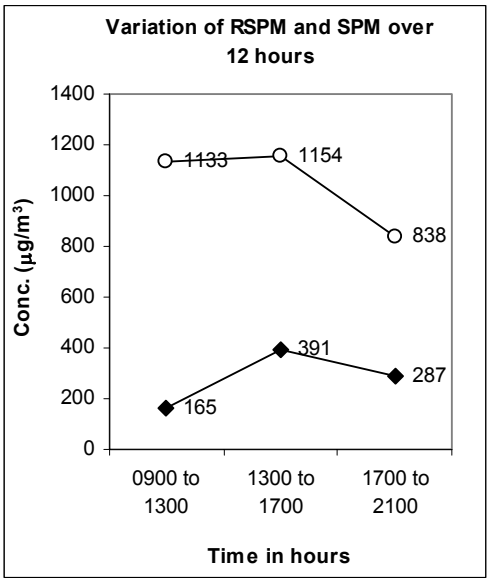


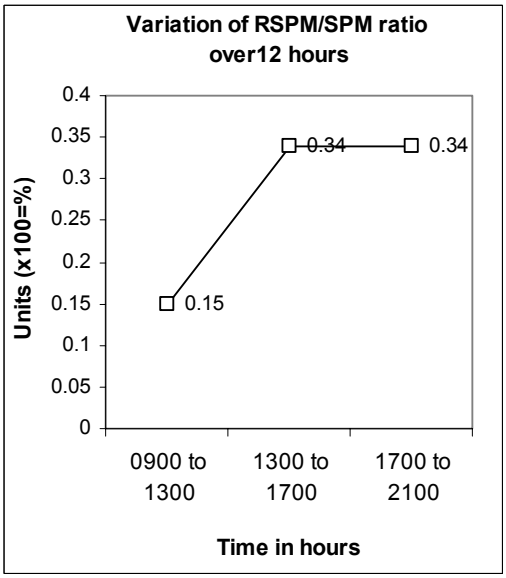


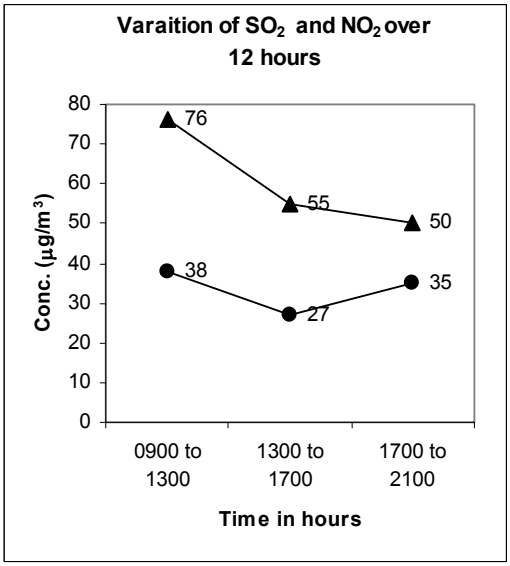
Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	333	100	150
SPM	1158	200	500
SO_2	46	80	120
NO_2	58	80	120
CO	4930	4000 (1 hr average)	10,000 (1 hr. average)



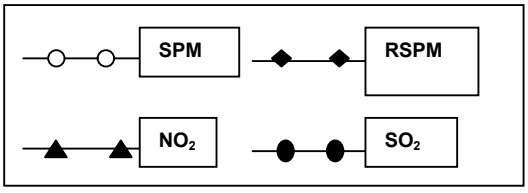
Date: 22 March 2005; Traffic junction (1.5 m off ground level near KK Police *chowky*)







Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	281	100	150
SPM	1042	200	500
SO_2	33	80	120
NO_2	60	80	120
CO	6750	4000 (1 hr average)	10,000 (1 hr. average)



Kopar Khairane: Summer (March-April 2005)

(a) 24 hours monitoring in a residential area for one day:

1. In this season, the day temperatures had risen to 30-31 º C.
2. RSPM levels were largely above the NAAQS, with the weighted average of 204 µg/m^3.
3. SPM levels varied during the 24 hours, with the weighted average of 346 µg/m^3, which was above NAAQS for the residential area.
4. The contribution of RSPM to the total particulate load was high (varying from 46, 52, 60, 61 and 83 per cent). During the period (5.00 to 9.00 time slot), RSPM contributed more than 80% of the total particulate load.
5. Both SO_2 and NO_2 were within NAAQS, with the weighted averages of 29 and 41 µg/m^3 respectively.
6. CO levels were within NAAQS.
7. Of all the air pollutants monitored, RSPM appeared to be the major pollutant in Kopar Khairane in this season.

(b) 12 hours monitoring at the traffic junction for two days:

1. Air monitoring was carried out at the Kopar Khairane traffic junction from 9.00 to 21.00 hrs on day 1 and day 2.
2. High concentrations of RSPM, above the NAAQS, with weighted averages of 333 and 281 µg/m^3, were observed on the two days.
3. High concentrations of SPM, well above the NAAQS for industrial areas, on the two days were observed, with the weighted averages being 1158 µg/m^3 on day 1 and 1042 µg/m^3 on day 2.
4. In this season, the RSPM contribution to the total particulate load is moderate, ranging from 26 to 36% on day 1 and 15 to 34% on day 2.
5. SO_2 and NO_2 were within the NAAQS for industrial areas on both days.
6. CO was recorded below NAAQS.

AIR MONITORING BY THE STUDENTS OF F.G. NAIK COLLEGE, KOPAR KHAIRANE

Students studying the map to locate the different air (and water) monitoring points.

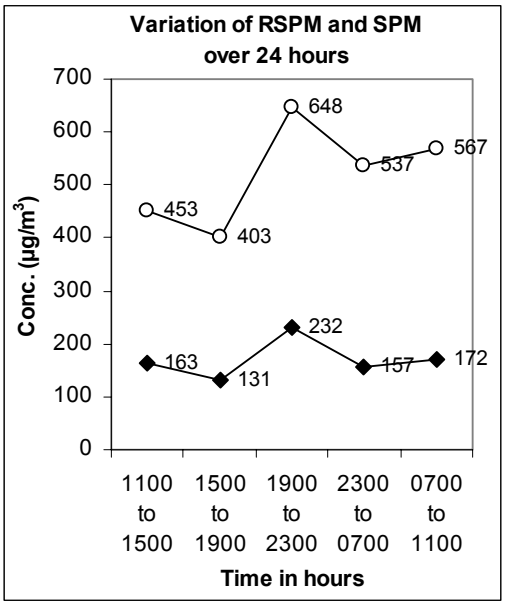
Air monitoring at the traffic junction at Kopar Khairane (right).

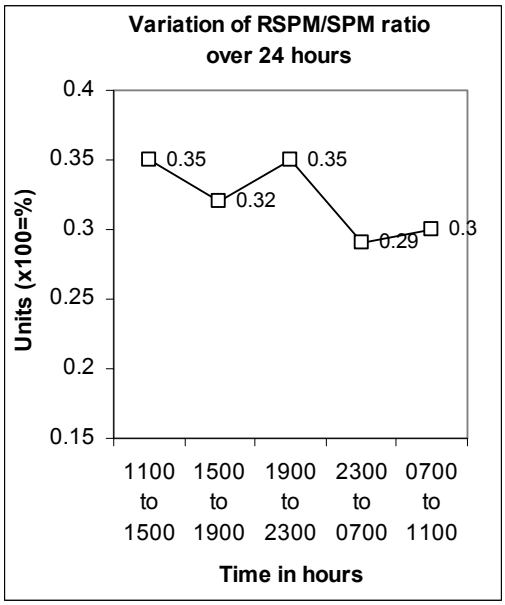
NERUL

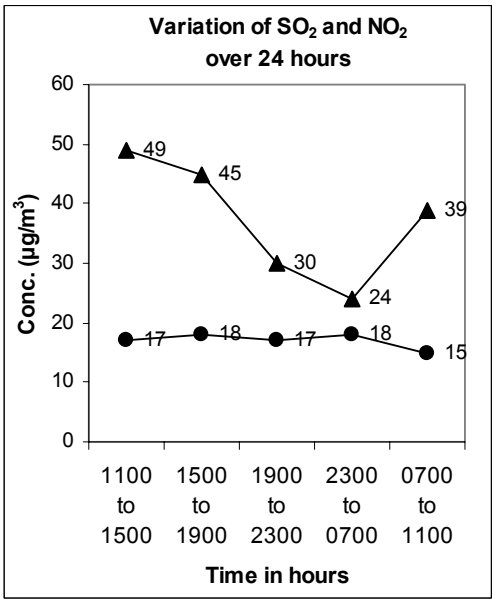
MONSOON (SEPTEMBER 2004) :

VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 24 HOURS

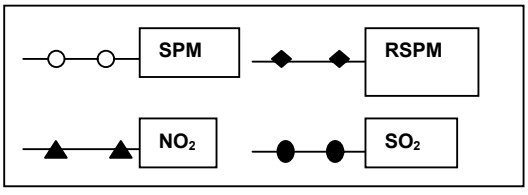
Date: 8 Sept. 2004; Residential area (Terrace – at about 15m height -- of SIES College, Sector 5)





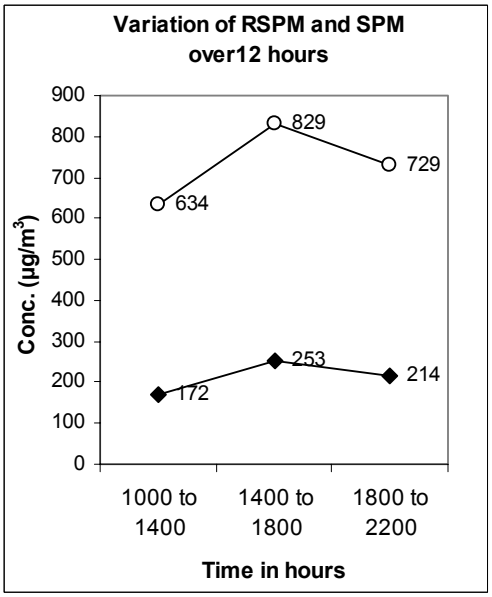


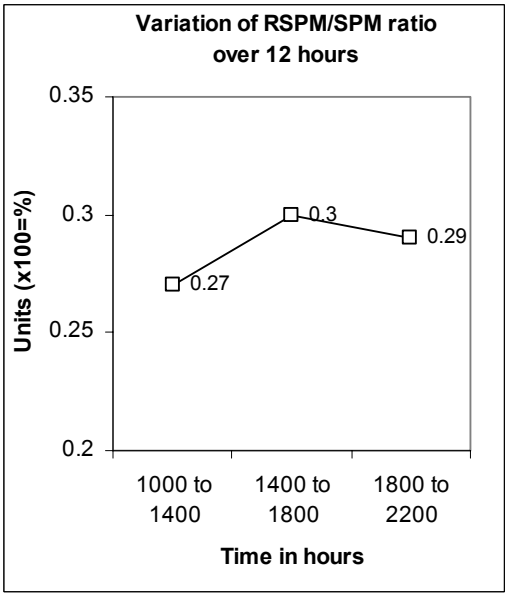
Pollutant	Conc. ($\mu g/m^3$) (weighted averages over 24 hrs)	Standards – Residential over 24 hours (in $\mu g/m^3$)*
RSPM (PM_{10})	169	100
SPM	524	200
SO_2	17	80
NO_2	35	80
CO	1260	4000 (1 hr average)

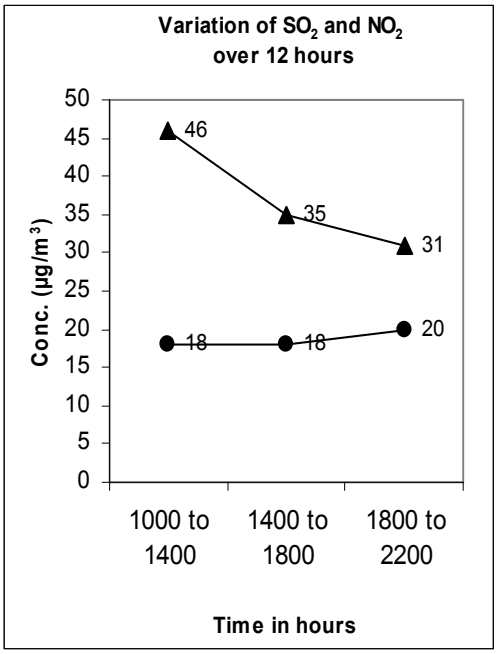


VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 12 HOURS

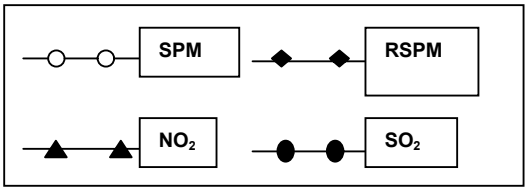
Date: 8 Sept. 2004; Traffic junction (1.5 m off ground level, on TBR)



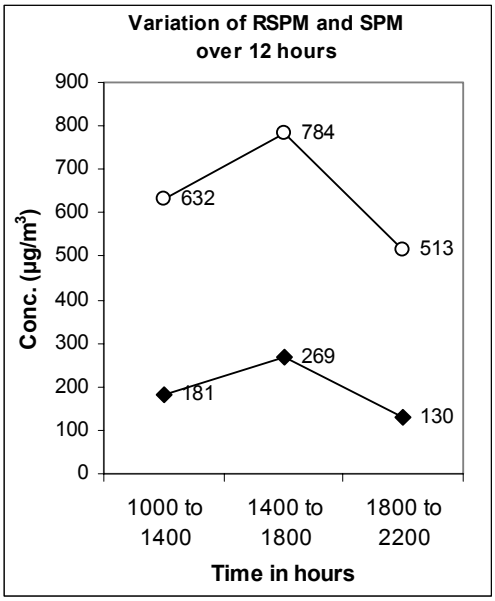


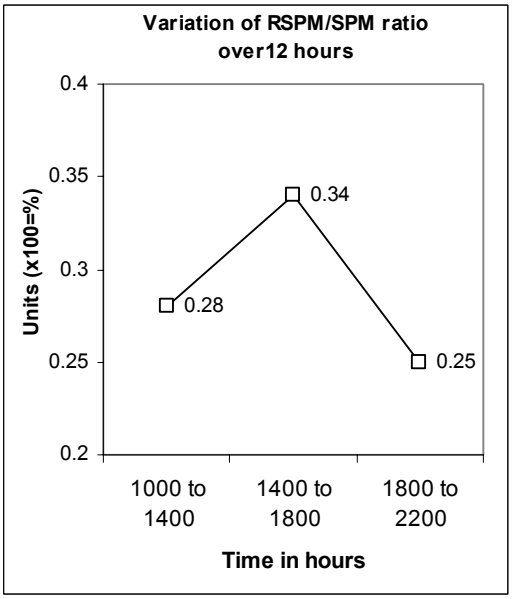


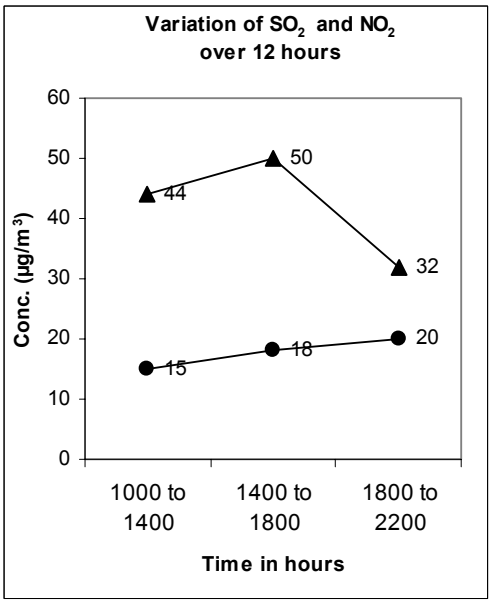
Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	213	100	150
SPM	731	200	500
SO_2	19	80	120
NO_2	37	80	120
CO	3180	4000 (1 hr average)	10,000 (1 hr. average)



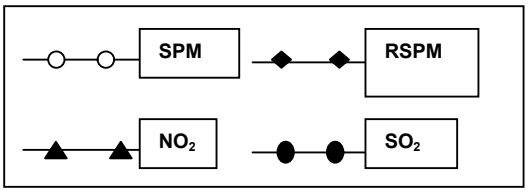
Date: 9 Sept. 2004; Traffic junction (1.5 m off ground level, on TBR)







Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	193	100	150
SPM	643	200	500
SO_2	18	80	120
NO_2	42	80	120
CO	3410	4000 (1 hr average)	10,000 (1 hr. average)



Nerul: Monsoon (September 2004)

(a) 24 hours monitoring in residential area for one day:

1. The high volume air sampler was installed on the terrace of SIES (Nerul) College of Arts, Science and Commerce, Sector 5, Nerul, at an approximate height of 15 metres.
2. It was drizzling on the day of air monitoring.
3. The College is situated
4. in a residential area, with shops and residential complexes around it. The Thane Belapur road lies on one side of the College.
5. RSPM levels were above the NAAQS of residential area, with the weighted average of 169 $\mu g/m^3$. The high levels of RSPM could be from the fine dust.
6. SPM levels were also above the NAAQS of residential area, with the weighted average of 524 $\mu g/m^3$.
7. In the 19.00-23.00 time slot, both RSPM and SPM were observed to increase.
8. The contribution of RSPM to the total air particulate load ranged from 29 to 35%. This indicated that the particulate load was being contributed more by the larger (>10μ) particulates. The source of this could be the heavy traffic on the Thane Belapur road, which lies in the vicinity.
9. The high levels of particulates in monsoon is a cause of concern and the source apportionment should be carried out to pin point the source.
10. Both SO_2 and NO_2 were within NAAQS, with the weighted averages of 19 and 37 $\mu g/m^3$, respectively.
11. CO levels were also within the NAAQS.

(b) 12 hours monitoring at the traffic junction for two days:

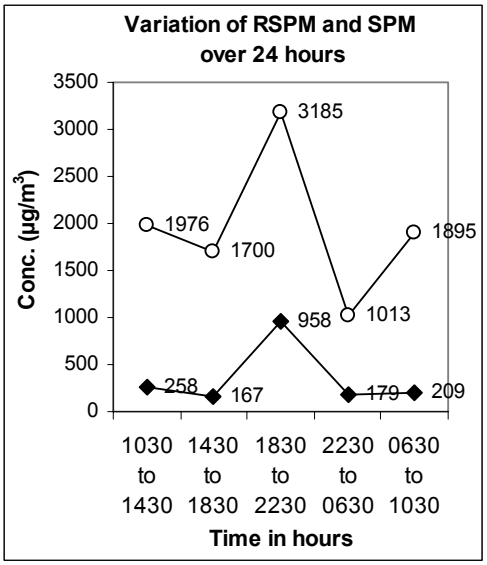
1. The traffic junction at Nerul was located on the main Thane Belapur Road, (TBR) under the Nerul flyover, opposite London Pilsner. This main road is used by heavy motor vehicles and buses, nearly round the clock. The high volume sampler was kept on one side of the road.
2. On the two days of monitoring at the traffic junction, the weighted average concentrations of RSPM (213 and 193 $\mu g/m^3$) were above the NAAQS for industrial area.
3. SPM levels were above NAAQS, with the weighted averages being 731 and 643 $\mu g/m^3$ resp. on the two days. These are high SPM levels in the monsoon season, and could be due to road and traffic dust.
4. In the time slot of 14.00-18.00, RSPM and SPM were observed to rise on day 1 and day 2 of air monitoring.
5. The contribution of RSPM to the total air particulate load (SPM) was 27, 30 and 29% on day 1 and 28, 34 and 25 % on day 2. This implies that the bigger particulates (>10μ) form the major constituent of the particulate pollution, being contributed by heavy traffic.
6. The three gaseous pollutants, SO_2, NO_2 and CO, were within the NAAQS on both days. This could be due to use of cleaner vehicular fuels in addition to washout of gases due to heavy rains.

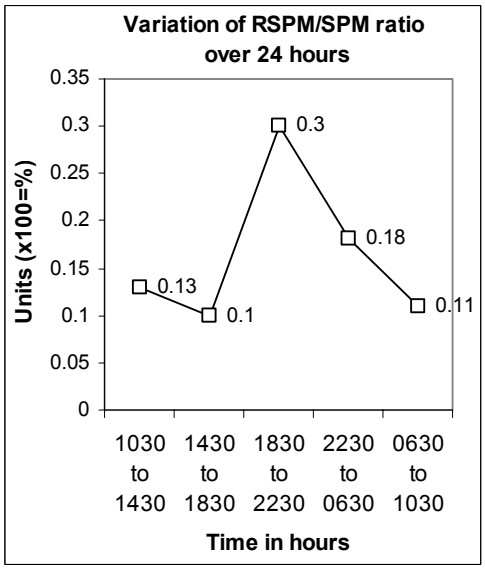
NERUL

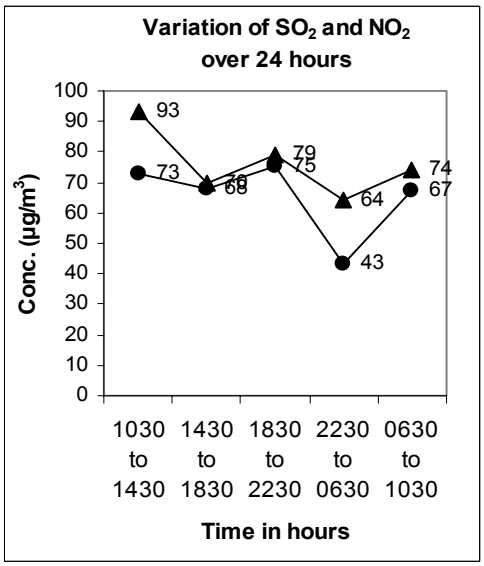
WINTER (JANUARY 2005) :

VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 24 HOURS

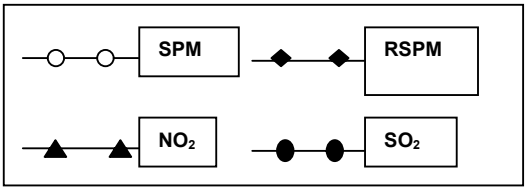
Date: 27 January 2005; Residential area (Terrace of SIES College, Sector 5)





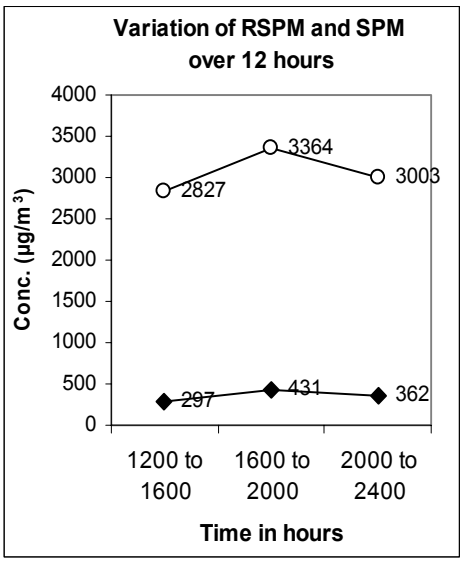


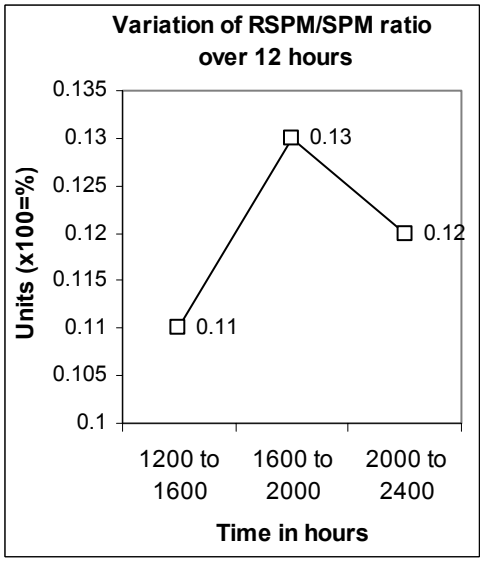
Pollutant	Conc. (µg/m^3) (weighted averages over 24 hrs)	Standards – Residential over 24 hours (in µg/m^3)*
RSPM (PM_{10})	325	100
SPM	1797	200
SO_2	61	80
NO_2	74	80
CO	4575	4000 (1 hr average)

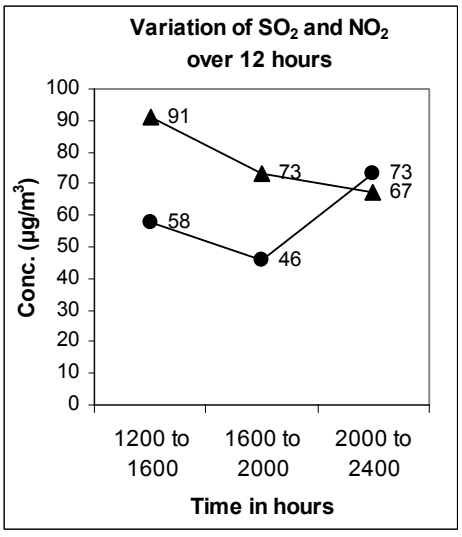


VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 12 HOURS

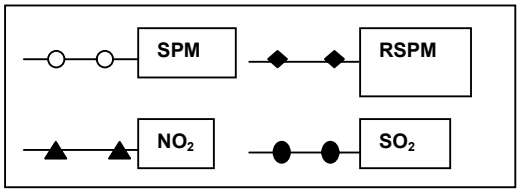
Date: 27 January 2005;Traffic junction (1.5 m off ground level, on TBR)



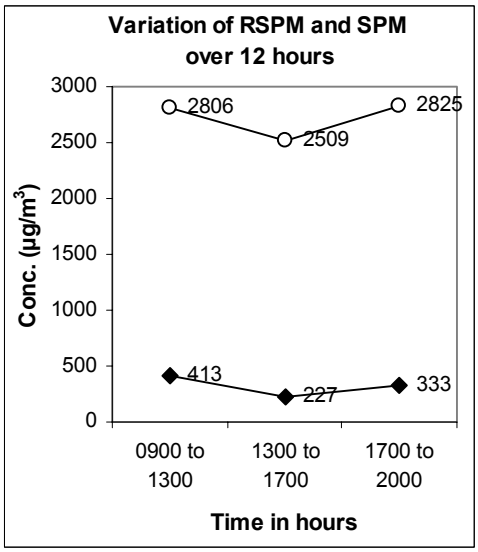


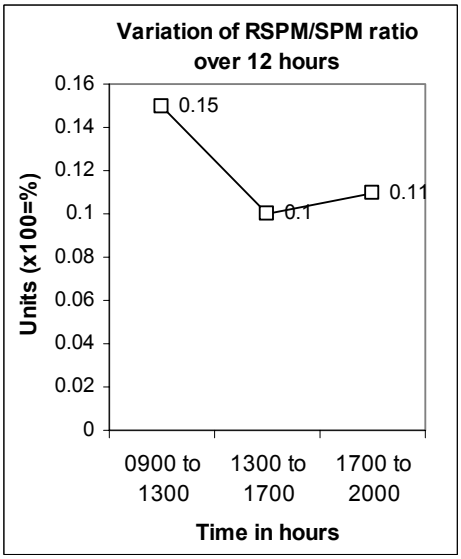


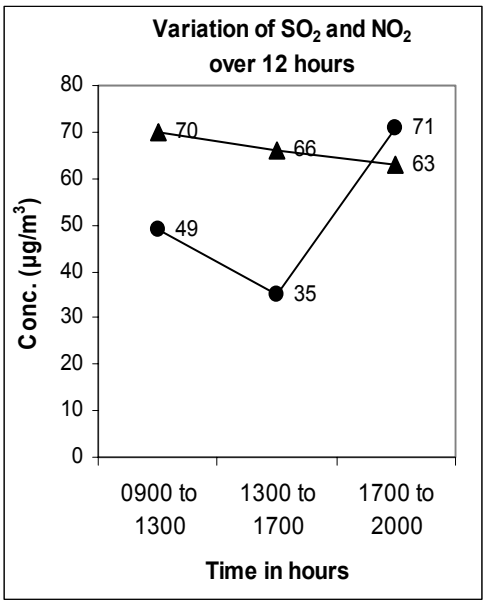
Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	363	100	150
SPM	3065	200	500
SO_2	59	80	120
NO_2	77	80	120
CO	6280	4000 (1 hr average)	10,000 (1 hr. average)



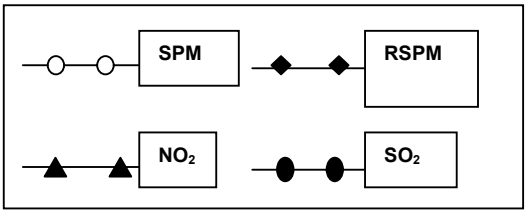
Date: 28 January 2005 Traffic junction (1.5 m off ground level, on TBR)







Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	324	100	150
SPM	2713	200	500
SO_2	51	80	120
NO_2	67	80	120
CO	5690	4000 (1 hr average)	10,000 (1 hr. average)



Nerul: Winter (January 2005)

(a) 24 hours monitoring in a residential area for one day:

1. In this season, the day temperatures had lowered slightly (27 to 28 º C), with smog-like conditions.
2. The weighted average of RSPM concentrations was 325 μg/m^3 being above the NAAQS for residential area.
3. High RSPM (958 μg/m^3) concentration was observed in the 18.30 to 22.30 time slot.
4. SPM levels were well above the NAAQS for the residential area.
5. High SPM levels were observed in 24 hours (1976, 1700, 3185, 1013, and 1895 μg/m^3), with the weighted average of 1797 μg/m^3.
6. Both SPM and RSPM were observed to rise and fall simultaneously throughout the monitoring period.
7. The contribution of RSPM to the total particulate load was 13,10, 30,18 and 11% . The high particulate load is mostly caused by the larger sized PM_{10} particulates
8. Both SO_2 and NO_2 were within NAAQS. However, the weighted averages in winter (61 and 74 μg/m^3) were greater than those observed in monsoon in Nerul (19 and 37 μg/m^3) for these two gases.
9. CO levels were above NAAQS for residential area.
10. The overall higher levels of air pollutants—both gases and particulates—in this season could be attributed to low-based temperature inversion, combined with calm winds leading to weak pollutant dispersal.

(b) 12 hours monitoring at the traffic junction for two days:

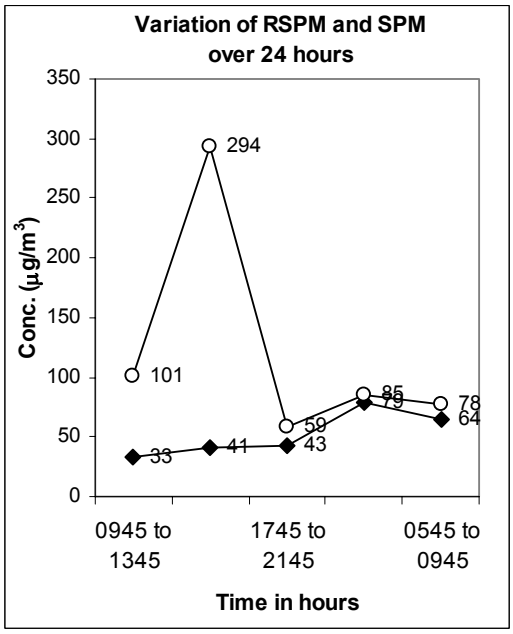
1. Air monitoring was carried out at the Nerul traffic junction on the Thane Belapur road, opposite London Pilsner factory .
2. RSPM levels above the NAAQS of industrial area, with weighted averages of 363 and 324 $\mu g/m^3$, were observed on the two days.
2. High concentrations of SPM, well above the NAAQS for industrial area, on the two days were observed, with the weighted averages being 3065 $\mu g/m^3$ on day 1 and 2713 $\mu g/m^3$ on day 2.
3. The overall contribution of RSPM to the total particulate load was 11, 13, and 12% on day 1 and 15, 10 and 11% on day 2.
4. SO_2 and NO_2 were within the NAAQS of industrial area on both days; the weighted averages of the two gases were 59 and 77 $\mu g/m^3$ (day1) and 51 and 67 $\mu g/m^3$ (day 2)
5. CO level was above NAAQS.

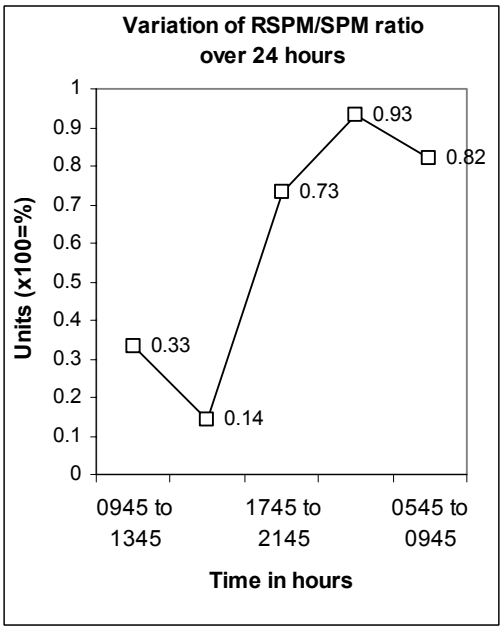
NERUL

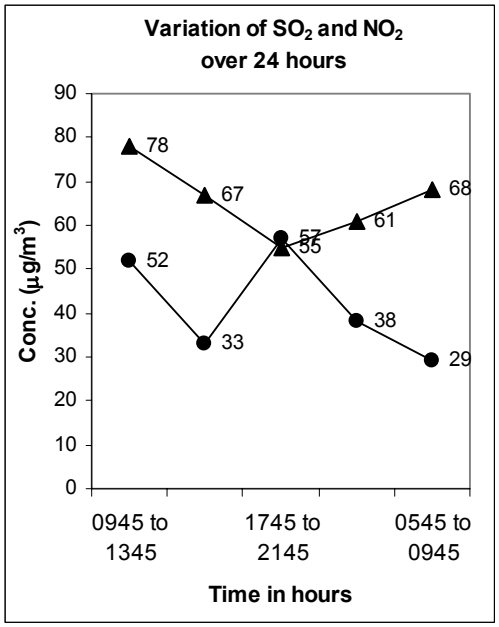
SUMMER (APRIL 2005) :

VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 24 HOURS

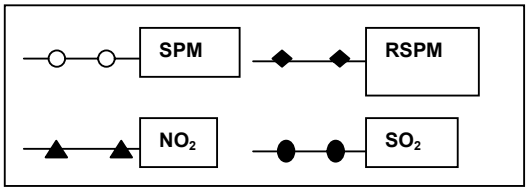
Date: 14 April 2005; Residential area (Terrace of SIES College, Sector 5)





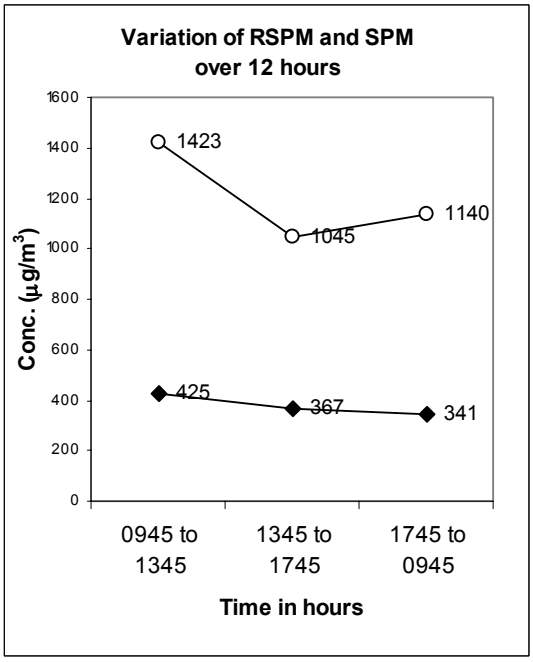


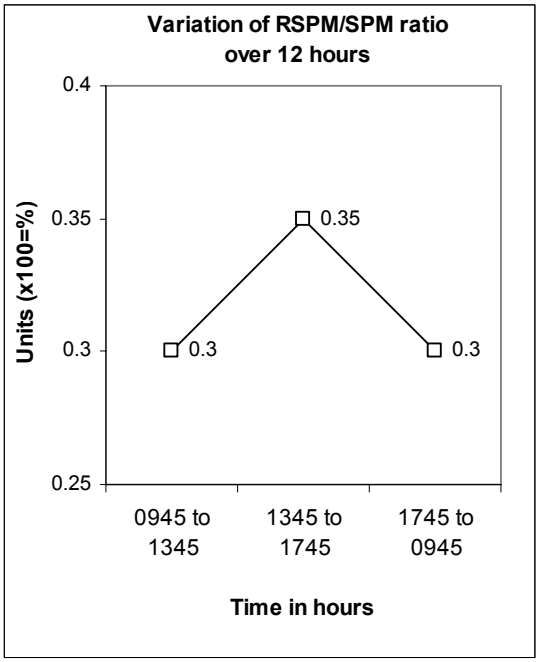
Pollutant	Conc. ($\mu g/m^3$) (weighted averages over 24 hrs)	Standards – Residential over 24 hours (in $\mu g/m^3$)*
RSPM (PM_{10})	57	100
SPM	117	200
SO_2	41	80
NO_2	65	80
CO	3545	4000 (1 hr average)

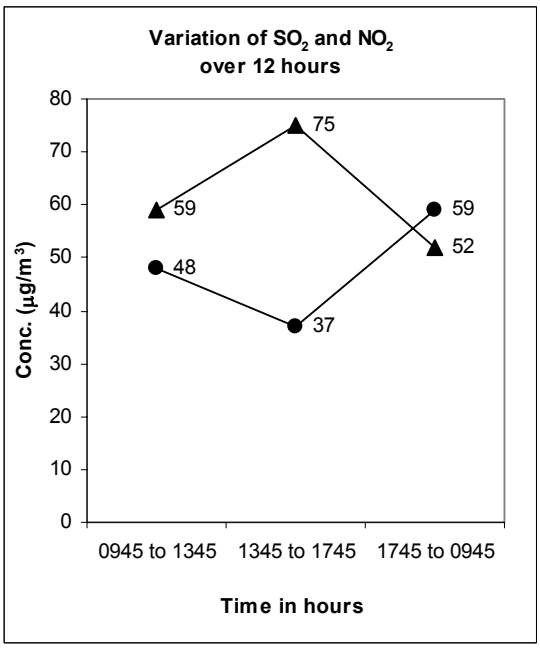


VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 12 HOURS

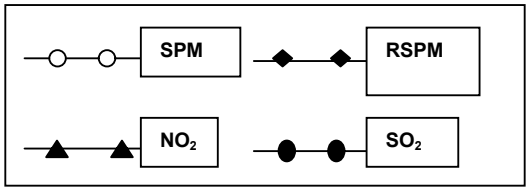
Date: 14 April; Traffic junction (1.5 m off ground level, on TBR)



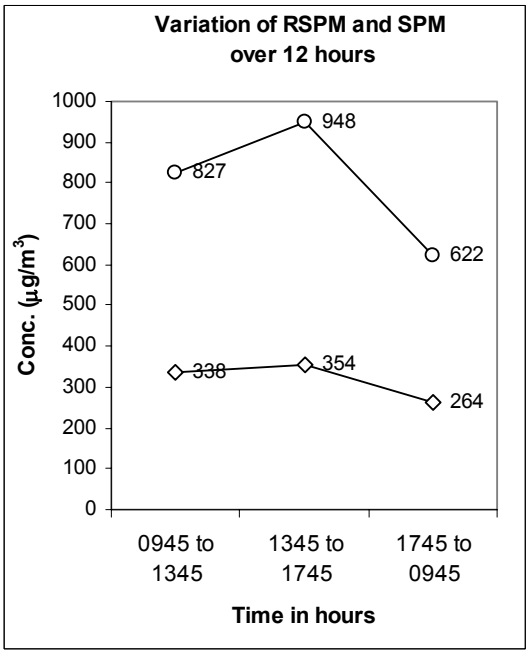


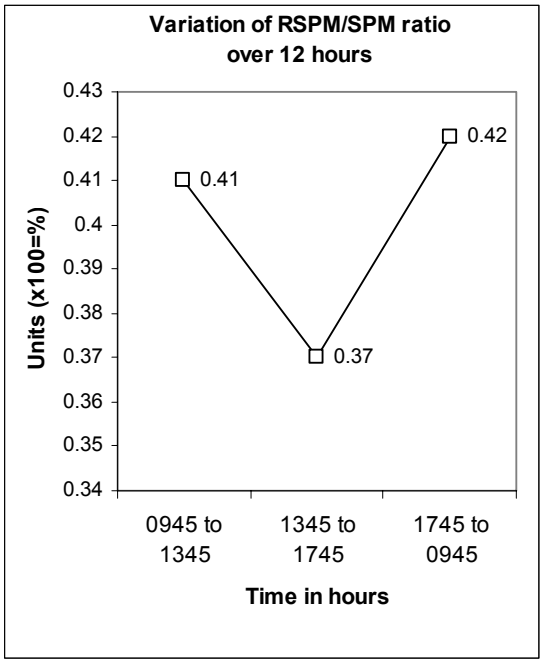


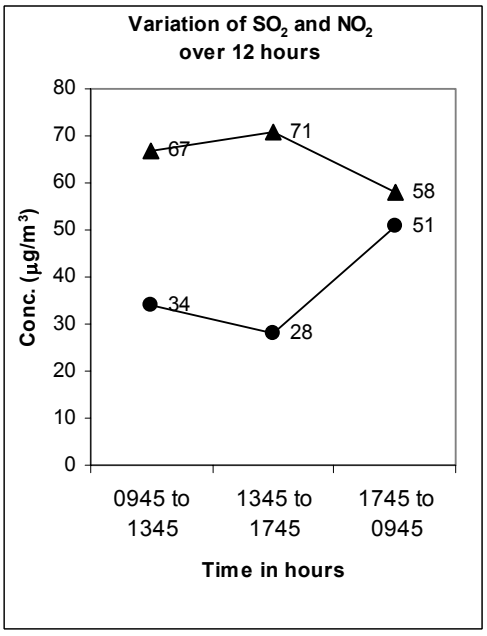
Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	378	100	150
SPM	1202	200	500
SO_2	48	80	120
NO_2	62	80	120
CO	5770	4000 (1 hr average)	10,000 (1 hr. average)



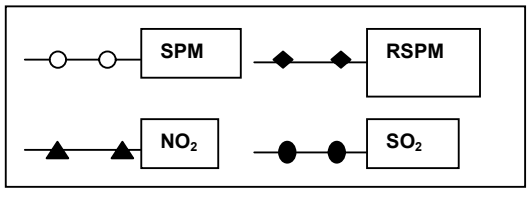
Date: 15 April 2005; Traffic junction (1.5 m off ground level, on TBR)







Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	319	100	150
SPM	799	200	500
SO_2	38	80	120
NO_2	66	80	120
CO	4460	4000 (1 hr average)	10,000 (1 hr. average)



Nerul: Summer (April 2005)

(a) 24 hours monitoring in a residential area for one day:

1. In this season, the day temperatures had risen to 30º C.
2. As the College had closed down for examinations, the college campus and its immediate surroundings were nearly devoid of traffic. (The air sampler was functioning on the terrace of the College).
3. RSPM levels were below the NAAQS for residential area, with the weighted average of 57 $\mu g/m^3$.
4. SPM levels greatly varied during the 24 hours, with the weighted average of 117 $\mu g/m^3$, which was below the NAAQS for residential area.
5. In the 13.45 to 17.45 time slot, SPM was observed to rise to 294 $\mu g/m^3$.
6. {In this season, the contribution of RSPM to the total particulate load was high (varying from 33, 14, 73, 93 and 82 per cent).}
7. Both SO_2 and NO_2 were within NAAQS, with the weighted averages of 41 and 65 $\mu g/m^3$, respectively. CO levels were also within NAAQS.

(b) 12 hours monitoring at the traffic junction for two days:

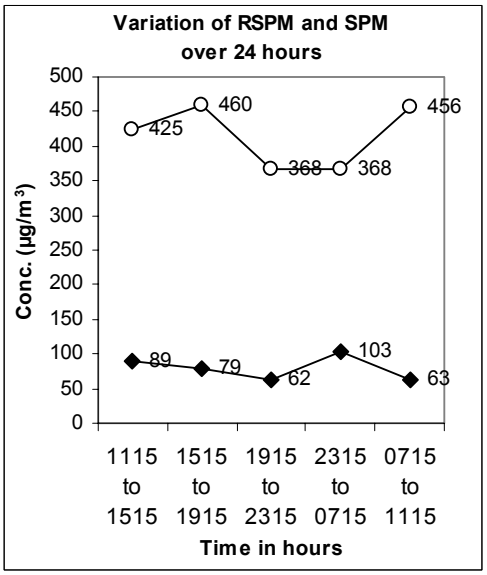
1. Air monitoring was carried out at the Nerul traffic junction from 9.45 to 21.45 hrs on day 1 and day 2.
2. High concentrations of RSPM above the NAAQS (industrial area) were observed. Their weighted averages on the two days were 378 and 319 $\mu g/m^3$.
3. High concentrations of SPM, well above the NAAQS for industrial areas, on the two days were observed, with the weighted averages being 1202 $\mu g/m^3$ on day 1 and 799 $\mu g/m^3$ on day 2.
4. In this season at the traffic junction, the RSPM contribution to the total particulate load is 30, 35 and 30% on day 1 and 41, 37 and 42% on day 2.
5. SO_2 and NO_2 were within the NAAQS for industrial areas on both days, with the weighted averages of SO_2 being 48 and 38 and of NO_2 being 62 and 66 $\mu g/m^3$ respectively on the two days.
6. CO was recorded below NAAQS of industrial area.

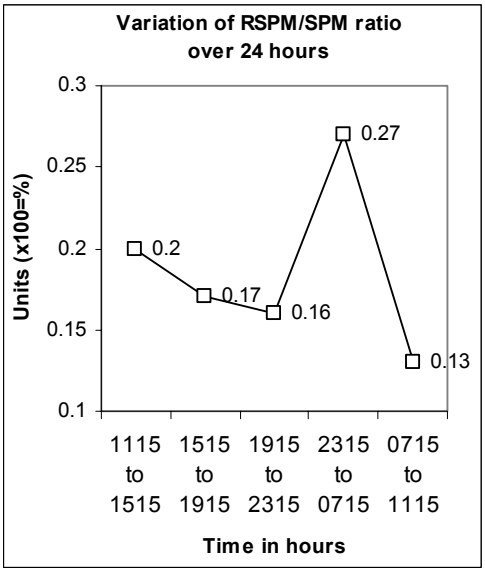
TURBHE

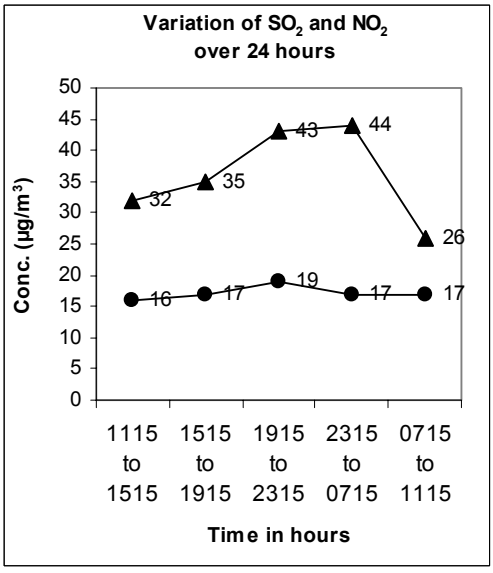
MONSOON (SEPTEMBER 2004) :

VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 24 HOURS

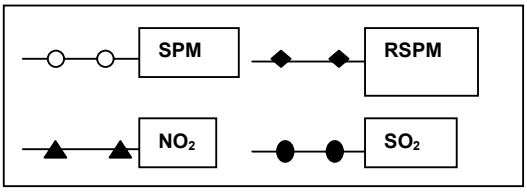
Date: 14 Sept. 2004; Residential area (Terrace – at about 12 m height-- of Municipal School No. 19, Sector 22, Vashi)





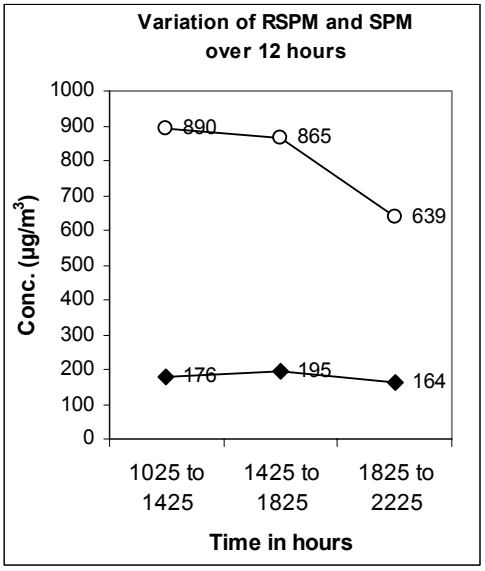


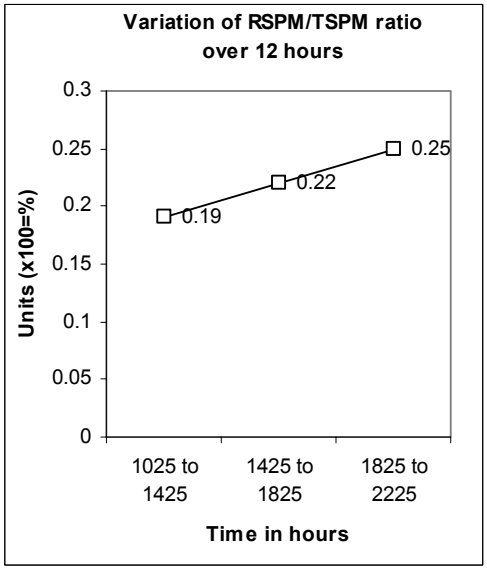
Pollutant	Conc. ($\mu g/m^3$) (weighted averages over 24 hrs)	Standards – Residential over 24 hours (in $\mu g/m^3$)*
RSPM (PM_{10})	83	100
SPM	408	200
SO_2	17	80
NO_2	37	80
CO	1950	4000 (1 hr average)

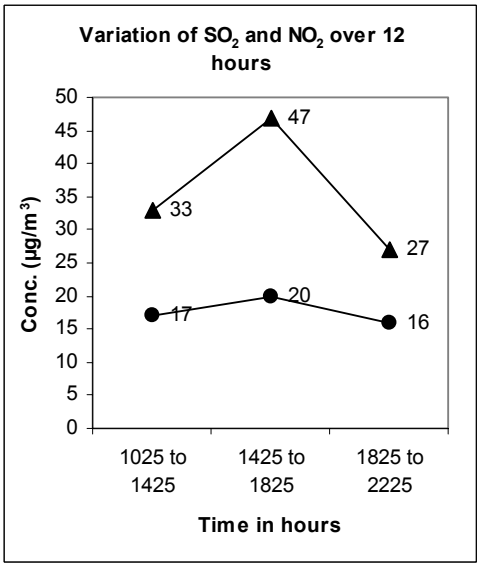


VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 12 HOURS

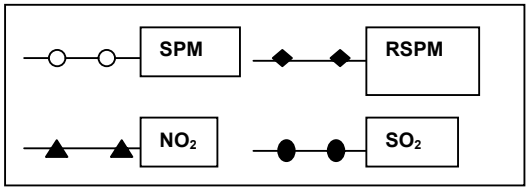
Date: 14 Sept. 2004; Traffic junction (1.5 m off ground level, on TBR, near Hanuman Nagar)



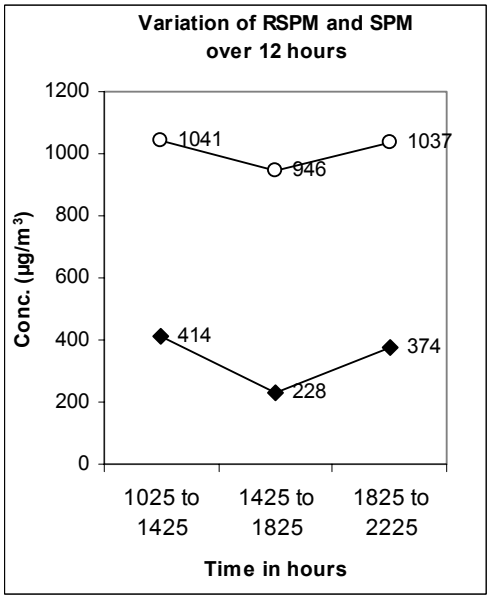


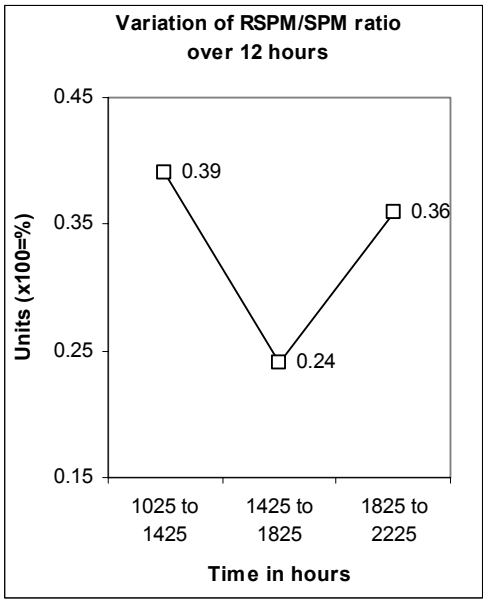


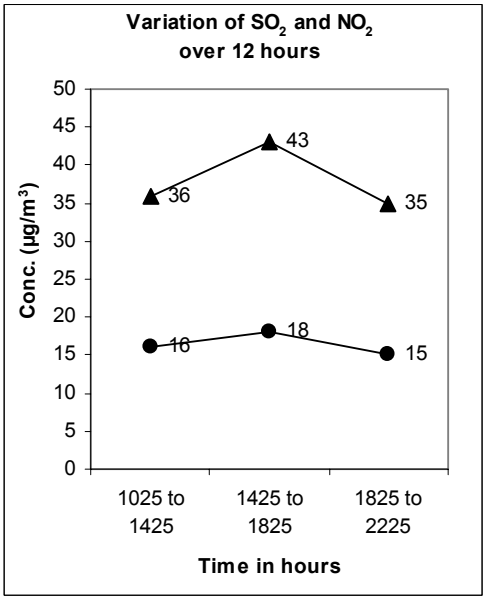
Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	178	100	150
SPM	798	200	500
SO_2	18	80	120
NO_2	33	80	120
CO	3520	4000 (1 hr average)	10,000 (1 hr. average)



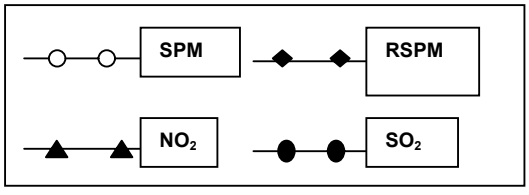
Date: 15 Sept. 2004; ; Traffic junction (1.5 m off ground level, on TBR, near Hanuman Nagar)







Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	339	100	150
SPM	1008	200	500
SO_2	16	80	120
NO_2	38	80	120
CO	3240	4000 (1 hr average)	10,000 (1 hr. average)



Turbhe : Monsoon (September 2004)

(b) 24 hours monitoring in residential area for one day:

1. The high volume air sampler was installed on the terrace of a Municipal School No. 19, in Turbhe *gaonthan* (village), Sector 22, Turbhe, Vashi, at an approximate height of 12 metres.
2. The school is situated in a residential area, with small shops and houses around it. While the immediate surroundings of the monitoring site is green and less populated with a water body nearby, the Turbhe village is bounded by major roads on its three sides.
3. It was raining heavily on the day of air monitoring.
4. RSPM levels were below the NAAQS for residential area, with the weighted average of 83 $\mu g/m^3$.
5. In the 23.15 to 7.15 time slot, RSPM was seen to rise to103 $\mu g/m^3$.
6. SPM levels were above the NAAQS for residential area, with the weighted average of 408 $\mu g/m^3$.
7. The contribution of RSPM to the total air particulate load during different time intervals was 13, 16, 17, 21 and 27%. This indicated that the particulate load was being contributed more by the larger (>PM10µ) particulates.
8. Both SO_2 and NO_2 were within NAAQS, with the weighted averages of 17 and 37 $\mu g/m^3$ respectively.
9. CO levels were recorded at 1950 $\mu g/m^3$, within the NAAQS (4000 $\mu g/m^3$) of residential area.
10. There was an effective washout of gases by the rains, even in this site.

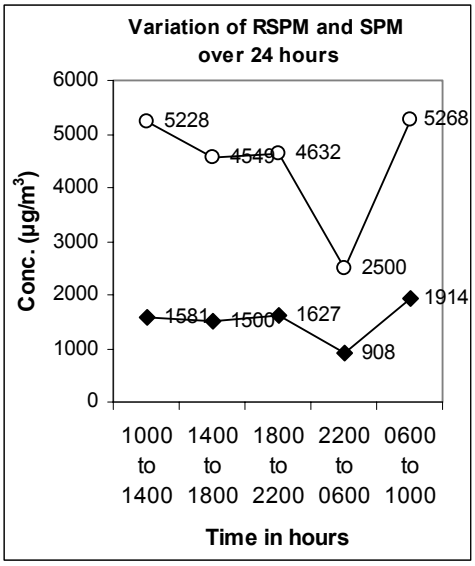
(c) 12 hours monitoring at the traffic junction for two days:

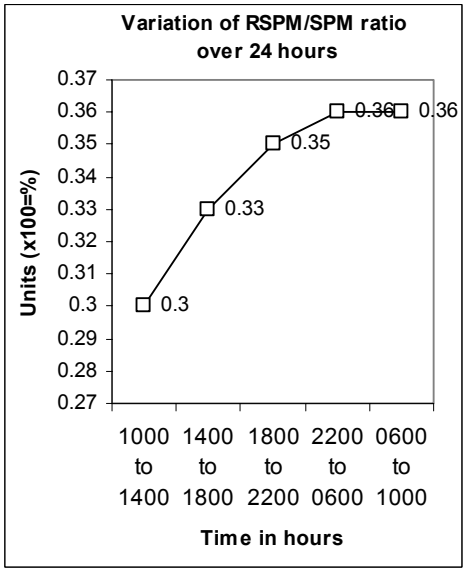
1. The air monitoring pump was positioned at the ground level at the traffic junction of the main Thane Belapur (TB) road, at Turbhe, near Hanuman Nagar, but at a distance of a few meters.
2. Large number of industrial units is located along one side of the monitoring point, with the TB road situated adjacent to the pump. This road is a main thorough fare with constant movement of heavy motor vehicles.
3. On the two days of air monitoring at the traffic junction, the weighted averages of RSPM (178 and 339 $\mu g/m^3$) were above the NAAQS even for industrial areas. (Note: It was raining heavily on the first day.)
4. SPM levels were above NAAQS, with the weighted averages being 798 and 1008 $\mu g/m^3$ resp. on the two days. These are high SPM levels in the monsoon season, more so when heavy rains were experienced. These high SPM levels could be due to road-, traffic dust and industrial emissions.
5. The contribution of RSPM to the total air particulate load (SPM) ranged from 19 to 25% on day 1 and 24 to 39% on day 2. This implies that the bigger particulates ($>PM_{10\mu}$) form the major constituent of the particulate pollution.
6. The three gaseous pollutants, SO_2, NO_2 and CO, were within the NAAQS on both days. The washout effect of rains on gases seems to be highly effective, in contrast to the washout of particulates.

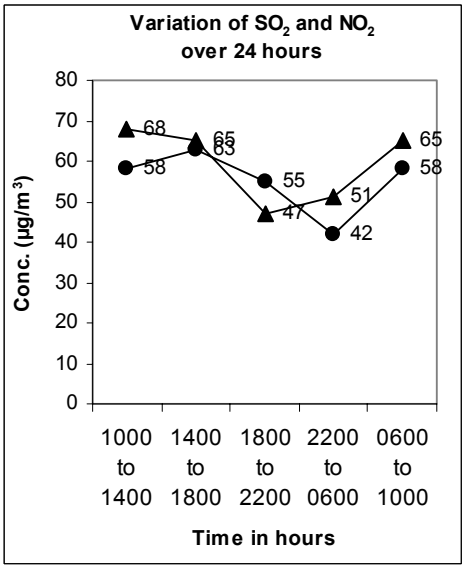
TURBHE
WINTER (JANUARY 2005) :

VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 24 HOURS

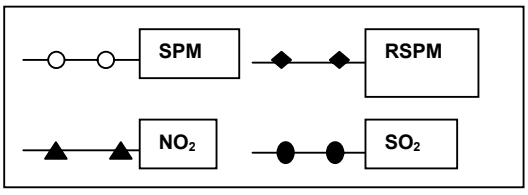
Date: 14 January 2005; Residential area (Terrace of Municipal School No. 19, Sector 22, Vashi)





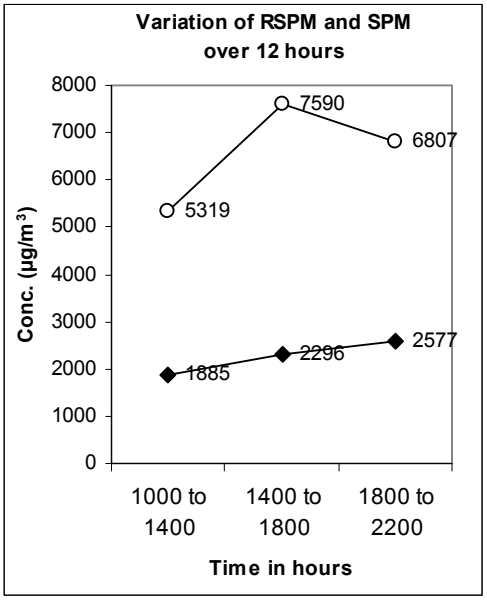


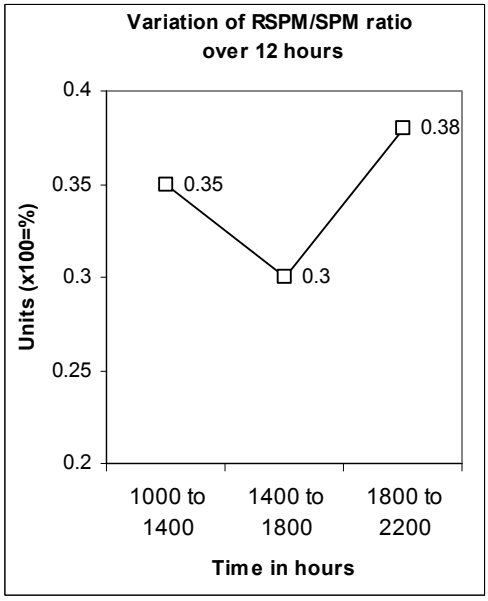
Pollutant	Conc. ($\mu g/m^3$) (weighted averages over 24 hrs)	Standards – Residential over 24 hours (in $\mu g/m^3$)*
RSPM (PM_{10})	1406	100
SPM	4112	200
SO_2	53	80
NO_2	58	80
CO	4890	4000 (1 hr average)

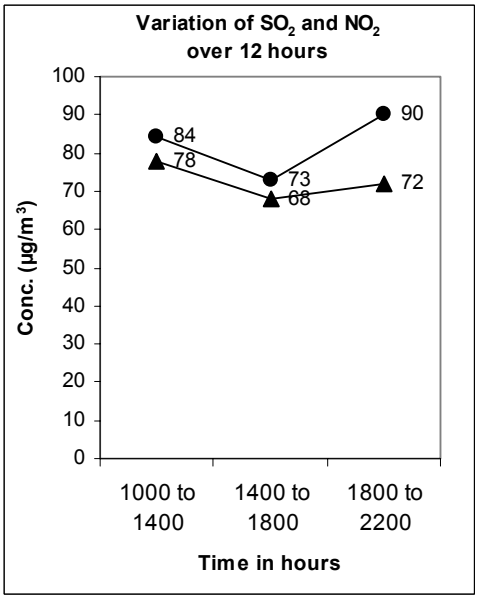


VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 12 HOURS

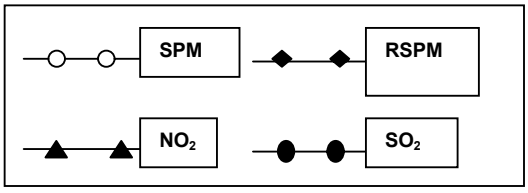
Date: 14 January 2005; Traffic junction (1.5 m off ground level, on TBR, near Hanuman Nagar)



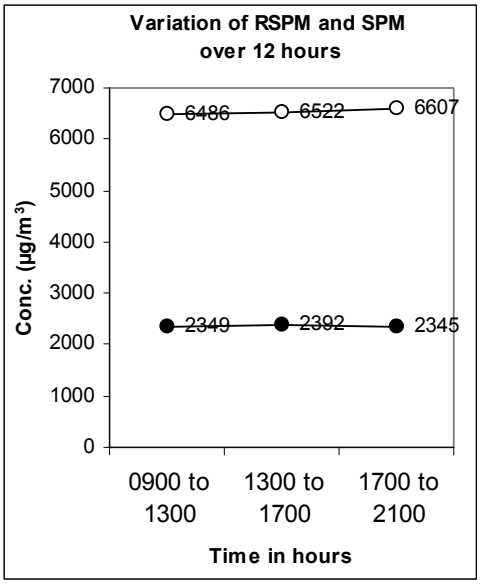


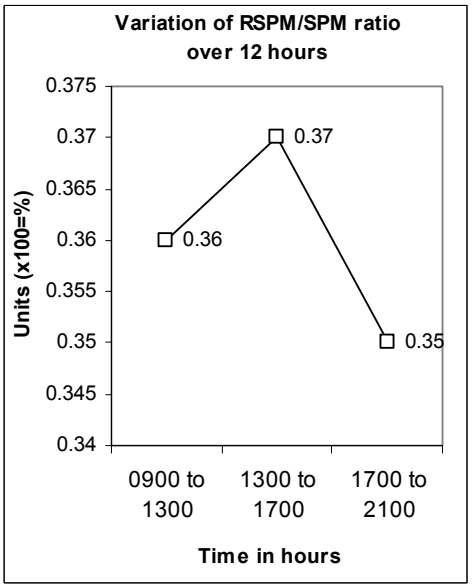


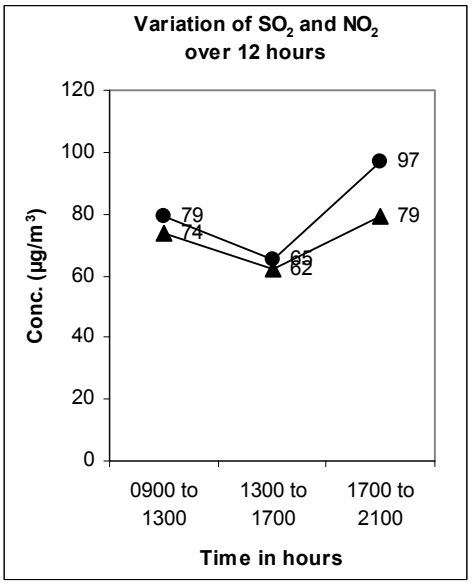
Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	2252	100	150
SPM	6572	200	500
SO_2	82	80	120
NO_2	73	80	120
CO	7250	4000 (1 hr average)	10,000 (1 hr. average)



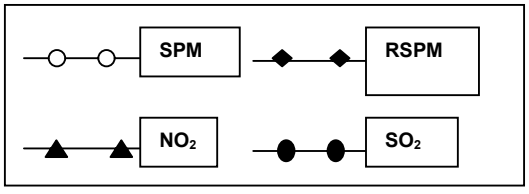
Date: 15 January 2005; Traffic junction (1.5 m off ground level, on TBR, near Hanuman Nagar)







Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	2362	100	150
SPM	6538	200	500
SO_2	80	80	120
NO_2	72	80	120
CO	6890	4000 (1 hr average)	10,000 (1 hr. average)



Turbhe: Winter (January 2005)

(a) 24 hours monitoring in a residential area for one day:

1. In this season, the day temperatures had lowered slightly (29 º C), with smog like conditions.
1. All RSPM concentrations were very high (908 to 1914 µg/m^3), with the weighted average of 1406 µg/m^3.
2. A decrease (908 µg/m^3) in the 22.00 to 06.00 timeslot and then an increase (1914 µg/m^3) in 0600 to 1000 timeslot in RSPM concentrations were observed.
3. SPM levels were well above the NAAQS for the residential area.
4. High SPM levels (5228, 4549, 4632, 2500 and 5268 µg/m^3), with the weighted average of 4112 µg/m^3. in 24 hours were observed
5. Both SPM and RSPM were observed to rise and fall simultaneously throughout the monitoring period.
6. Though the overall RSPM concentrations were very high, its contribution to the total particulate load was moderate to high (30, 33, 35, 36 and 36%).
7. Both SO_2 and NO_2 were within NAAQS for residential area. However, the weighted averages in winter (53 and 58 µg/m^3) were greater than those observed in monsoon (17 and 37 µg/m^3).
8. CO levels were above NAAQS of the residential area (4000 µg/m^{3-}) , with the weighted average of 4890 µg/m^3
9. The high levels of air pollutants in this season, including that of CO, could be ascribed to temperature inversion prevalent in this season with resultant concentration of pollutants.
10. The terrain of Turbhe, combined with its other geographical features such as the close proximity of hills, and the adjacent industrial belt, further seem to compound the pollution problem.

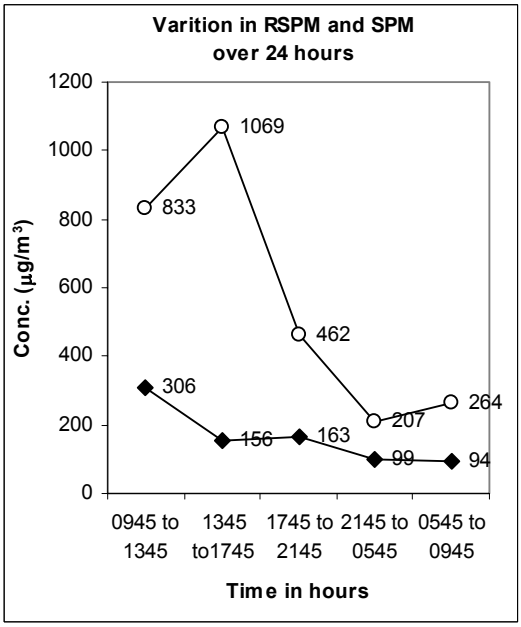
(b) 12 hours monitoring at the traffic junction for two days:

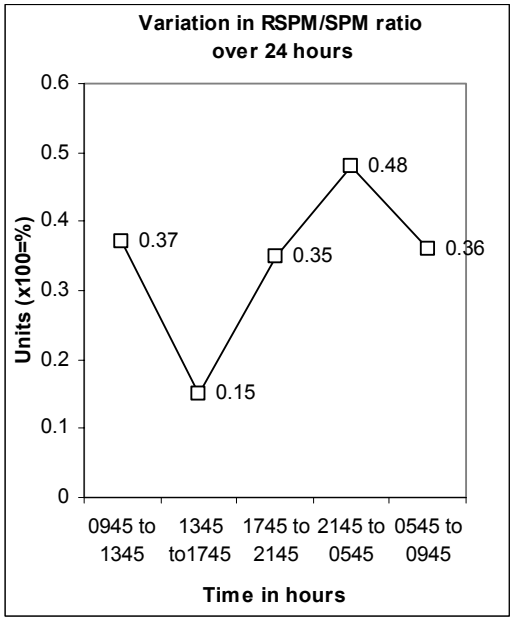
1. Air monitoring was carried out at the Turbhe traffic junction from 10.00 to 22.00 on day 1 and from 09.00 to 21.00 hrs on day 2.
2. High concentrations of RSPM, well above the NAAQS of industrial area (150 $\mu g/m^3$) with weighted averages of 2253 and 2362 $\mu g/m^3$ were observed on the two days.
3. On both the days of air monitoring at the traffic junction, high concentrations of SPM, well above the NAAQS for industrial areas (500 $\mu g/m^3$) were observed, with the weighted averages being 6572 $\mu g/m^3$ on day 1 and 6538 $\mu g/m^3$ on day 2.
4. The overall RSPM contribution to the total particulate load was alarmingly high; its contribution ranged from 30 to 38% on day 1 and 35 to 37% on day 2.
5. SO_2 and NO_2 were within the NAAQS (120 $\mu g/m^3$ for both SO_2 and NO_2) on both days. The weighted averages were 82 and 73 $\mu g/m^3$ for SO_2 and NO_2 on day 1, and 80 and 72 $\mu g/m^3$ on day 2.
6. CO level was recorded below NAAQS for industrial area (10,000 $\mu g/m^3$), with its concentration of 7250 on day 1 and 6890 on day 2.

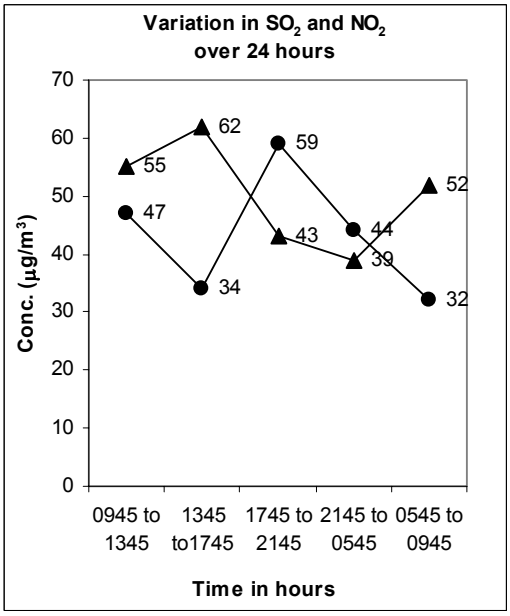
TURBHE
SUMMER (APRIL 2005) :

VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 24 HOURS

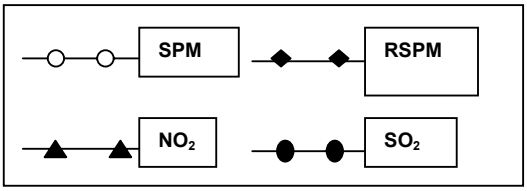
Date: 12 April 2005; Residential area (Terrace of Municipal School No. 19, Sector 22, Vashi)





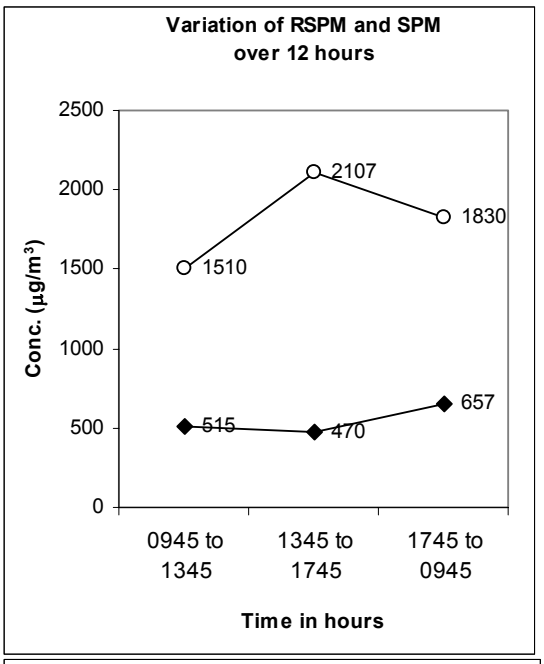


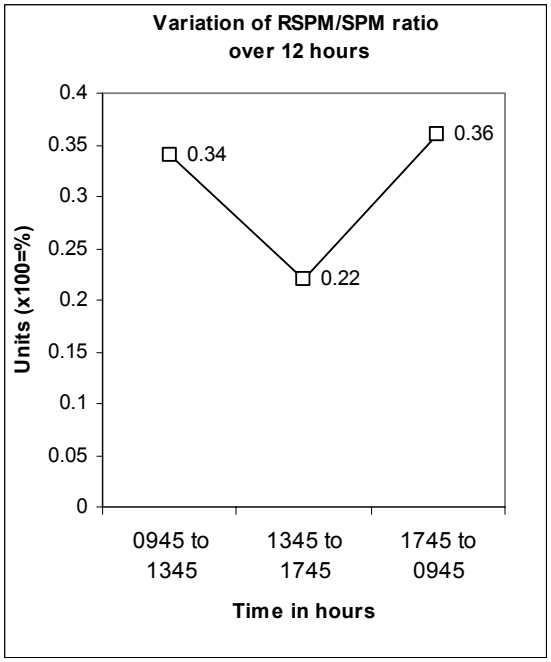
Pollutant	Conc. ($\mu g/m^3$) (weighted averages over 24 hrs)	Standards – Residential over 24 hours (in $\mu g/m^3$)*
RSPM (PM_{10})	153	100
SPM	507	200
SO_2	43	80
NO_2	48	80
CO	3395	4000 (1 hr average)

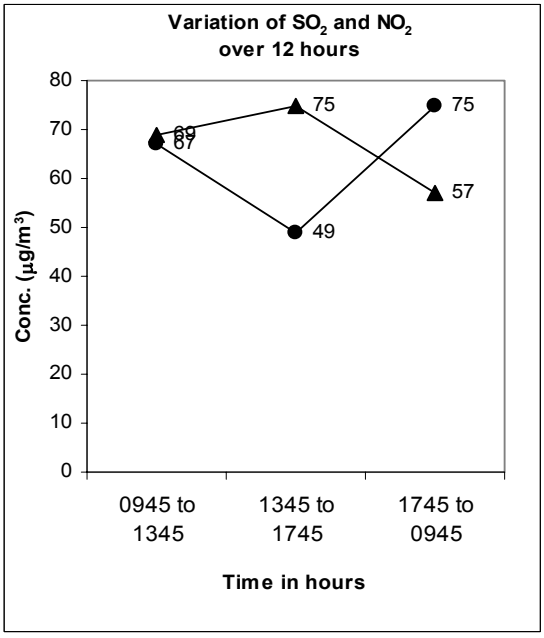


VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 12 HOURS

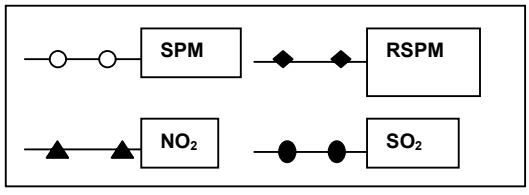
Date: 12 April 2005;Traffic junction (1.5 m off ground level, on TBR, near Hanuman Nagar)





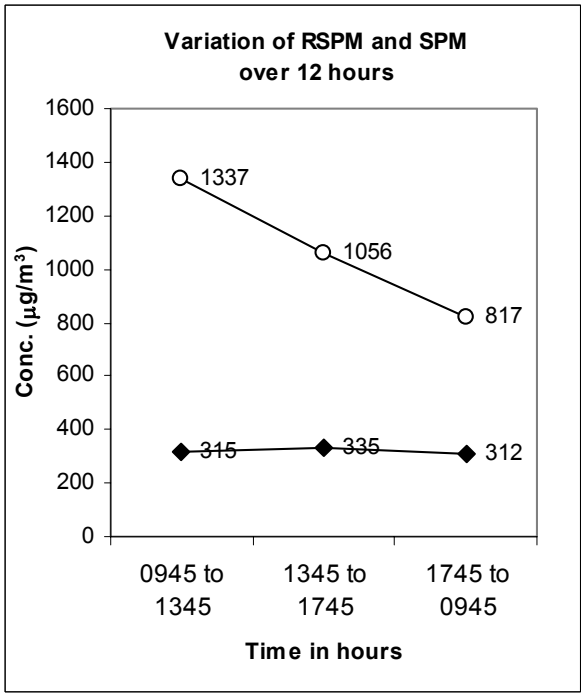


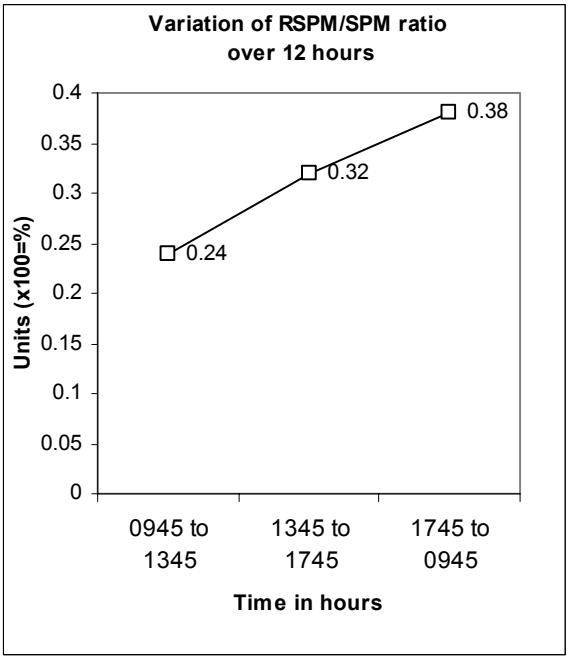
Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	547	100	150
SPM	1816	200	500
SO_2	64	80	120
NO_2	67	80	120
CO	6640	4000 (1 hr average)	10,000 (1 hr. average)

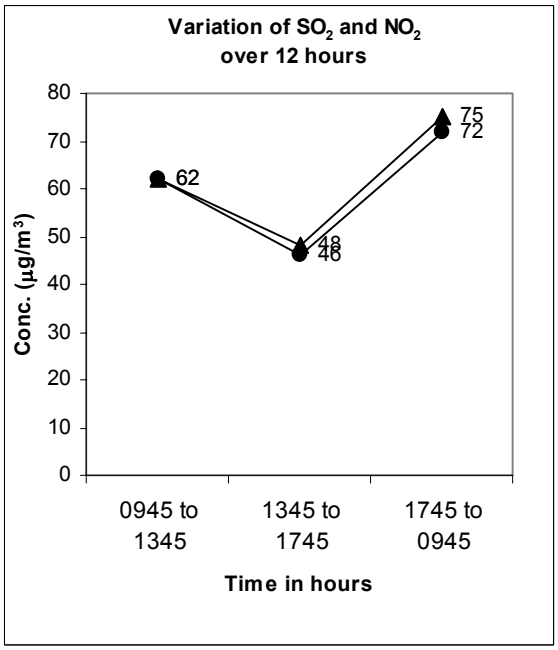


Date: 16 April 2005: Traffic junction (1.5 m off ground level, on TBR, near Hanuman Nagar)

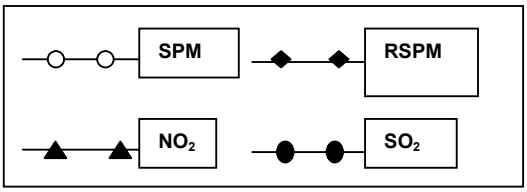
(Due to a power failure on 13 April and other logistic reasons, the air monitoring at Turbhe was continued on 16 April, 2005.)







Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	321	100	150
SPM	1070	200	500
SO_2	60	80	120
NO_2	62	80	120
CO	6570	4000 (1 hr average)	10,000 (1 hr. average)



TURBHE: Summer (April 2005)

(a) 24 hours monitoring in a residential area for one day:

1. In this season, the day temperatures had risen to 30º C.
2. There was not much traffic around the school where the high volume sampler was installed on the terrace.
3. The RSPM levels were largely above the NAAQS for residential area, with the weighted average of 153 µg/m^3.
4. SPM levels varied during the 24 hours, with the weighted average of 507 µg/m^3, which was above the NAAQS for the residential area.
5. In the time slot, 9.45 to 17.45, SPM levels were 833 and 1069 µg/m^3.
6. In this season, the contribution of RSPM to the total particulate load was high (varying from 37, 15, 35, 48 and 36 per cent).
7. SO_2, NO_2 and CO levels were within NAAQS, with the weighted averages of 43, 48 and 3395 µg/m^3 respectively.

(b) 12 hours monitoring at the traffic junction for two days:

1. Air monitoring was carried out at the Turbhe traffic junction, right off the Thane Belapur Road, and on the fringes of Hanuman Nagar, from 9.45 to 21.45 hrs on day 1 and day 2.
2. High concentrations of RSPM above the NAAQS for industrial area were observed at all monitoring times; the weighted averages were 547 and 321 µg/m^3 on the two days.
3. High concentrations of SPM, well above the NAAQS for industrial areas, on the two days were observed, with the weighted averages being 1816 µg/m^3 on day 1 and 1070 µg/m^3 on day 2.
4. In this season, the RSPM contribution to the total particulate load was 34, 22 and 36% on day 1 and 24, 32 and 38% on day 2.
5. SO_2 and NO_2 were within the NAAQS for industrial areas on both days; their weighted averages were 64 and 67 µg/m^3 on day 1 and 60 and 62 µg/m^3 on day 2.
6. CO was recorded below NAAQS for industrial area, with the reading being 6640 µg/m^3 on day 1 and 6570 µg/m^3 on day 2.

AIR MONITORING BY THE STUDENTS OF K.B. PATIL (MODERN) COLLEGE AT TURBHE

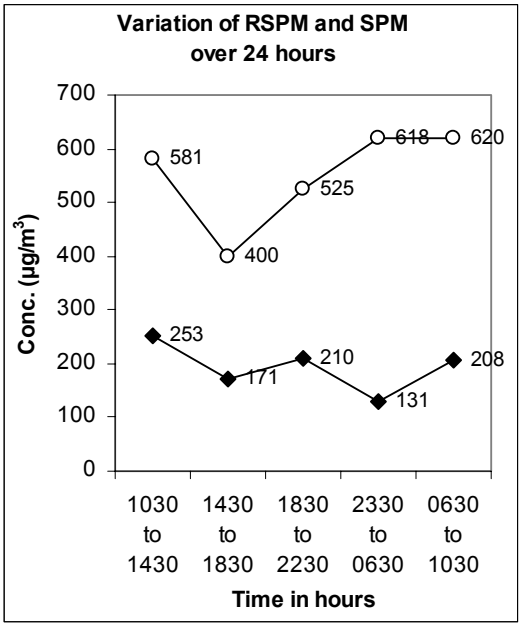
On the terrace of the Municipal School No. 19 Sector 22, Vashi, near Turbhe village

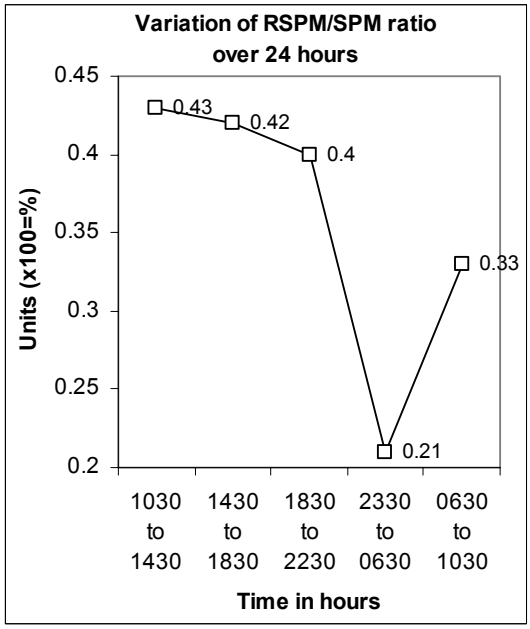
VASHI

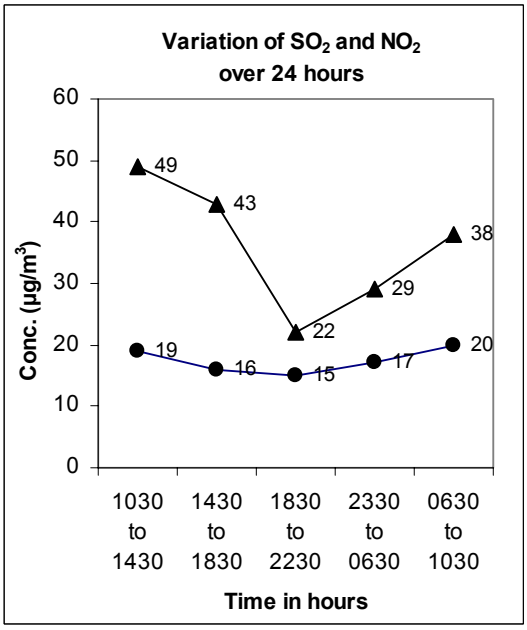
MONSOON (SEPTEMBER 2004) :

VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 24 HOURS

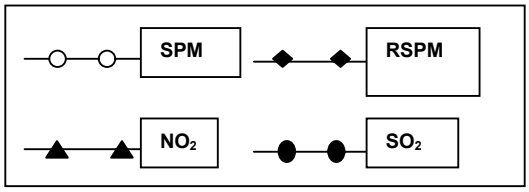
Date: 3 Sept. 2004; Residential area (Terrace –at about 12m height -- of ICLES' College, Sector 9A)





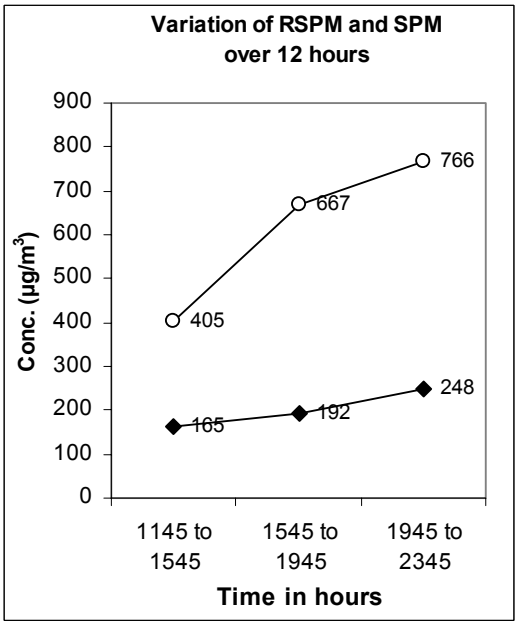


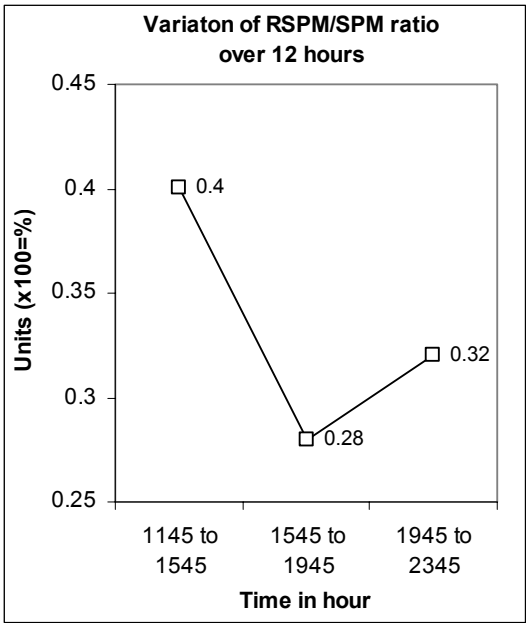
Pollutant	Conc. (µ/m^3) (weighted averages over 24 hrs)	Standards – Residential over 24 hours (in µ/m^3)*
RSPM (PM_{10})	184	100
SPM	560	200
SO_2	17	80
NO_2	35	80
CO	1200	4000 (1 hr average)

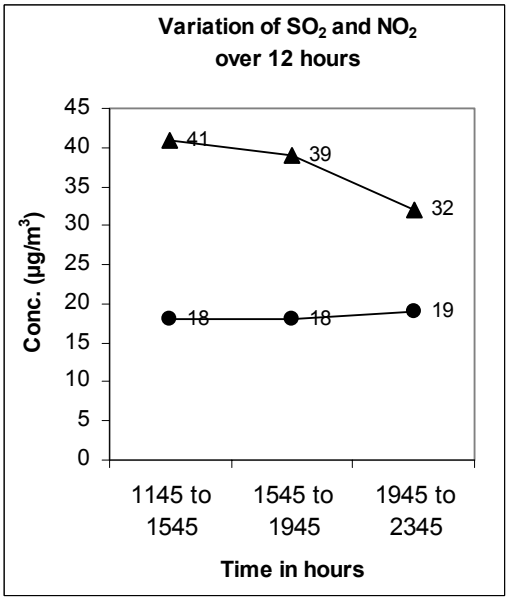


VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 12 HOURS

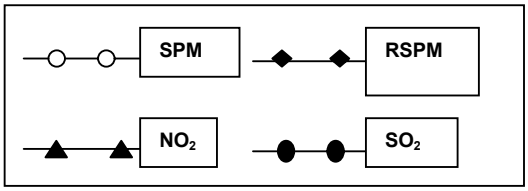
Date: 3 Sept. 2004; Traffic junction (1.5 m off ground level, opp. Vashi bus depot)



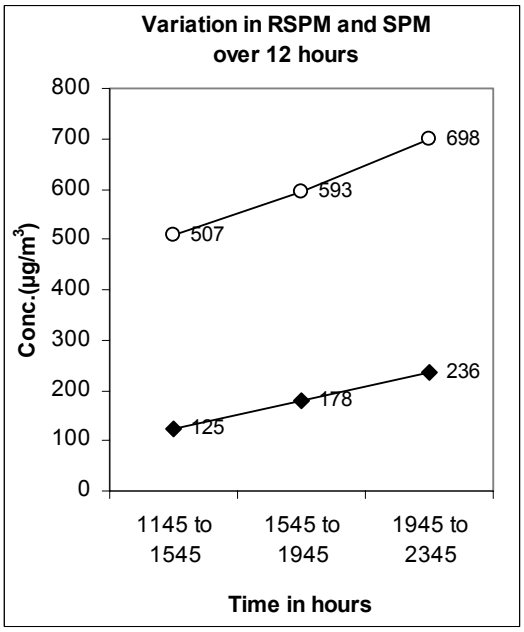


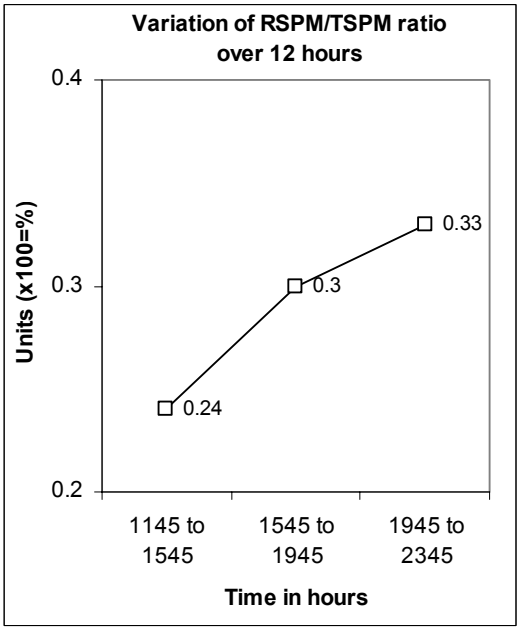


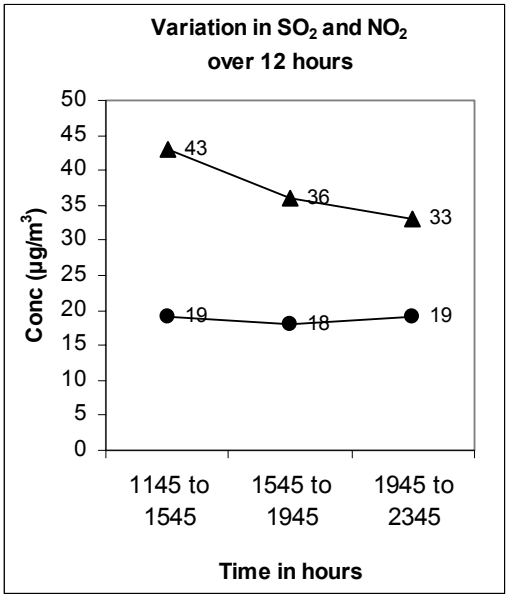
Pollutant	Concentrations (weighted averages in μ/m^3, over 12 hrs)	Standards (24 hours, in μ/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	202	100	150
SPM	613	200	500
SO_2	18	80	120
NO_2	37	80	120
CO	3200	4000 (1 hr average)	10,000 (1 hr. average)



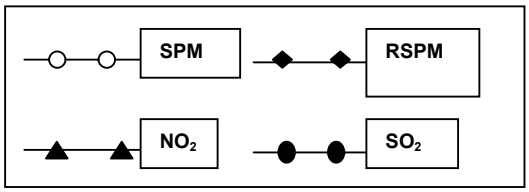
Date: 4 Sept. 2004; Traffic junction (1.5 m off ground level, opp. Vashi bus depot)







Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	180	100	150
SPM	599	200	500
SO_2	18	80	120
NO_2	37	80	120
CO	3190	4000 (1 hr average)	10,000 (1 hr. average)



Vashi: Monsoon (September 2004)

(a) 24 hours monitoring in residential area for one day:

1. The high volume air sampler was installed on the terrace of ICLES' M.Jhunjhunwala College, Sector 9A, Vashi, at an approximate height of 12 metres.
2. The College is situated in a residential area; it is flanked by a school, *masjid* and other houses on the four sides; the Thane creek is situated nearby.
3. It was not raining on the day of air monitoring.
4. RSPM levels (253, 171, 210, 131 and 208 µg/m3) at all monitoring times were above the NAAQS for residential area (100 µg/m^3), the weighted average of RSPM being 184 µg/m^3.
5. In the 23.30-06.30 time slot, RSPM level was observed to dip to 131 µg/m^3.
6. SPM levels (581, 400, 525, 618 and 620 µg/m^3) were also above the NAAQS for residential area (200 µg/m^3); the weighted average of SPM was 560 µg/m^3.
7. In this season, the contribution of RSPM to the total air particulate load was 43, 42, 40, 21 and 33%. This indicated that RSPM (< 10µ) load was generally high during the day of monitoring. The importance of emission source characterisation/identification becomes apparent in this sort of situation.
8. Both SO_2 and NO_2 were within NAAQS, with the weighted averages of 17 and 35 µg/m^3
9. CO levels were also within the NAAQS, with the weighted average of 1200 µg/m^3.

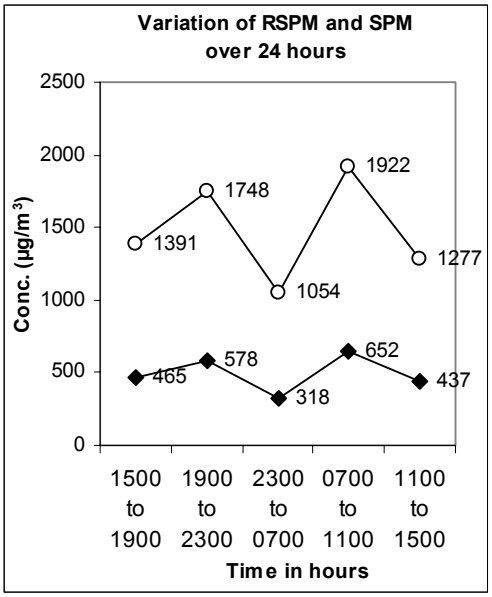
(b) 12 hours monitoring at the traffic junction for two days:

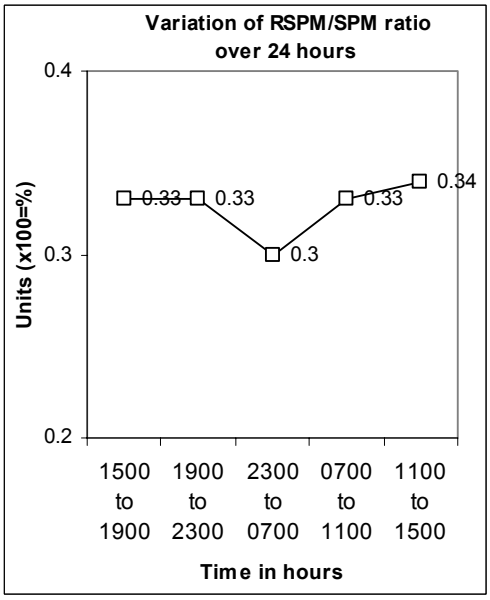
1. The high volume air sampler was positioned at the ground level near the Vishnudas Bhave Hall, opposite the Vashi bus depot. This is one of the main traffic routes in Vashi.
2. On the two days of monitoring at the traffic junction, the weighted average concentrations of RSPM (202 and 180 $\mu g/m^3$) were above the NAAQS (150 µg/m3) even for industrial areas.
3. SPM levels were above NAAQS, with the weighted averages being 613 and 599 $\mu g/m^3$ resp. on the two days. These are high SPM levels in the monsoon season, and could be due to road- and traffic dust.
4. The contributions of RSPM to the total air particulate load (SPM) were 40, 28 and 32% on day 1 and 24, 30 and 33% on day 2. The bigger particulates (>10µ) form the major constituent of the particulate pollution.
5. The gaseous pollutants, SO_2 and NO_2 were within the NAAQS on both days, with the weighted averages of 18 and 37 $\mu g/m^3$ on day 1 and day 2.
6. The CO concentration was 3200 $\mu g/m^3$ on day 1 and 3190 $\mu g/m^3$ on day 2, both values being below the NAAQS.

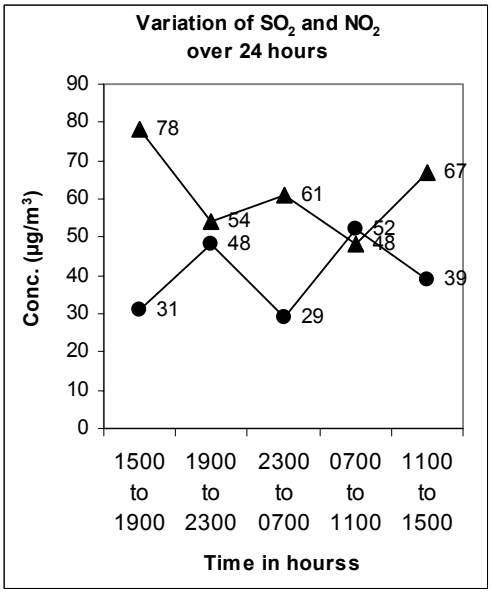
VASHI

WINTER (JANUARY 2005): VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 24 HOURS

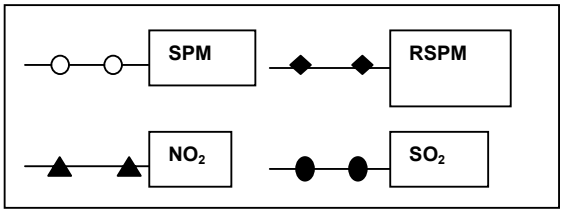
Date: 7 January 2005; Residential area (Terrace of ICLES' College, Sector 9A)





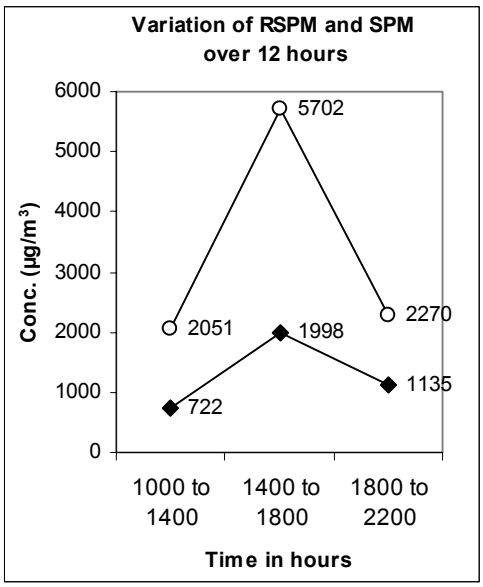


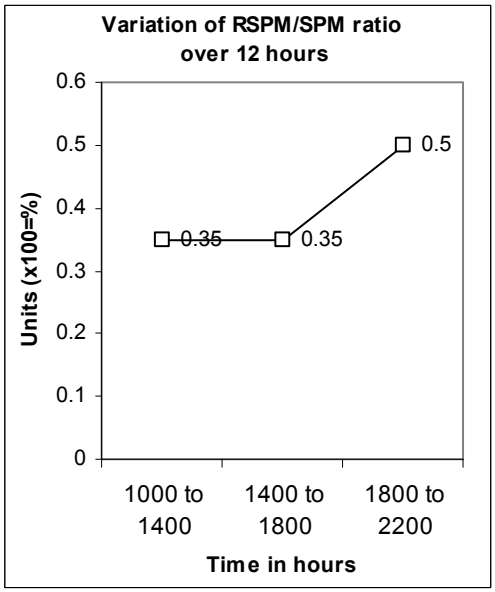
Pollutant	Conc. ($\mu g/m^3$) (weighted averages over 24 hrs)	Standards – Residential over 24 hours (in $\mu g/m^3$)*
RSPM (PM_{10})	461	100
SPM	1408	200
SO_2	38	80
NO_2	62	80
CO	4410	4000 (1 hr average)

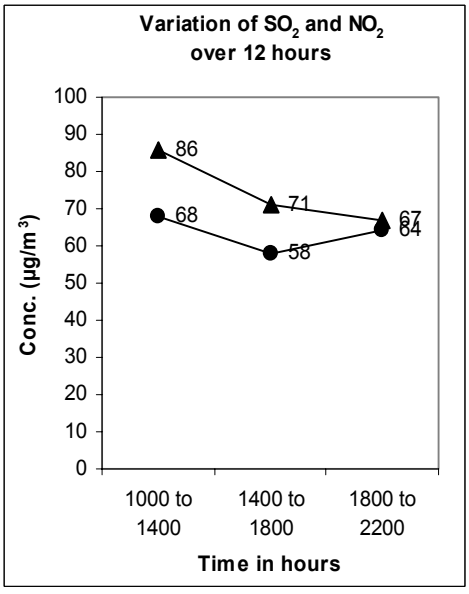


VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 12 HOURS

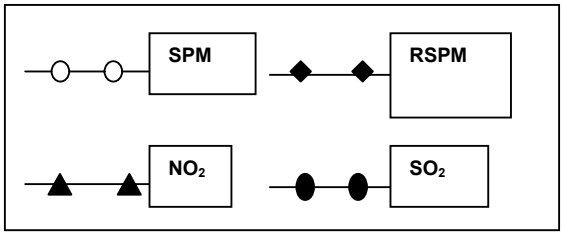
Date: 7 January 2005; Traffic junction (1.5 m off ground level, opp. Vashi bus depot)



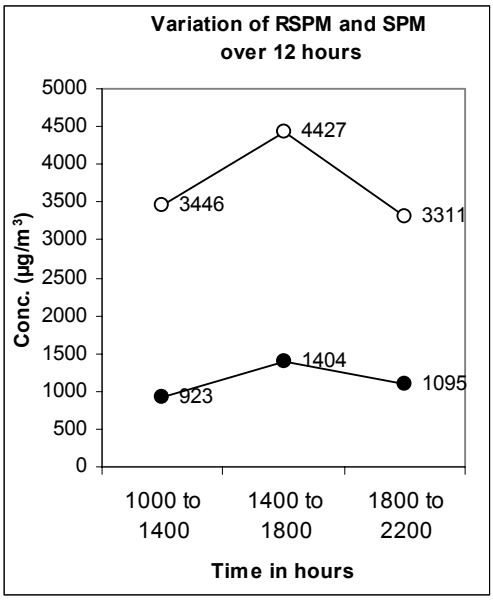


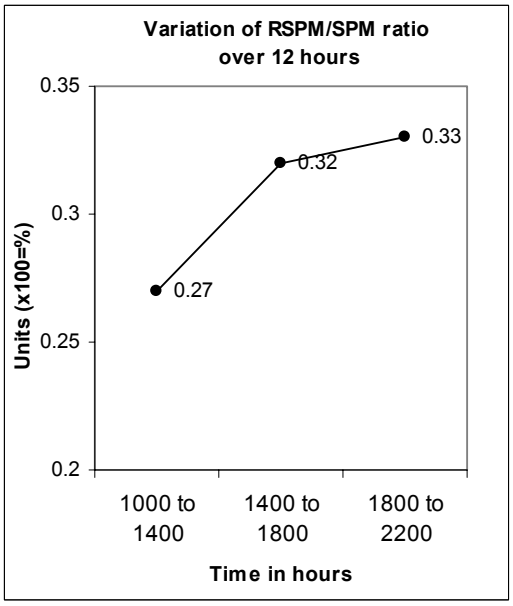


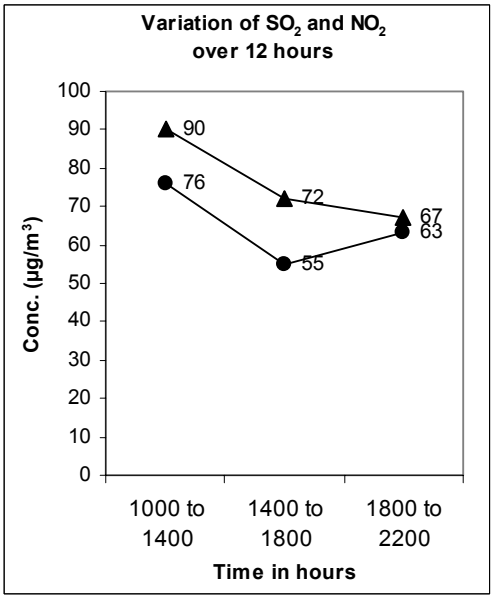
Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	1285	100	150
SPM	3341	200	500
SO_2	63	80	120
NO_2	76	80	120
CO	6210	4000 (1 hr average)	10,000 (1 hr. average)



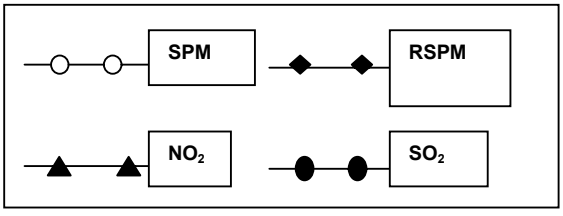
Date: 8 January 2005; Traffic junction (1.5 m off ground level, opp. Vashi bus depot)







Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	1141	100	150
SPM	3728	200	500
SO_2	65	80	120
NO_2	76	80	120
CO	7340	4000 (1 hr average)	10,000 (1 hr. average)



Vashi: Winter (January 2005)

(a) 24 hours monitoring in a residential area for one day:

1. In this season, the day temperatures had lowered slightly (29º C), with smog like conditions in the early morning hours.
2. All RSPM concentrations (465, 578, 318, 652 and 437 µg/m^3) were above the residential NAAQS (100 µg/m^3), with the weighted average of 461 µg/m^3.
3. Highest RSPM (652 µg/m^3) concentration was observed in the 7.00 to 11.00 am time slot.
4. All SPM levels were well above the NAAQS for residential area (200µg/m^3).
5. High SPM levels were observed during 24 hours (1391, 1748, 1054, 1922 and 1277 µg/m^3), with the weighted average of 1408 µg/m^3.
6. Both SPM and RSPM were observed to rise and fall simultaneously throughout the monitoring period, with increases observed in 19.00 to 23 hours and 07.00 to 1100 hours time slots.
7. Though the overall RSPM concentrations were well above the NAAQS, its contribution to the total particulate load was moderately high (33, 33, 30, 33 and 34 per cent).
8. Both SO_2 and NO_2 were within NAAQS. However, the weighted averages in winter (38 and 62 µg/m^3) were greater than those observed in monsoon (17 and 35 µg/m^3).
9. CO levels were above NAAQS (4000 µg/m^3), with the weighted average being 4410 µg/m^3.

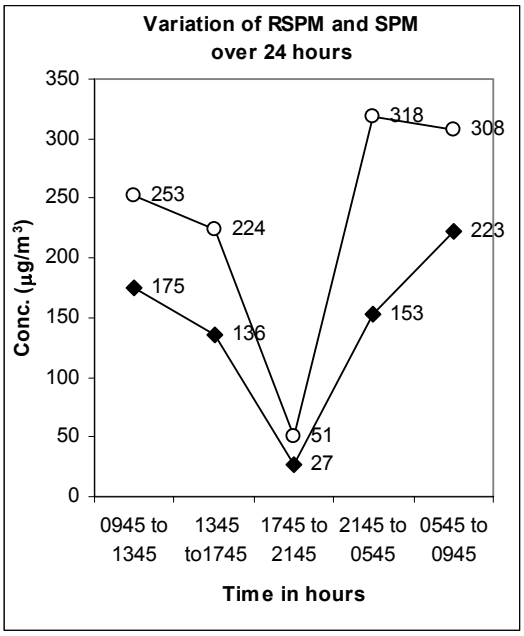
(b) 12 hours monitoring at the traffic junction for two days:

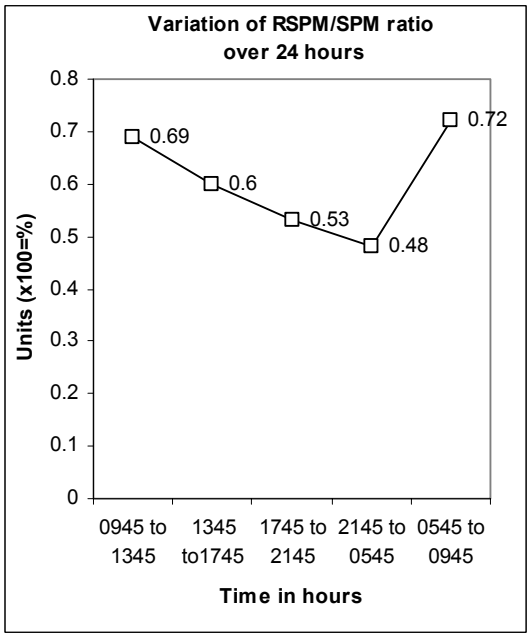
1. Air monitoring was carried out at the ground level near Vishnudas Bhave Hall, Vashi, opposite Vashi bus depot.
2. Air monitoring was carried out from 10.00 hrs to 22.00 hours on both days.
3. High concentrations of RSPM, well above the NAAQS, with weighted averages of 1285 and 1141 $\mu g/m^3$ were observed on the two days.
4. Perceptibly high levels of RSPM (1998 and 1404 $\mu g/m^3$) were observed in the 14 -18 hour time slot on day 1 and day 2.
5. Rise in this time slot was also observed for SPM levels.
6. High concentrations of SPM, well above the NAAQS for industrial areas, were observed on the two days, with the weighted averages being 3341 $\mu g/m^3$ on day 1 and 3728 $\mu g/m^3$ on day 2.
7. Here too, the overall contribution of RSPM to the total particulate load was moderately high (35, 35 and 50% on day 1 and 27, 32 and 33% on day 2 respectively).
8. SO_2 and NO_2 were within the NAAQS for industrial area on both days; the weighted averages for SO_2 were 63 and 65 $\mu g/m^3$ on day 1 and 2, and for NO_2 they were 76 $\mu g/m^3$ for both days.
9. CO levels (6210 and 7340 $\mu g/m^3$) were recorded below NAAQS for industrial area on both days.

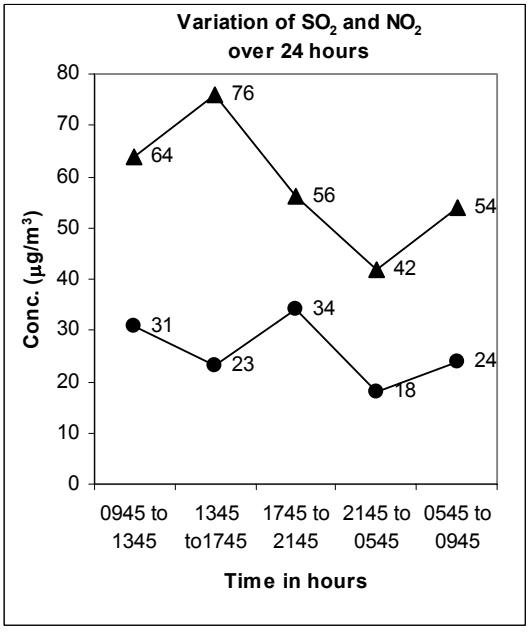
VASHI

<u>SUMMER (APRIL 2005):</u> VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 24 HOURS

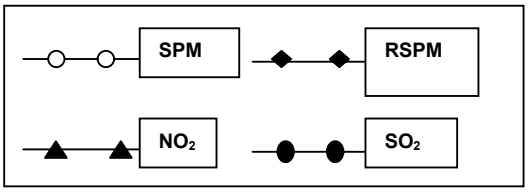
<u>Date: 4 April 2005;</u> Residential area (Terrace of ICLES' College, Sector 9A)





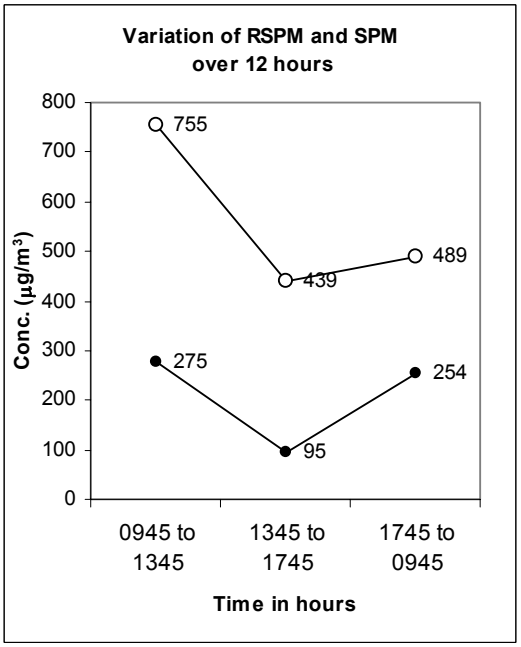


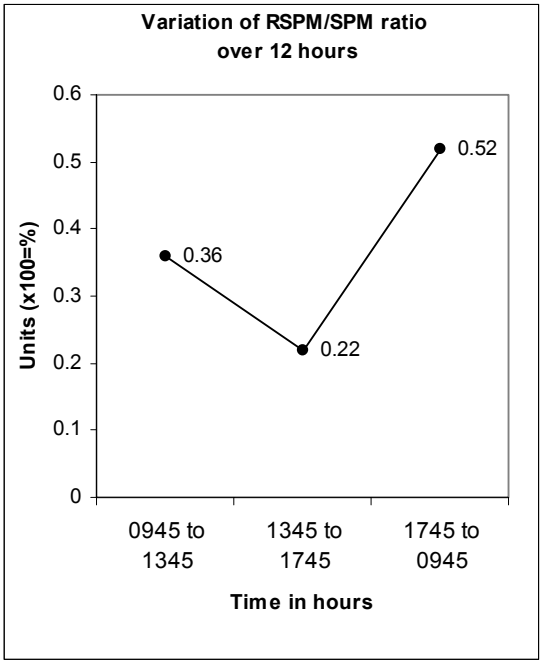
Pollutant	Conc. ($\mu g/m^3$) (weighted averages over 24 hrs)	Standards – Residential over 24 hours (in $\mu g/m^3$)*
RSPM (PM_{10})	124	100
SPM	242	200
SO_2	27	80
NO_2	58	80
CO	3500	4000 (1 hr average)

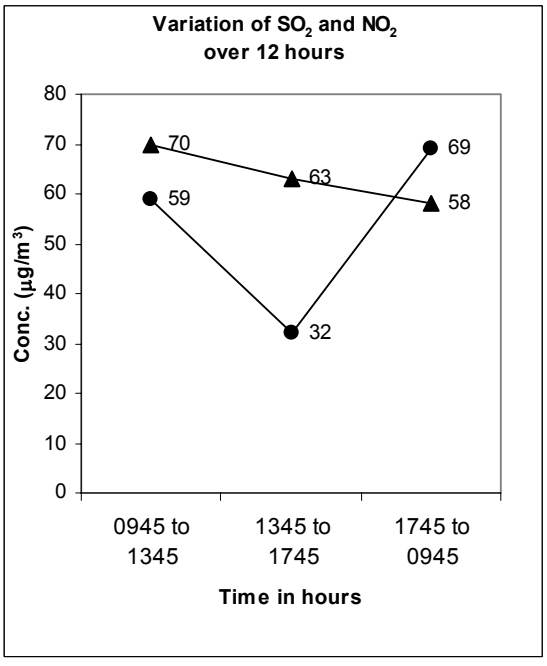


VARIATION IN CONCENTRATIONS OF DIFFERENT AIR POLLUTANTS OVER 12 HOURS

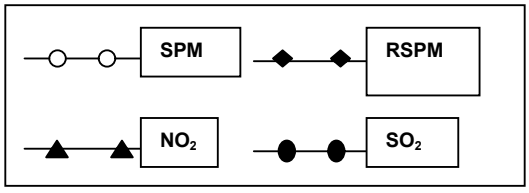
Date:4 April 2005; Traffic junction (1.5 m off ground level, opp. Vashi bus depot)



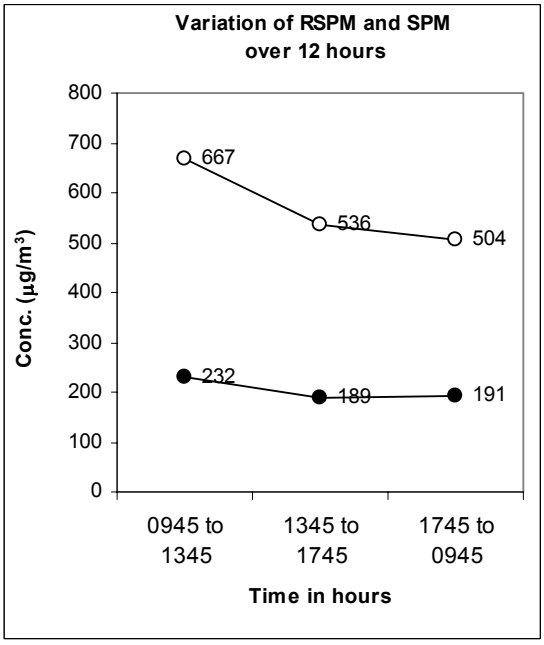


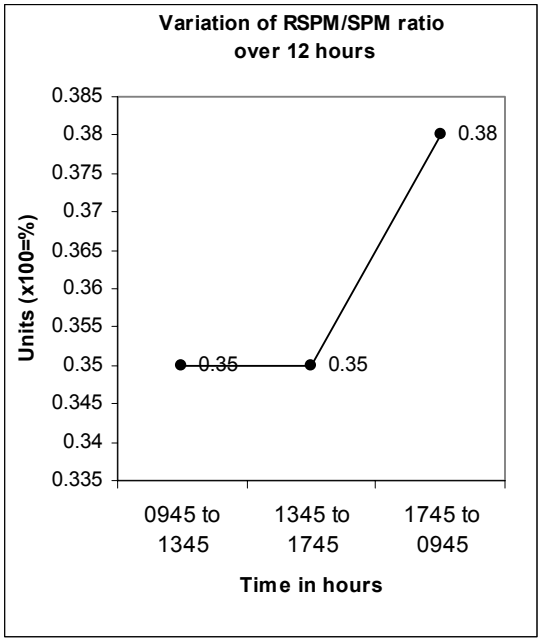


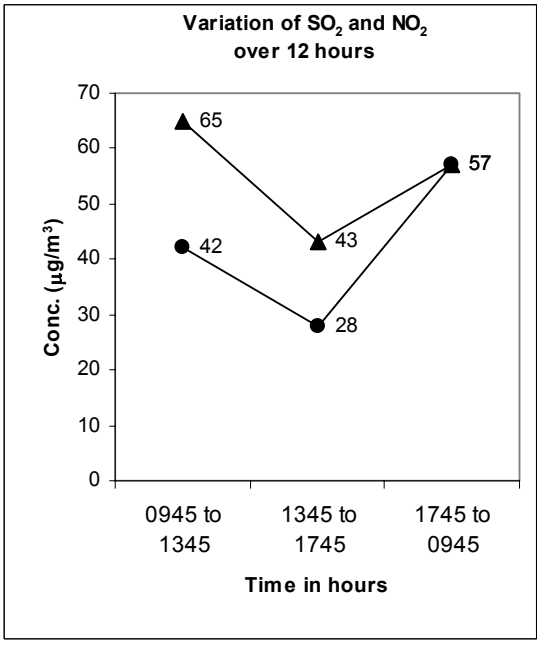
Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	208	100	150
SPM	561	200	500
SO_2	53	80	120
NO_2	64	80	120
CO	5160	4000 (1 hr average)	10,000 (1 hr. average)



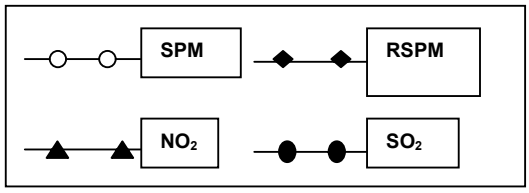
Date:5 April 2005; Traffic junction (1.5 m off ground level, opp. Vashi bus depot)







Pollutant	Concentrations (weighted averages in µg/m^3, over 12 hrs)	Standards (24 hours, in µg/m^3)*	
		Residential	Industrial
RSPM (PM_{10})	204	100	150
SPM	569	200	500
SO_2	43	80	120
NO_2	55	80	120
CO	5370	4000 (1 hr average)	10,000 (1 hr. average)



Vashi: Summer (April 2005)

(a) 24 hours monitoring in a residential area for one day:

1. In this season, the day temperatures had risen to 31º C and above.
2. RSPM levels were largely above the NAAQS (100µg/m^3), with the weighted average of 124 µg/m^3.
3. SPM levels varied during the 24 hours, with the weighted average of 242 µg/m^3, which was above NAAQS (200 µg/m^3) for the residential area.
4. In this season, the contribution of RSPM to the total particulate load was high (69, 60, 53, 48 and 72 per cent).
5. Both SO_2 and NO_2 were within NAAQS, with the weighted averages of 27 and 58 µg/m^3 respectively.
6. CO levels were within NAAQS of residential area, with the weighted average of 3500 µg/m^3.

(b) 12 hours monitoring at the traffic junction for two days:

1. Air monitoring was carried out at Vishnudas Bhave Hall, opposite Vashi bus depot.
2. Air monitoring was carried out at the traffic junction from 9.45 to 21.45 hrs on day 1 and day 2.
3. High concentrations of RSPM, above the NAAQS, with weighted averages of 208 and 204 µg/m^3, were observed on the two days.
4. High concentrations of SPM above the NAAQS for industrial areas on the two days were observed; the weighted averages of SPM were 561 µg/m^3 on day 1 and 569 µg/m^3 on day 2.
5. In this season, the RSPM contribution to the total particulate load was 36, 22 and 52 per cent on day 1 and 35, 35 and 38 per cent on day 2.
6. SO_2 and NO_2 were within the NAAQS for industrial areas on both days; the weighted averages for SO_2 were 53 and 43 µg/m^3 on day 1 and 2 and for NO_2 the averages were 64 and 55 µg/m^3 on the two days.
7. CO levels (5160 and 5370 µg/m^3) were recorded below NAAQS.

AIR MONITORING BY THE STUDENTS OF ICLES' M.J. COLLEGE, VASHI

Air monitoring on the terrace of ICLES' College, Sec. 9A, Vashi.

Computerised air monitoring station installed at the fire station by the NMMC in 2004 (right).

Discussion

Air quality was monitored in five zones (Airoli, Kopar Khairane, Nerul, Turbhe and Vashi) of Navi Mumbai over three seasons: monsoon, winter and summer of 2004-2005. Two monitoring points (residential and traffic) were set up in each zone. Monitoring was carried out for 24 hours (at a height varying from 10-15 metres at residential sites) and for 12 hours at ground level at traffic junctions in each of the three seasons. Due to logistic reasons, air monitoring was assigned to Mahabal Enviro Engineers Pvt. Ltd, Thane, Mumbai, with regular supervision of participating teachers and students. Attempts were made to observe a fixed time schedule and fixed locations for air monitoring for the three seasons in the year under study.

It is to be noted that here one is dealing with an extremely dynamic system with several variables (temperature, humidity, variation in source emission characteristics, spontaneous chemical reactions and complex synergies between the pollutants in the atmosphere) operating at all times. Factors like wind direction and wind speed, terrain of a place and bright sunlight, all determine the quality of air in a place at any given time.

The terrain of Navi Mumbai is complex with hills on the east and the water body of the Thane creek on the west and flat lands lying in between. The Thane Belapur Industrial Belt situated in the north to south direction is an integral part of this region.

The prevailing wind speed and wind direction combined with the terrain of the place greatly affect the air quality of Navi Mumbai. According to the Environmental Status Reports of Navi Mumbai (2002-2003, 2003-2004), the dominant winds are from south west direction in monsoon, and north east and north west winds with varying speeds in summer and winter.

All attempts were made to maintain uniform working conditions during air monitoring, with allowable excursions on time of samplings. The summer data should be viewed with care. Despite these constraints, the results bring out

several important trends of the quality of air in the studied zones of Navi Mumbai. Overall results based on 24 hour data are presented here. The prime reason for non inclusion of the 12 hour data is the non availability of NAAQS for 12 hours, though the12 -hour results have been presented in the early section on Results and show pollutant levels during different peak and non peak traffic hours in a day. The detailed seasonal results of each individual zone have also been presented in the early section.

Some important general trends on air pollution in Navi Mumbai are presented below from three different perspectives:

(i) overall concentrations of air pollutants vis-à-vis the NAAQS;
(ii) contribution of RSPM to the total particulate load and
(iii) air quality index (AQI)

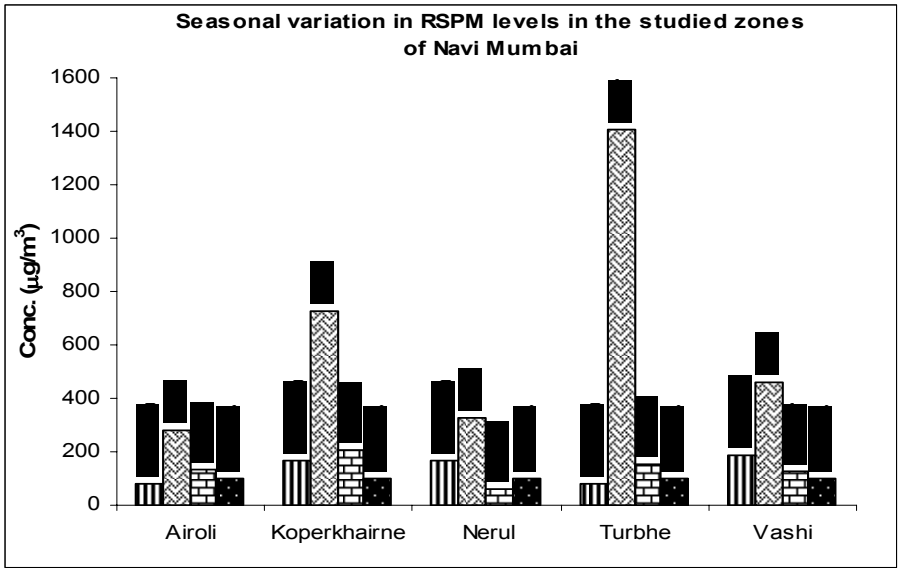
NOTE: Two categories of particulates are discussed here: RSPM and SPM. Both these broad categories embrace an entire range of particles emanating from different sources. As source apportion was not covered in this study, RSPM was considered to be collected on the fine filter paper and hence their size was considered to be below 10 μm; SPM was considered as the total suspended matter (particulates collected in the hopper and on the filter paper).

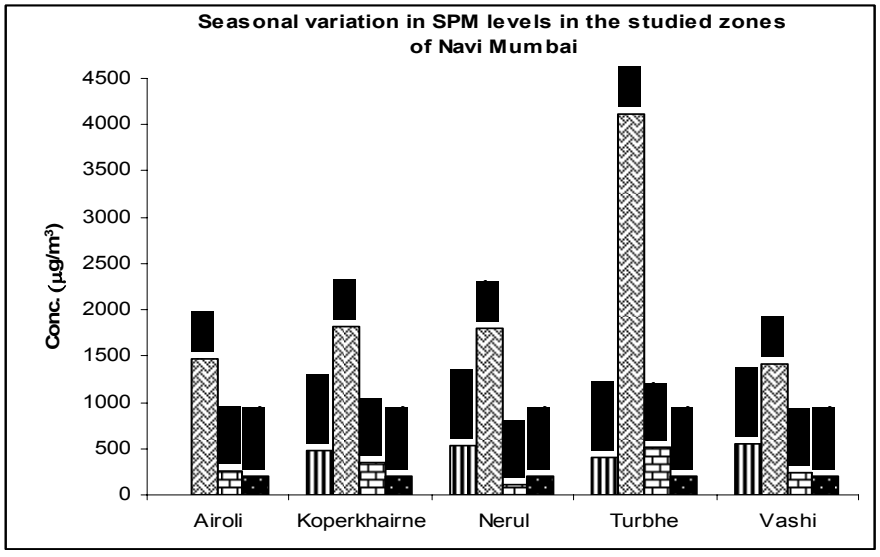
(i) Overall concentrations of air pollutants vis-à-vis the NAAQS

(a) To a large extent, the levels of RSPM and SPM were above the NAAQS in the three seasons in all the studied zones.
(b) These concentrations were lowest in monsoon. Rains effectively lowered the concentrations of particulates in the atmosphere by washing them down or settling them on different surfaces.
(c) Further, the RSPM levels were markedly observed to decrease on the days when it was actually raining heavily, as in Airoli (80 $\mu g/m^3$) and Turbhe (83 $\mu g/m^3$).
(d) SPM levels and gaseous pollutants were also observed to decrease during monsoons due to washout by heavy rains.

(e) Particulate concentrations were highest in winter. The observed high RSPM and SPM levels (above the NAAQS) in winter could be attributed to low temperatures and calm winds from the north-east (and north-west) directions. These conditions lead to concentration of particulates in the lower layers of the atmosphere, making vertical dispersion difficult in this season; however, horizontal dispersion was prevalent, often leading to smog-like conditions in the morning hours.

(f) Gaseous pollutants were below the NAAQS in all the three seasons, but their concentrations were high in winter compared to the other two seasons, reflecting emissions from mobile sources.





Air quality status in selected zones of Navi Mumbai

24 hr. weighted averages (n=5) during MONSOON (SEPT. 2004) IN RESIDENTIAL AREAS:

Zones	Air pollutants								
	RSPM (µg/m^3)			SPM (µg/m^3)			SO_2 (µg/m^3)	NO_x (µg/m^3)	CO (µg/m^3)
	Ave.	Max.	Min.	Ave.	Max.	Min.			
Airoli	**80**	**116**	**54**	**NA**	**--**	**--**	**17**	**38**	**1220**
Kopar Khairane	**168**	**195**	**115**	**471**	**563**	**301**	**17**	**32**	**1280**
Nerul	**169**	**232**	**131**	**525**	**648**	**403**	**17**	**35**	**1260**
Turbhe	**83**	**103**	**62**	**408**	**460**	**368**	**17**	**37**	**1950**
Vashi	**184**	**256**	**131**	**560**	**620**	**400**	**17**	**35**	**1200**
Average for NM	137			491			17	35	1382
24 hrs. standards	**100**			**200**			**80**	**80**	**4000**

24 hr. weighted averages (n=5) during WINTER (JAN. 2005) IN RESIDENTIAL AREAS:

Zones	Air pollutants								
	RSPM (µg/m^3)			SPM (µg/m^3)			SO_2 (µg/m^3)	NO_x (µg/m^3)	CO (µg/m^3)
	Ave.	Max.	Min.	Ave.	Max.	Min.			
Airoli	**280**	**720**	**80**	**1470**	**1827**	**1233**	**53**	**54**	**3350**
Kopar Khairane	**726**	**1015**	**562**	**1817**	**2480**	**1402**	**47**	**60**	**3380**
Nerul	**325**	**958**	**167**	**1797**	**3185**	**1013**	**61**	**74**	**4575**
Turbhe	**1406**	**1914**	**908**	**4112**	**5268**	**2500**	**53**	**58**	**4890**
Vashi	**461**	**652**	**318**	**1408**	**1922**	**1054**	**38**	**62**	**4410**
Average for NM	640			2121			50	62	4121
24 hrs. standards	**100**			**200**			**80**	**80**	**4000**

24 hr. weighted averages (n=5) during SUMMER (APRIL 2005) IN RESIDENTIAL AREAS:

Zones	Air pollutants								
	RSPM (µg/m^3)			SPM (µg/m^3)			SO_2 (µg/m^3)	NO_x (µg/m^3)	CO (µg/m^3)
	Ave.	Max.	Min.	Ave.	Max	Min.			
Airoli	**136**	**244**	**91**	**248**	**487**	**123**	**36**	**47**	**3405**
Kopar Khairane	**204**	**241**	**155**	**346**	**465**	**316**	**29**	**41**	**2975**
Nerul	**57**	**79**	**33**	**117**	**294**	**59**	**41**	**65**	**3545**
Turbhe	**153**	**306**	**94**	**507**	**1069**	**207**	**43**	**48**	**3395**
Vashi	**124**	**223**	**27**	**242**	**318**	**51**	**27**	**58**	**3500**
Average for NM	135			292			35	52	3364
24 hrs. standards	**100**			**200**			**80**	**80**	**4000**

(ii) Contribution of RSPM to the total particulate load

RSPM/SPM ratio: Epidemiological studies, among others, have established the harmful effects of RSPM, especially in causing diseases of deeper respiratory tissues/organs. The use of RSPM/SPM ratio gives an idea about the contribution of RSPM to the total particulate load.

(a) In monsoon, the RSPM load ranged from 20 to 36% in the different zones.

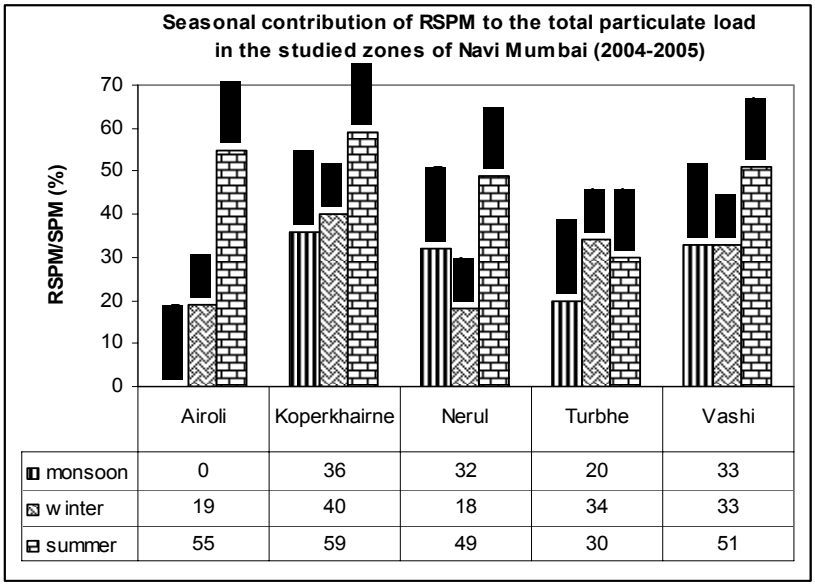
(b) RSPM load was 20% in Turbhe in monsoon; this washout of the finer particulates could be attributed to heavy rains on the day of monitoring.

(c) In winter this load ranged from 18 to 40%.

(d) Significantly, RSPM loads were 19% and 18% in Airoli and Nerul in winter, despite the fact that RSPM concentrations were above the NAAQS. Apparently, the bigger particles far exceeded in the total concentrations of particulates in these zones in this season.

(e) RSPM/SPM ratio indicated that load of different particulates in Vashi, and Kopar Khairane is largely similar in both monsoon and winter seasons. Determination of point source(s) of RSPM in these areas needs to be looked into.

(f) The source of particulates could be fine dust from the road, construction activities, factories and hill quarrying in Navi Mumbai. It would therefore be very pertinent that the chemical composition of RSPM is identified for source apportionment with extensive data.



(iii) Air Quality Index (AQI):

Air quality index provides information about the quality of air in an area. The index meshes together different parameters of air pollution (particulates and gases) and uses an equation to come up with a meaningful number, which indicates what effect(s) the air could have on our health, especially on the respiratory functions of individuals. These health problems tend to get aggravated in the elderly and in very young children. In other words, AQI is an index indicating how polluted or clean the air is and the effects it can have on our health.

Global environmental agencies have evolved different indices, with many overlaps in sections. In India, the Central Pollution Control Board (CPCB), along with the Indian Institute of Technology (IIT), Kanpur, in a sponsored project, used the segmented linear function to relate the actual concentrations of air pollutants to a normalized number. The CPCB's air quality index is known as IND-AQI, where the maximum value of sub-index becomes the AQI. (Equation 1: $I = \max(I_1, I_2 \ldots I_n)$. In this method, IND-AQI is reported as Good (0-100), Moderate (101-200), Poor (201-300), Very Poor (301-400) and Severe (401-500).

(2) Environmental Status Reports (2001-2002; 2002-2003) of the Navi Mumbai Municipal Corporation (NMMC) uses the AQI evolved by the United States Environment Protection Agency (USEPA, 1976, 1998). According to these Reports, AQI is calculated using the equations 2 and 3.

Equation 2: $AQI_{(SPM)} = 39.2 (SPM /200 + SO_2/80 + NO_2/80)^{0.967}$

Equation 3: $AQI_{(RSPM)} = 39.2 (RSPM /100 + SO_2/80 + NO_2/80)^{0.967}$

As per USEPA, the different ranges and classes of air quality are: Excellent (0-20), Good (21-40), Fair (41-60), Poor (61-80), Bad (81-100), and Dangerous (>100).

(3) Rao and Rao (Air Pollution, Tata Mcgraw Hill, New Delhi, 2001) calculate the AQI as:

Equation 4: 1/3 ((SPM /200 + SO_2/80 + NO_2/80) × 100

Equation 5: 1/3 ((RSPM /100 + SO_2/80 + NO_2/80) × 100

As per Rao and Rao, the different ranges and classes are: Clean air (0-25), Light air pollution (26-50), Moderate air pollution (51-75), Heavy air pollution (76-100), Severe air pollution (>100).

In this Technical Report, AQI (USEPA) was used to establish the quality of air.

Air quality index (USEPA) for different zones of Navi Mumbai (2004-2005)

Sampling zones	AQI – USEPA					
	RSPM			SPM		
	Sep 04	Jan 05	Apr 05	Sep 04	Jan 05	Apr 05
AIROLI	58	155	91	NA	79	87
KOPAR KHAIRANE	87	314	110	112	378	99
NERUL	89	184	73	123	387	73
TURBHE	58	553	101	103	777	138
VASHI	95	217	87	129	303	86

Range (AQI)	Class
0-20	Excellent
21-40	Good
41-60	Fair
61-80	Poor
81-100	Bad
More than 100	Dangerous

The above results prompted us to take a look at the pollutant concentrations (on the same days as done in the HEAL programme), and thence calculate the AQIs in a few major metros of the country. The different air pollutant concentrations were obtained from the website of the Central Pollution Control Board

(www//cpcb.nic.in). The tables given below show the quality of air (as per USEPA) in these cities.

AQIs (USEPA) in the four metros of the country: Pollutant levels were obtained from the website of Central Pollution Control Board.

Monitoring Locations ↓	AQI-USEPA		
	RSPM		
	Sept. '04	Jan. '05	April '05
Delhi	126	182	138
Mumbai	132	103	146
Chennai	16	39	39
Kolkata	47	100	143

Range (AQI)	Class
0-20	Excellent
21-40	Good
41-60	Fair
61-80	Poor
81-100	Bad
More than 100	Dangerous

Monotoring Season ↓	Monitoring Locations											
	Delhi			Mumbai			Chennai			Kolkata		
	RSPM	SO_2	NO_2	RSPM	SO_2	NO_2	RSPM	SO_2	NO_2	RSPM	SO_2	NO_2
Monsoon 08/09/04	234	6	74	228	17	83	13	9	12	87	4	26
Winter 10/01/05	379	6	83	181	23	53	67	4	31	165	14	64
Summer 01/04/05	249	8	87	228	24	106	71	4	21	282	4	62

The above tables give a fairly good idea about the air quality in Navi Mumbai (and in other Indian cities too).

As indicated in the above tables (of Navi Mumbai and of the four metros), the air quality (AQI_{RSPM}) was as follows:

(a) AQI_{RSPM} was fair to bad in monsoon in all the studied zones.

(b) Heavy rains (on the actual day of monitoring) had a dramatic effect in enhancing the (AQI_{RSPM}), as in Airoli and Turbhe.

(c) In winter, the air quality (AQI_{RSPM}) was 'dangerous', with the worst air quality being observed in Turbhe, followed by Kopar Khairane. This could be due to extended inversion conditions, which does not allow effective

dispersal of pollutants. This results in trapping of the same within the air shed defined by lower mixing height.

(d) In summer, (AQI_{RSPM}) ranged from bad to dangerous, with again Kopar Khairane and Turbhe being the worst affected.

(e) $AQI_{(SPM)}$ in all three seasons ranged from poor to dangerous, with worst quality being observed in winter, especially in Turbhe.

(f) $AQI_{(RSPM)}$ for other Indian cities revealed the bad/dangerous air quality in all seasons; however in monsoon the air quality was excellent/fair in Chennai and Kolkatta.

(g) Chennai had good air quality in all seasons.

The above discussion gives us some idea about the air quality in Navi Mumbai. Besides more detailed, long term studies involving source identification of different pollutants, some steps (such as, better traffic management with emphasis on public transport, good road maintenance, construction practices and waste disposal practices, along with strict monitoring of industrial emissions with regulated hill quarrying) could help considerably in cleaning up the Navi Mumbai air.

WATER QUALITY

Introduction

The quality of any surface water aquifer or open water body is linked to its end use vis a vis the pollution load received by it. Urbanization and the associated waste water disposal practices, industrialization, agricultural practices, rains, and the geology of an area are some of the main features which dictate the water quality.

Navi Mumbai has a number of fresh water lakes and tanks as surface water aquifers, both perennial and some rainfed. In addition, creek water has been impounded along the shoreline; thus water-holding ponds have been created in several parts of the city, essentially to prevent floods in the city and also for recreational purposes. The fresh water bodies are largely being used for recreational and domestic purposes, such as washing and bathing activities by villagers in the vicinity. Several inlets/outlet channels with their openings into the fresh water bodies were also observed. Generally, the flow pattern was from landside to creekside as expected in this topography.

The west coast of Navi Mumbai is flanked by the Thane creek, extending from Airoli in the north to Nagaon in the south. At several places, the once thickly covered shoreline with mangroves and other vegetation was observed to be in a state of denudation/degradation, with massive cutting for enabling construction activities. Our observations revealed that at several points along the coastline, untreated effluents (both domestic and industrial) were being directly disposed off in the creek. These effluents were being discharged into the creek waters either through the open surface drains (*nullahs*) running in the east to west direction from the Trans Thane creek area or via pipeline system/storm water drains. It is understood that an efficient Common Effluent Treatment Plant (CETP) is in operation at the Kopar Khairane node treating major volume (50-60%) of the effluent generated at the TTC area. The treated effluent adhering to the Maharashtra Pollution Control Board (MPCB) standards is discharged into the creek as marine outfall. However, the large *nullah* (where the CETP influent and effluent are in operation), still carries coloured and odorous organic and inorganic

untreated effluents generated by some of the industries. This and other many such *nullahs* throughout the studied zones could be a source of seepage into the open water bodies through soil, depending on the slope characteristics.

Treated municipal water (either from the NMMC or Maharashtra Industrial Development Corporation--MIDC) is the major source of drinking water in the studied zones.

HEAL Project Survey

Under HEAL, water quality was monitored as under:

- Open water bodies, both fresh water and creek water, were checked in each of the five study zones: Airoli, Kopar Khairane, Nerul, Turbhe, and Vashi.
- Water samples were collected according to the standard protocol of procedures (HEAL Protocol Guide).
- These samples were collected at the four corners of the fresh water body, depending on the ease/accessibility of sample collection.
- The locations of sampling points and sampling method were mostly kept constant during the three seasons (Monsoon--September, 2004; Winter—January 2005 and Summer---April 2005).
- Water quality was determined by studying its physical and chemical properties.
- The water samples were first checked for physical properties on the site and then analysed chemically at HBCSE laboratory on the next day. The samples were carefully stored in cold conditions during the interim period.
- The physical properties studied were: colour, odour, turbidity and temperature.
- The chemical properties studied were: pH, alkalinity, chlorides, fluorides, ammonia, phosphates, copper, iron, chromium (Cr^{+3}), dissolved oxygen (DO) and chemical oxygen demand (COD).
- Due to the time factor, water analysis kits were used for chlorides, fluorides, ammonia and alkalinity.
- Chemical analysis of water samples was carried out by following the procedures given in *Standard Methods for the Examination of Water and*

Wastewater; 20th edition, American Public Health Association (also given in HEAL Protocol Guide).

- For some chemicals (phosphates, copper, iron, chromium), colour grids were developed at HBCSE and hence the pollutant concentrations are expressed as Low (L), Permissible (P), High (H) and Critical (C).
- This fixed protocol was followed for the three seasons.
- The water samples were analysed for bacterial contamination (faecal coliforms) as MPN (Most Probable Number) test, only during April 2005.

Table: Locational details of water bodies studied under HEAL

Sr. No.	Site	No. of water bodies (studied)	Location and name	Nature of water body
1	Airoli	3	(i) Ganesh Talab, Sector 1	Fresh water
			(ii) Coastline, Sector 10	Creek water
			(iii) Diva lake, Sector 9	Fresh water
2	Kopar Khairane	2	(i) Khairane lake, Sector 19	Fresh water
			(ii) Coastline, Sector 14	Creek water
3	Nerul	4	(i) Ganesh Talab, Karave *gaon*, Sector 32/38	Fresh water
			(ii) Creek water (opposite Chanakya, Palm Beach Road)	Creek water
			(iii) Chincholi lake, Sec. 8	Fresh water
			(iv) Shiv Mandir lake, Sec. 18A	Fresh water
4	Turbhe	3	(i) Turbhe gaon *talao* (near Ram Tanu *mandir*), Sector 22	Fresh water
			(ii) Turbhe *nullah*	Industrial waste from TTCA*
			(iii) Ganesh *talao*, Kopri pada, Sector 26	Fresh water
5	Vashi	4	Mini seashore, Sector 10A	Creek water
			Shiv Mandir *Talao*, Sector 7	Fresh water
			Shore line (sector 12)	Creek water
			Shoreline, Vashi *Gaon*, Sec. 31	Creek water

TTCA*= Trans Thane Creek Area

AREA OF STUDY: AIROLI
SEASON: MONSOON (September 2004)

DATE OF SAMPLING: 7th September 2004

DATE OF ANALYSIS: 8th September 2004

CLIMATIC CONDITIONS: Cloudy day with heavy rains on the previous day.

TOTAL NO. OF WATER BODIES STUDIED: Three (2 freshwater and 1 creek)

NO. OF WATER SAMLPLES COLLECTED: 8 samples (3/fresh water bodies & 2 from the creek.

Sampling Site I: Ganapati talab, Sector 1, Airoli (Fig. 1)

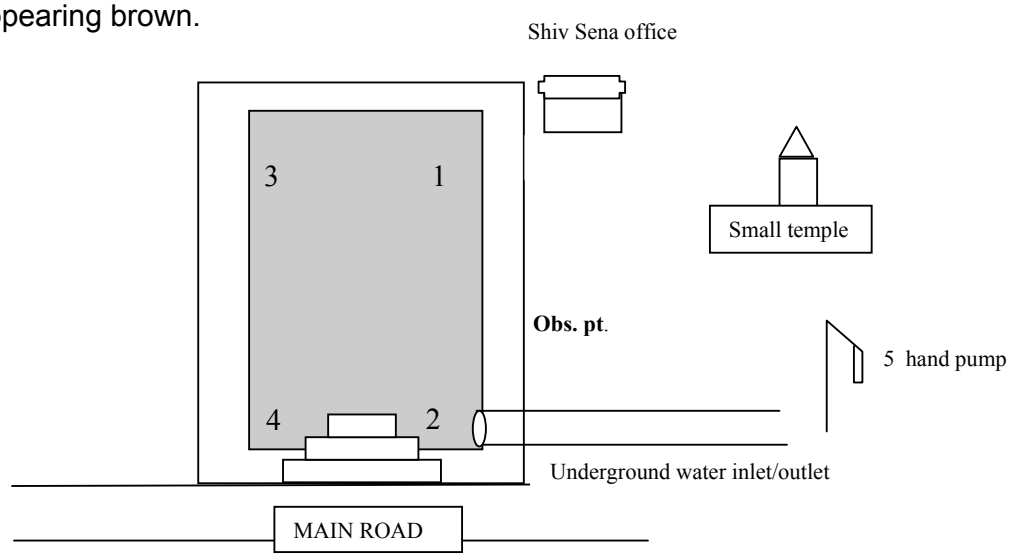
Type of water body: Fresh water body

Outlets/Inlets: One inlet/outlet covered with a metal net, near the road (sampling pt. 2).

General observations: Built and maintained by the NMMC; bound by cemented wall; steps on one side. Shape of the pond is an (irregular) quadrilateral; situated at the center of a resi dential area, the pond is surrounded by houses, shops, etc., with a small temple in the vicinity. The pond was being cleaned on the day of sampling; dead fish was observed on the surface near sampling points 1 and 2; dumping of *nirmalya* (*puja* materials) and garbage was observed. *Ganapati visargan* was underway.

At the gross level, the water body had no prominent odour, with the entire water body appearing brown.

Fig. 1



Sampling Site II Part of Thane Creek, Sector 10, Airoli (Fig. 2)

Type of water body: Creek water

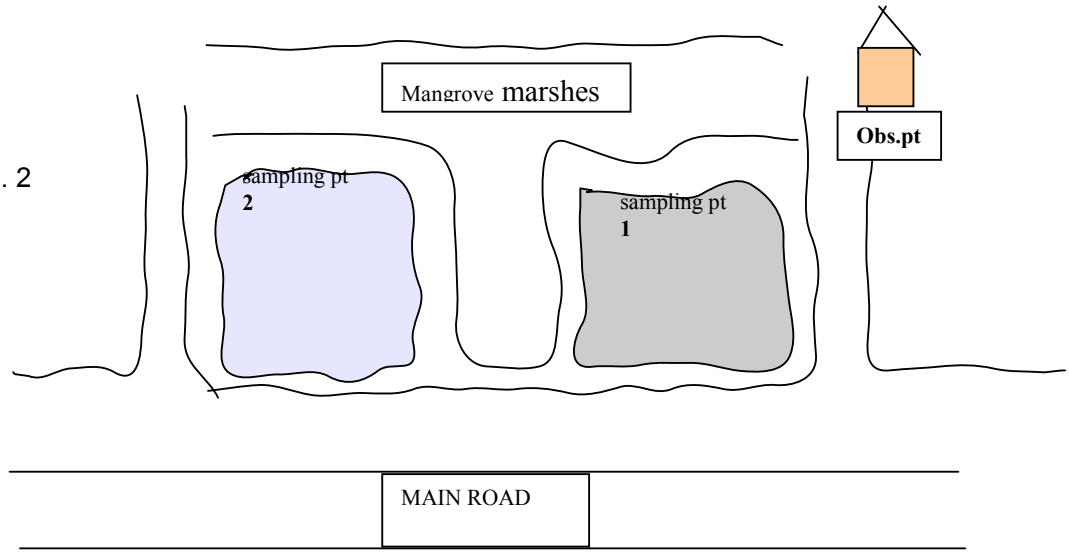
General observations: At this site, the water body was compartmentalized into neat squares for fish cultivation. Mangroves were present to a limited extent.

Water samples were collected from two sites in this area. At pt. 1, some construction activity seemed to be in the planning stage.

At pt. 2, mangroves were removed and this part of the water body appeared to be maintained by a private party for fishing purposes. A small hut (with liquor bottles and some litter) was located nearby.

The water samples from these two points represented the creek water in Airoli. Fishing and garbage dumping were observed. Overall, the water body appeared clean and green with no odour.

Fig. 2



Sampling Site III: Diva lake, Sector 9, Airoli (Fig. 3)

Type of water body: Rain fed fresh water body

Outlets/Inlets: None.

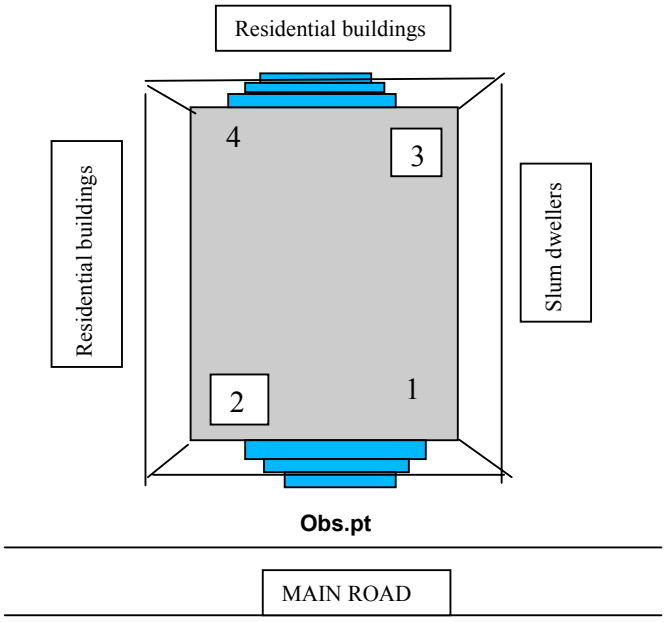
General observations: This lake is built and maintained by the NMMC; it is enclosed by a fenced wall; steps are provided on one side. The rectangular pond had an approximate area of 32 x16 m^2.

The lake is located in a residential area, with buildings on two sides and small huts on one side.

Bathing by children, along with washing of clothes was observed at the site. Garbage in the form of plastic, flowers was observed at the corners of the lake.

This lake is mostly fed by rain water. At the gross level, the lake appeared clean and light green and did not have any odour.

Fig. 3



AIROLI (RESULTS)

SEASON: MONSOON (Septermber 2004)

Due to heavy rains, mixing of water is expected.

1. High turbidity was observed in all water bodies.
2. High levels of ammonia, alkalinity and COD were observed in the three water bodies.
3. Low DO was recorded at all points in Diva lake.

Table: Monsoon: Airoli: Physical and chemical characteristics of water samples

AIROLI	Water body I			Water body II		Water body III			Stds.
Name	Ganapati Talab (sec. 1)			Creek (sec10)		Diva lake (sec.9)			
Sample No. →	1	2	3	1	2	1	2	3	
Parameters ↓									
Colour	LG	LG	LG	L.G	LG	LG	LG	LG	C
Odour	marshy	marshy	marshy	O	O	O	O	O	O
pH	7	6.8	6.9	7.2	7.5	6.9	7	7.3	6.5 to 8.5
Temp ^{o}C	32	32	32	30	30	32	32	32	
Turbidity (NTU)	>100			>100		>100			No Turbidity
Phosphates (mg/l)	L	P	BDL	BDL	BDL	L	H	BDL	0.1
Copper (mg/l)	BDL	BDL	BDL	BDL	L	BDL	L	BDL	0.05 to 1.5
Iron (mg/l)	L	BDL	L	C	L	P	H	P	0.3
Ammonia (mg/l)	1.2	>2	1.8	1.6	>2	>2	1.6	1.6	0.5
Fluorides (mg/l)	0.2	0.5	0.5	0.5	0.2	0.2	0.5	0.2	1.5
Total alkalinity (mg $CaCO_3$ /l)	560	1400	1400	2100	2100	490	350	560	200
Chlorides (mg/l)	140	140	70	2100	4900	140	140	140	200-250
DO (mg/l)	3.6	3.2	4	7.2	5.2	1.6	1.6	1.6	4-6
COD (mg/l)	820	740	760	880	680	540	800	760	4-10
Chromium (mg/l)	BDL			BDL		BDL			0.05

C= colourless; G=green; Br= brown; R=red; B=Black; LG=light green; DG=dark green; GBr=greenish brown;

O=odourless; U=unpleasant; F=fishy; E=faecal; S=sweetish; Sp=soapy

L=low; P=permissible; H=high; C=critical; BDL=below detection limit; NA=not available

COD=chemical oxygen demand; DO=dissolved oxygen

NTU=Nephelometric Turbidity Units; Cl=clear

Chemical concentration range followed for colour grid:

Pollutant	L –low (mg/l)	P-permissible (mg/l)	H-high (mg/l)	C-critical (mg/l)
Phosphates	Below 0.1	0.1	0.1-1.0	Above 1
Copper	Below 0.05	0.05 -1.5	1.5- 10	Above 10
Iron	Below 0.3	0.3	0.3-1.0	Above 1.0
Chromium	Below 0.05	0.05	0.05-0.5	Above 0.5

SEASON: WINTER (January, 2005)

DATE OF SAMPLING: 20th January 2005

DATE OF ANALYSIS: 21st January 2005.

CLIMATIC CONDITIONS: Bright and pleasant

TOTAL NO. OF WATER BODIES STUDIED: Three (2→ freshwater and 1 →creek)

NO. OF WATER SAMPLES COLLECTED : 9 samples (4 in fresh water bodies and 1 in creek

Sampling Site I: Ganapati talab, Sector1 (fresh water body) (Fig. 1)

General observations: At a gross level, the water body had no prominent odour, and it appeared brown, though at pt. 1, it appeared to be blackish. Several rats were observed in the inlet/outlet pipe located near pt. 2. NMMC personnel were busy cleaning up the water body. The water level was quite high and comparable to that in monsoon.

Sampling Site II: Sector 10 (creek water): Fig. 2

General observations: The overall water body appeared dark green with no prominent odour. It was greatly reduced in size as it was compartmentalized into neat squares.

Sampling Site III: Diva lake, Sector 9 (rain fed fresh water body): Fig. 3

General observations: The water levels had greatly reduced and the lake was littered with plastic bags containing *puja* materials, etc.; clothes were being washed between pts.1 and 2. Prawns and small fish were being dried at its edges by nearby slum dwellers.

AIROLI (RESULTS)

1. High COD was observed in the three water bodies in Airoli.
2. Low DO was observed in all three water bodies.
3. High alkalinity and chloride levels were observed in Diva lake, which is a fresh water body. There could be intrusion of creek water into this rain fed lake.

***Table: Winter: Airoli:* Physical and chemical characteristics of water samples**

AIROLI	Water body I				Water body II	Water body III				Stds.
Name	Ganapati Talab sec 1				Creek sec10	Diva lake				
Sample No. →	1	2	3	4	1	1	2	3	4	
Parameters ↓										
Colour	Br	Br	Br	Br	DG	G	G	G	G	**C**
Odour	O	O	O	O	F	U	U	U	U	**O**
pH	6-7	6-7	6-7	6-7	6-7	6-7	6-7	6-7	6-7	**6.5 to 8.5**
Temp ^{o}C	26	26	26	26	28	28	27.5	28	28	
Turbidity (NTU)	-				-	>100				**No turbidity**
Phosphates (mg/l)	BDL	L	BDL	L	BDL	BDL	BDL	BDL	BDL	**0.1**
Copper (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	**0.05 to 1.5**
Iron (mg/l)	BDL	BDL	L	L	BDL	BDL	BDL	L	L	**0.3**
Ammonia (mg/l)	0.4	0.2	0.4	0.4	0.4	0.4	0.8	1	0.4	**0.5**
Fluorides (mg/l)	0.2	0.2	0.5	0.5	1.5	0.5	0.5	0.5	0.5	**1.5**
Total alkalinity (mg $CaCO_3$ /l)	210	200	230	220	160	310	350	300	300	**200**
Chlorides (mg/l)	90	90	100	90	33500	420	490	400	350	**200-250**
DO (mg/l)	**0.8**	**0.4**	**1.2**	**0.4**	**1.2**	**1.4**	**0.4**	**2**	**1.2**	**4-6**
COD (mg/l)	**320 (mix)**				**600**	**860 (mix)**				**4-10**
Chromium (mg/l)	BDL				BDL	BDL				**0.05**

C= colourless; G=green; Br= brown; R=red; B=Black; LG=light green; DG=dark green; GBr=greenish brown

O=odourless; U=unpleasant; F=fishy; E=faecal; S=sweetish; Sp=soapy

L=low; P=permissible; H=high; C=critical; BDL=below detection limit; NA=not available

COD=chemical oxygen demand; DO=dissolved oxygen

NTU=Nephelometric Turbidity Units; Cl=clear

Chemical concentration range followed for colour grid:

Pollutant	L –low (mg/l)	P-permissible (mg/l)	H-high (mg/l)	C-critical (mg/l)
Phosphates	Below 0.1	0.1	0.1-1.0	Above 1
Copper	Below 0.05	0.05 -1.5	1.5- 10	Above 10
Iron	Below 0.3	0.3	0.3-1.0	Above 1.0
Chromium	Below 0.05	0.05	0.05-0.5	Above 0.5

SEASON: SUMMER (April, 2005)

DATE OF SAMPLING: 2nd April 2005

DATE OF ANALYSIS: 3rd April 2005

CLIMATIC CONDITIONS: Hot and humid

TOTAL NO. OF WATER BODIES STUDIED: Three (2→freshwater & 1 →creek)

NO. OF WATER SAMPLES COLLECTED : 9 samples (5/2 samples/fresh water body and 2/creek, depending on the accessibility (and availability) of water.

Sampling Site I: Ganapati talab, Sector 1 (fresh water body): Fig. 1

General observations: The water body appeared dirty and dark green. It was littered with *nirmalaya*, etc. It had a chemical odour, perhaps due to pesticides being sprayed on the water body. Water sample was also collected from a hand pump (near pt. 2) and was labeled as pt. 5. The water from this hand pump was being extensively used by residents for domestic use.

Sampling Site II: Part of Thane Creek, Sector 10 (creek water): Fig. 2

General observations: The creek area was being filled up near the two sampling points. Samples were collected at two points as in monsoon. The overall water appeared clean and green with no odour.

Sampling Site III: Diva lake, Sector 9 (rain fed fresh water body): Fig. 3

General observations: Very little water was observed at the site; the water body appeared dark parrot green; buffaloes were immersed in the water; women were observed to wash clothes.

AIROLI (RESULTS):

1. High turbidity was observed in all water samples, except in the hand pump and the creek samples (pt. 2).
2. Low DO and high COD were observed in all water bodies.
3. The water sample from the hand pump recorded high iron content, low DO (2.8 mg/l) and high COD (20 mg/l). The latter two could perhaps be attributed to mixing of pollutants from the adjacent water body to the ground water.

Table: Summer: Airoli: Physical and chemical characteristics of water samples

AIROLI	Water body I					Water body II		Water body III		Stds.
Name	Ganapati *Talao*, sec 1					Creek sec10		Diva lake		
Sample No. →	1	2	3	4	5 (hand pump)	1	2	1	2	
Parameters ↓										
Colour	DG	GBr.	DG	DG	C	G	C	G	G	C
Odour	Chem.	U	U	Chem.	O	F	O	U	U	O
pH	7	7	7	7	7	9	10	9	9	6.5 to 8.5
Temp ^{O}C	31	30	31	30	28	29	30	30	31	
Turbidity (NTU)	>100				Clear	>100	clear	>>100		No turbidity
Phosphates (mg/l)	BDL	L	BDL	L	P	H	BDL	L	BDL	0.1
Copper (mg/l)	BDL	BDL	BDL	L	BDL	BDL	BDL	L	BDL	0.05 to 1.5
Iron (mg/l)	L	L	BDL	P	H	H	L	L	H	0.3
Ammonia (mg/l)	0.4	1.4	NA	0.4	BDL	NA	>2	0.2	0.4	0.5
Fluorides (mg/l)	1	0.2	0.2	0.2	BDL	2	1.5	0.5	0.5	1.5
Total alkalinity (mg $CaCO_3$ /l)	30	60	220	30	290	280	170	40	40	200
Chlorides (mg/l)	120	NA	180	70	90	22800	29100	320	410	200-250
DO (mg/l)	0.4	0.4	0.4	0.4	2.8	0.8	0.8	BDL	BDL	4-6
COD (mg/l)	250				20	1000	525	NA		4-10
Chromium (mg/l)	BDL					BDL		BDL		0.05

C= colourless; G=green; Br= brown; R=red; B=Black; LG=light green; DG=dark green; GBr=greenish brown

O=odourless; U=unpleasant; F=fishy; E=faecal; S=sweetish; Sp=soapy

L=low; P=permissible; H=high; C=critical; BDL=below detection limit; NA=not available

COD=chemical oxygen demand; DO=dissolved oxygen;

NTU=Nephelometric Turbidity Units; Cl=clear

Chemical concentration range followed for colour grid:

Pollutant	L –low (mg/l)	P-permissible (mg/l)	H-high (mg/l)	C-critical (mg/l)
Phosphates	Below 0.1	0.1	0.1-1.0	Above 1
Copper	Below 0.05	0.05 -1.5	1.5- 10	Above 10
Iron	Below 0.3	0.3	0.3-1.0	Above 1.0
Chromium	Below 0.05	0.05	0.05-0.5	Above 0.5

WATER SAMPLING AND ANALYSIS BY THE STUDENTS OF J.V. MANDAL'S COLLEGE, AIROLI

Water sampling at Ganapati *talao*, Sector 1, Airoli.

Water sampling (Sept. 2004) at creek side, Sector 10, Airoli. In April 2005, this entire stretch with its mangrove cover and fish ponds was filled up, with hectic construction activity underway.

Water sampling at Diva lake, Sector 9, Airoli.

Physical analysis of water samples at J.V. Mandal College, Airoli.

AREA OF STUDY: KOPAR KHAIRANE

SEASON: MONSOON (September 2004)

DATE OF SAMPLING: 2nd September 2004

DATE OF ANALYSIS: 3rd September 2004

CLIMATIC CONDITIONS: Cloudy day with heavy rains on the previous day.

NO. OF WATER BODIES STUDIED: Two (1→ freshwater and 1 →creek)

NO. OF WATER SAMLPLES COLLECTED: 10 samples (4/fresh water body & 2 from the creek).

Sampling Site I: Kopar lake, sector 19 : Fig. 4

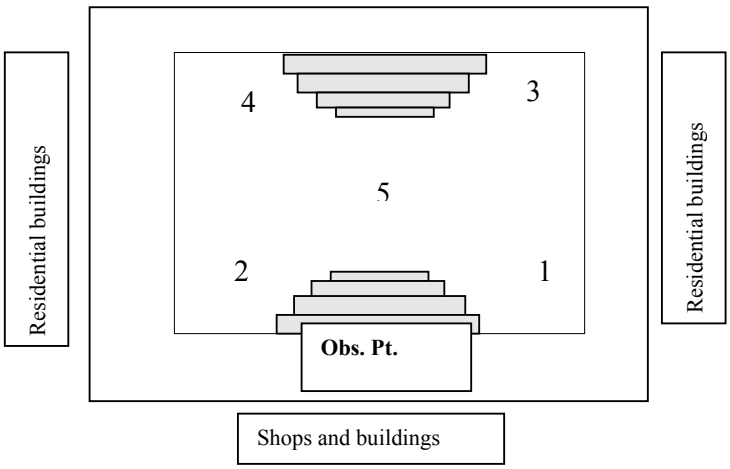
Type of water body: Fresh water body; **Outlets/Inlets:** Not observed

General observations: Built and maintained by the NMMC; enclosed by a wall with iron railings; approachable by steps on two opposite sides (see figure). Shape of the pond is rectangular (having an approximate area of 26x37 m^2), situated at the center of a residential area; the pond is surrounded by houses and shops.

At the gross level, the water body had no prominent odour and appeared brown akin to soil colour. Large volumes of garbage: plastic bags, bottles, tyres, vegetable and fish waste, *nirmalaya,* pipes and bricks, was observed at the periphery. Washing of clothes, bathing/swimming was also observed.

The centre of the pond was relatively clean. Sample 5 was collected from the centre of the pond.

Fig. 4



Sampling Site II: CIDCO water holding pond,Sector 14: Fig. 5

Type of water body: Creek water

Outlets/Inlets: Inlets emptying waste water from the city side (Kopar Khairane/Vashi); another inlet/outlet for seawater to enter into the holding pond and for enclosed water to empty into the creek (figure).

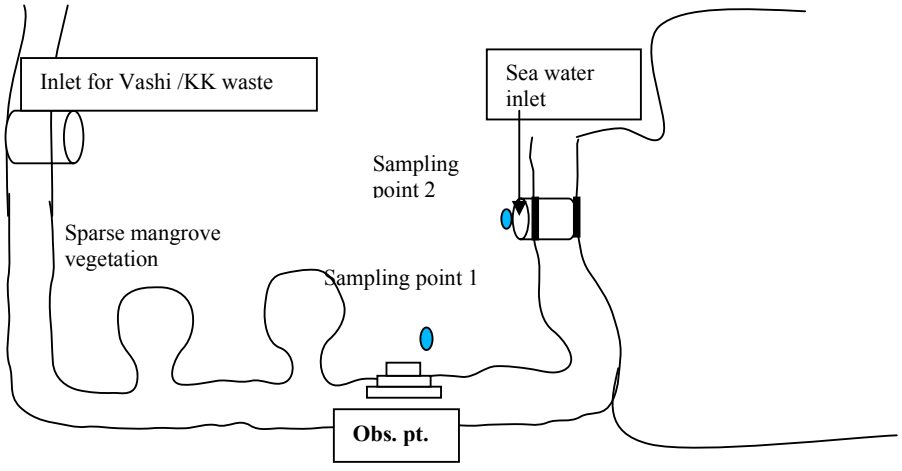
General observations: Shape of this water body is irregular, though the natural contours were maintained. The observation point was littered with *nirmalya* (*pooja* materials), and thermocole, bricks, etc, were found at the periphery of the holding pond.

This shore line was once covered with mangroves but is now highly denuded; the water body now appears as a regular *nullah*, where the municipal/industrial liquid wastes are being disposed through various inlet point(s) (fig. 5). One outlet/inlet point created by appropriate bunding allows the creek water into this holding pond, thus diluting the liquid waste water in this holding pond.

At the gross level, the water body appeared as an unpleasant odourous marshy land, with black- brown water.

Water samples were collected from two sampling points as shown in the figure below.

Fig: 5



KOPAR KHAIRANE (RESULTS)

SEASON: MONSOON (September 2004)

1. Due to heavy rains, there was great mixing of water.
2. Water samples from the second water body—creek (holding pond) -- were highly turbid
3. High levels of iron and COD were detected in both water bodies.
4. High levels of ammonia and low levels of DO were detected in the creek water (II).
5. Water body III, located in sector 12 (as indicated in the CIDCO map), opposite the facility of Animal Quarantine, was completely covered with vegetation of *typha* and other plants. A slum on its periphery was encroaching on this water body.
6. The water body in sector 14 has assumed the looks of a waste water *nullah*. Wastewater from Kopar Khairane/Vashi was directly being poured into this holding pond as also evidenced by the unpleasant strong odour and brown/black colour.

Table: Monsoon: Kopar Khairane: Physical and chemical characteristics of water samples

KOPAR KHAIRANE	Water body I					Water body II		Water body III	Stds.
Name	Kopar lake (sec. 19)					Coastline (sec. 14)		Sec. 12	
Sample No. →	1	2	3	4	5	1	2	ENCHROCHED UPON	
Parameters ↓									
Colour	G	G	G	G	G	Br	Br		C
Odour	Slight	O	O	O	O	U	U		O
pH (pH paper)	7	7	7	7	7	7	7		6.5 to 8.5
Temp °C	31	31	31	31	31	30	30		
Turbidity (NTU)	NA					>100	>100		No turbidity
Phosphates (mg/l)	L	H	L	L	L	P	NA		0.1
Copper (mg/l)	L	L	L	L	L	BDL	BDL		0.05 To 1.5
Iron (mg/l)	H	L	H	H	H	H	NA		0.3
Ammonia (mg/l)	0.2	0.4	0.2	0.2	2	>2	>2		0.5
Fluorides (mg/l)	NA	0.2	0.5	0.5	NA	0.5	0.5		1.5
Total alkalinity (mg $CaCO_3$ /l)	NA	NA	50	NA	NA	1000	400		200
Chlorides (mg/l)	60	60	300	50	100	7250	NA		200-250
DO (mg/l)	**2.4**	**2**	**1.2**	**4**	**4.8**	**0.8**	**NA**		4-6
COD (mg/l)	**320**	**850**	**510**	**1030**	**880**	**1820**	**NA**		4-10
Chromium (mg/l)	BDL		L	BDL		BDL			0.05

C= colourless; G=green; Br= brown; R=red; B=Black; LG=light green; DG=dark green; GBr=greenish brown

O=odourless; U=unpleasant; F=fishy; E=faecal; S=sweetish; Sp=soapy

L=low; P=permissible; H=high; C=critical; BDL=below detection limit; NA=not available

COD=chemical oxygen demand; DO=dissolved oxygen

NTU=Nephelometric Turbidity Units; Cl=clear

Chemical concentration range followed for colour grid:

Pollutant	L –low (mg/l)	P-permissible (mg/l)	H-high (mg/l)	C-critical (mg/l)
Phosphates	Below 0.1	0.1	0.1-1.0	Above 1
Copper	Below 0.05	0.05 - 1.5	1.5- 10	Above 10
Iron	Below 0.3	0.3	0.3-1.0	Above 1.0
Chromium	Below 0.05	0.05	0.05-0.5	Above 0.5

SEASON: WINTER (January, 2005)

DATE OF SAMPLING: 11ith January 2005

DATE OF ANALYSIS: 12th January 2005

CLIMATIC CONDITIONS: Bright and pleasant

TOTAL NO. OF WATER BODIES STUDIED: Two (1 freshwater and 1 creek)

NO. OF WATER SAMPLES COLLECTED: Six samples (4 samples in fresh water body and two in creek).

Sampling Site I: Kopar lake, sector 19 (fresh water body): Fig. 4

General observations: At the gross level, the water body appeared clean with little litter of flowers, etc. at the edges. (The samples were collected in the morning and the water body had been cleaned by the municipal workers.) Women were washing clothes near the steps (between pts. 1& 2 and 3 & 4). There was no odour and the water body appeared dark brown. Here, there was a slight drop in water levels.

Sampling Site II: CIDCO water holding pond, Sector 14 (creek water): Fig. 5

General observations: At the gross level, the creek area under study had further deteriorated with the mangrove cover highly denuded. It appeared as an unpleasant odorous *nullah*, with black- brown water. One could observe a clear shrinkage of the water mass.

KOPAR KHAIRANE (RESULTS)

1. High levels of ammonia were observed in both water bodies.
2. The very low DO levels were undetectable in all water samples.
3. Water samples from the second water body were highly turbid.
4. Total alkalinity and ammonia levels were very high in the creek samples.
5. High COD levels were observed in the creek water samples.
6. Pond III remained extensively covered with vegetation.
7. The water body (holding pond) in sector 14 appeared like a *nullah*. Apparently, untreated wastewater from Kopar Khairane area was being directly discharged into this holding pond.

Table: Winter: Kopar Khairane: Physical and chemical characteristics of water samples

KOPAR KHAIRANE	Water body I				Water body II		*Water body III*	Stds.
Name	Kopar lake (sec.19)				Coastline (sec. 14)		sec. 12	
Sample No. →	1	2	3	4	1	2	ENCHROCHED UPON	
Parameters ↓								
Colour	LG	LG	LG	LG	B	Br		C
Odour	O	O	O	O	U	U		O
pH (pH paper)	6-7	6-7	6-7	6-7	7-8	7-8		6.5 To 8.5
Temp. °C	27				30			
Turbidity (NTU)	NA				> 100			No turbidity
Phosphates (mg/l)	P	P	P	BDL	L	L		0.1
Copper (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL		0.05 To 1.5
Iron (mg/l)	L	C	P	L	H	L		0.3
Ammonia (mg/l)	1.4	1.2	1.4	1.2	>2	>2		0.5
Fluorides (mg/l)	0.5	0.5	0.5	0.5	0.5	0.5		1.5
Total alkalinity (mg $CaCO_3$ /l)	180	130	130	200	1000	1000		200
Chlorides (mg/l)	90	100	90	90	16000	22500		200-250
DO (mg/l)	**1.2**	**2.4**	**1.2**	**2.4**	**BDL**	**BDL**		4-6
COD (mg/l)	**NA**				**4800**			4-10
Chromium (mg/l)	BDL				BDL			0.5

C= colourless; G=green; Br= brown; R=red; B=Black; LG=light green; DG=dark green; GBr=greenish brown

O=odourless; U=unpleasant; F=fishy; E=faecal; S=sweetish; Sp=soapy

L=low; P=permissible; H=high; C=critical; BDL=below detection limit; NA=not available

COD=chemical oxygen demand; DO=dissolved oxygen

NTU=Nephelometric Turbidity Units; Cl=clear

Chemical concentration range followed for colour grid:

Pollutant	L –low (mg/l)	P-permissible (mg/l)	H-high (mg/l)	C-critical (mg/l)
Phosphates	Below 0.1	0.1	0.1-1.0	Above 1
Copper	Below 0.05	0.05 to 1.5	1.5- 10	Above 10
Iron	Below 0.3	0.3	0.3-1.0	Above 1.0
Chromium	Below 0.05	0.05	0.05-0.5	Above 0.5

SEASON: SUMMER (April 2005)

DATE OF SAMPLING: 21st March 2005

DATE OF ANALYSIS: 22nd March 2005

CLIMATIC CONDITIONS: **Hot and humid**

TOTAL NO. OF WATER BODIES STUDIED: Two (1 freshwater and 1 creek)

NO. OF WATER SAMPLES COLLECTED: 4 samples from fresh water body and one from the creek area.

Sampling Site I: Kopar lake, sector 19 (fresh water body): Fig. 4

General observations: At the gross level, the water body appeared clean with gentle surface movement of water. Not much litter, except at the four corners (flowers, ashes) was observed, along with burning at pt. 4. It had no odour and the colour appeared dark green. As the water levels had dropped to some extent (from those observed in monsoon/winter), a 12" drain pipe was observed at pt.1.

Sampling Site II: CIDCO water holding pond, Sector 14 (creek water): Fig. 5

General observations: There was a major change in this creek area. It was observed that the few remaining mangrove plants were cut and a major refilling activity was underway. The entire area appeared odourous and dirty. The water around pt. 1 had evaporated and the soil appeared caked. Hence no sample was collected from this point. The area around pt. 2 had a strong foul odour.

KOPAR KHAIRANE : (RESULTS)

1. Both the water bodies have recorded high COD and low DO levels.
2. DO level (below zero) were recorded at pt. 1 of water body I. At this point, a 12" drain pipe was observed to enter the water body.
3. High to critical phosphate levels and high ammonia were recorded in the creek water sample from pt. 2.
4. Gross and chemical analysis of creek water lends credence that raw sewage was being poured and mixed at the water body II.
5. Massive cutting of mangroves was observed, with accompanying construction activities.

***Table: Summer: Kopar Khairane:* Physical and chemical characteristics of water samples**

KOPAR KHAIRANE	Water body I				Water body II		Water body III	Stds.
Name	Kopar lake, Sec. 19				Coastline, Sec. 14		Sec. 12	
Sample No. →	1	2	3	4	1	2	ENCHROCHED UPON	
Parameters ↓								
Colour	DG	DG	DG	DG	-	Gr		C
Odour	U	U	U	U	-	E		O
pH	6-7	7	7	6-7	-	8		6.5 to 8.5
Temp ^{O}C	NA				-	NA		
Turbidity (NTU)	CLEAR				-	>100		No Turbidity
Phosphates (mg/l)	L	L	L	L	-	C-H		0.1
Copper (mg/l)	L	L	L	L	-	L		0.05 to 1.5
Iron (mg/l)	L	L	L	BDL	-	BDL		0.3
Ammonia (mg/l)	0.2	0.2	0.2	2	-	>2		0.5
Fluorides (mg/l)	0.5	0.5	0.5	0.5	-	0.5		1.5
Total alkalinity (mg $CaCO_3$ /l)	160	170	170	180	-	600		200
Chlorides (mg/l)	70	70	70	70	-	3150		200-250
DO (mg/l)	**BDL**	**1.2**	**0.4**	**0.8**	**-**	**BDL**		4-6
COD (mg/l)	**125**				**-**	**1500**		4-10
Chromium (mg/l)	BDL				-	BDL		

C= colourless; G=green; Br= brown; R=red; B=Black; LG=light green; DG=dark green; GBr=greenish brown

O=odourless; U=unpleasant; F=fishy; E=faecal; S=sweetish; Sp=soapy

L=low; P=permissible; H=high; C=critical; BDL=below detection limit; NA=not available

COD=chemical oxygen demand; DO=dissolved oxygen

NTU=Nephelometric Turbidity Units; Cl=clear

Chemical concentration range followed for colour grid:

Pollutant	L –low (mg/l)	P-permissible (mg/l)	H-high (mg/l)	C-critical (mg/l)
Phosphates	Below 0.1	0.1	0.1-1.0	Above 1
Copper	Below 0.05	0.05 to 1.5	1.5- 10	Above 10
Iron	Below 0.3	0.3	0.3-1.0	Above 1.0
Chromium	Below 0.05	0.05	0.05-0.5	Above 0.5

WATER SAMPLING BY THE STUDENTS OF F. G. NAIK COLLEGE, KOPAR KHAIRANE:

Water sampling at Kopar lake, Sector 19, Kopar Khairane.

Water holding pond, sec.14, in Sept. 2004 (LHS);

The water body in sec. 12 was overgrown with vegetation, with slums at the periphery. Note the barely visible small patch of water in the centre (below).

AREA OF STUDY: NERUL

SEASON: MONSOON (September 2004)

DATE OF SAMPLING: 9th September 2004

DATE OF ANALYSIS: 10th September 2004

CLIMATIC CONDITIONS: Cloudy day with a continuous drizzle; at times heavy rains.

TOTAL NO. OF WATER BODIES STUDIED: Four (3→ freshwater and 1 →creek)

NO. OF WATER SAMLPLES COLLECTED: 14 samples (4/fresh water bodies & 2 from the creek.

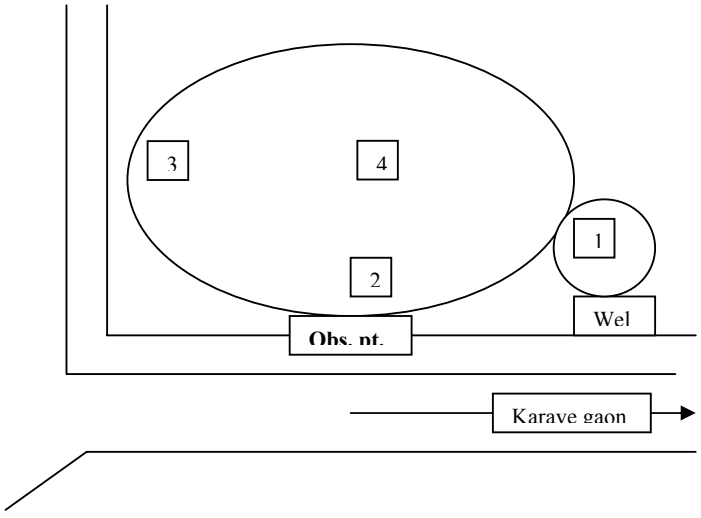
Sampling site I: Ganesh talab, Sector 32/38, Karave goan (Fig.6)

Type of water body: Fresh water body

Outlets/Inlets: No inlets or outlets were observed at the gross level.

General observations: This is a big water body (sampling pts. 2, 3, 4) with Karave village in the vicinity. Along side this water body, there is a big well (sampling pt.1), relatively clean, from which water is drawn and used by villagers. The main water body is maintained by the NMMC; it had a boundary wall. Beyond point 4, the entire lake was highly eutrophic with pistia and typha plants. Due to constraints in accessing the far corners of the water body, only three samples were collected. Samples were collected from pts. 3 and 4 by local boys. Women were washing clothes and children were bathing near pt. 3; some plastic waste along with leaves and vegetable matter were observed all along the periphery and at the corners of the lake.

Fig. 6



Sampling site II: Creek, Opp. Chanakya, Palm Beach Road (Fig. 7)

Type of water body: Creek water

Outlets/Inlets: Many

General observations: This site is on the Palm Beach Road, opposite *Chanakya.* This water body is impounded creek water.

Samples were collected from two points in the selected site. While one sample was near the shoreline (pt. 1), the other was at a distance –pt. 2 (a local boy collected the sample).

At the gross level, the creek site appeared clean with clear water. Gentle surface movement of water was observed. The entire area as such is unbounded and open, with road on one side.

Some litter was observed in the form of tyres, plastic, etc. Two men were fishing and some boys were swimming in the area.

One could see several inlets with *nullah* water gushing in this water body.

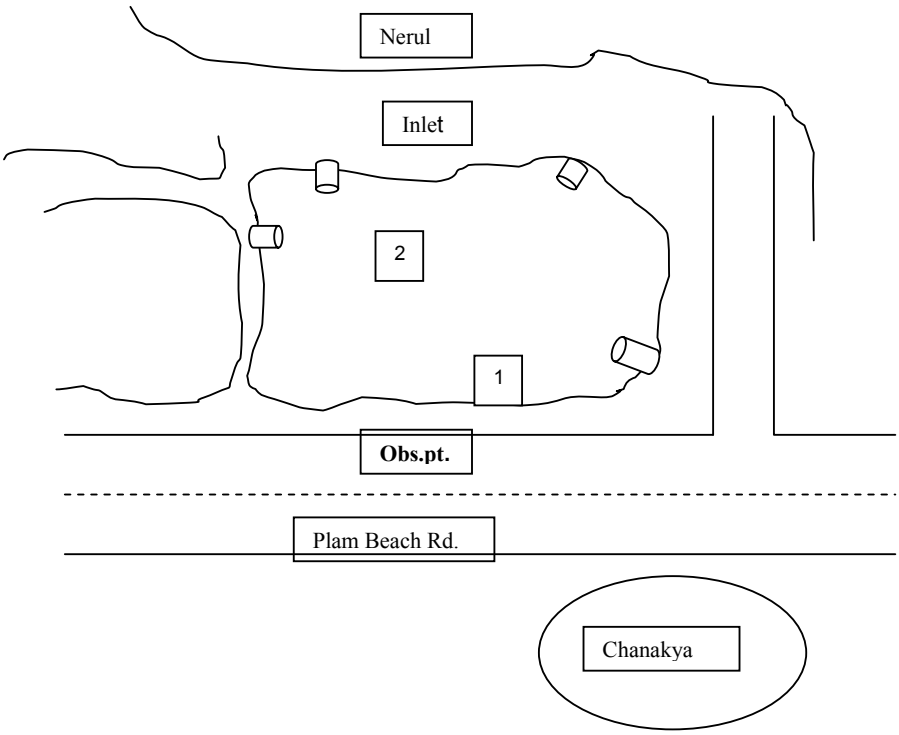


Fig. 7

Sampling site III: Chincholi lake, Sector 8 (Fig. 8)

Type of water body: Fresh water body

Outlets/Inlets: Not observed.

General observations: The lake is situated in the centre of a garden in a residential area. It is built and maintained by the NMMC; the water body could be approached by steps on all four sides. The rectangular pond has an area of about 80x60 m^2. Cemented pockets at the four corners of the water body are provided for dumping *pooja* flowers, etc. In this season, these pockets were full of garlands and plastics bags.

At the gross level, the water body was odourless, dirty and appeared dark green. Women were washing clothes and bathing; plastics bags, *pooja* flowers, etc, were littered at the edges. This litter had collected towards one edge/corner of the lake due to water movement and also due to certain cleaning by the NMMC workers. In spite of cemented pockets at corners provided for litter, one observed heavy littering by citizens, especially of *nirmalaya*, in the water body.

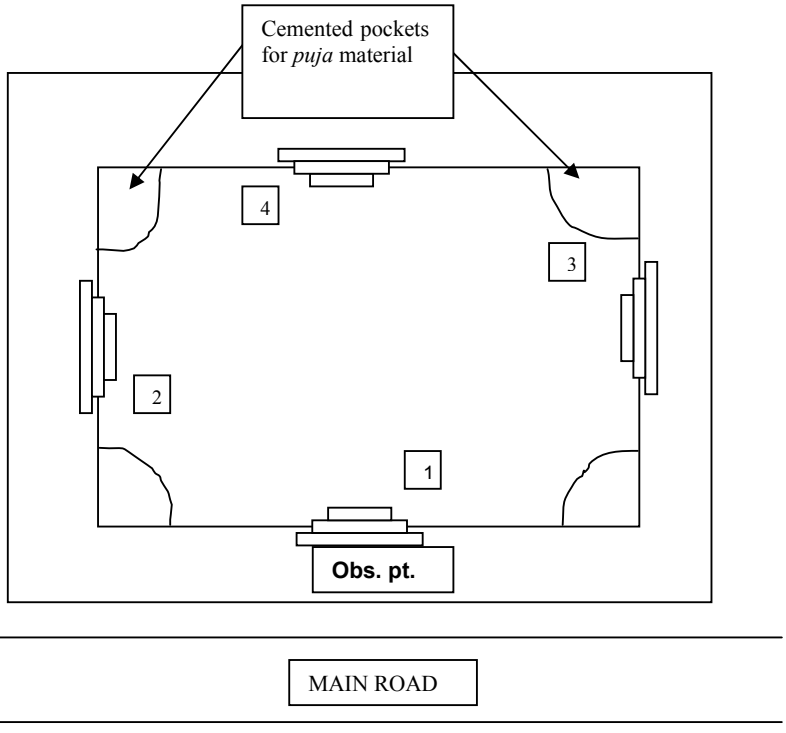


Fig.8

Sampling site IV: Shiv Mandir lake, Sector 18 A (Fig.9)

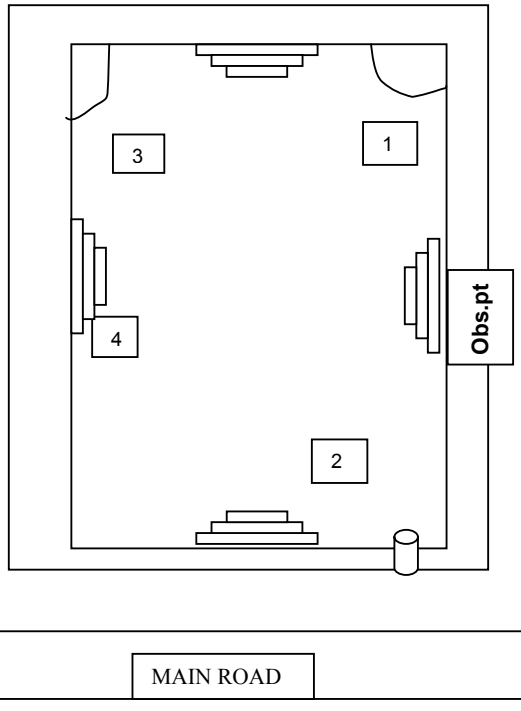
Type of water body: Fresh water body

Outlets/Inlets: One inlet.

General observations: Built and maintained by the NMMC; enclosed by a wall with railings; the water body is approached via steps on all four sides. The square pond has an approximate area of 60x60 m^2.The water body is surrounded by residential buildings on all four sides. The observation point (Obs.Pt) was chosen in front of the building called, Citizen Apartments. Cemented pockets were observed near the steps at points 1 and 3 for *nirmalaya*. At the gross level, the water body appeared to be fairly clean with slight movement of water.

Women were washing clothes; bathing and fishing were also observed. Plastic bottles, *pooja* flowers, and other garbage were strewn all around the water body.

Fig. 9



NERUL (RESULTS)

Monsoon—September 2004

1. Heavy rains had led to mixing of water, with high turbidity in all water samples.
2. High levels of ammonia, alkalinity and COD were observed in all water bodies. High levels of chlorides were observed at one point (pt. 3) in Chincholi lake.
3. Low DO was observed at pt. 4 of Ganesh *talao* , Karave village,

***Table: Monsoon Nerul:* Physical and chemical characteristics of water samples**

NERUL	Water body I				Water body II		Water body III				Water body IV				Stds.
Name	Ganesh talab (Karave goan--sec.32/38)				Creek (opp. Chanakya, Palm Beach Rd)		Chincholi lake (sec. 8)				Shiv Mandir lake (sec.18A)				
Sample No. →	1-well	2	3	4	1	2	1	2	3	4	1	2	3	4	
Parameters ↓															
Colour	DG	DG	DG	DG	C	C	LG	LG	LG	LG	DG	DG	DG	DG	C
Odour	Nil	Nil	Nil	Nil	F	F	NIL	NIL	NIL	NIL	NIL	NIL	NIL	F	O
pH	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.5-8.5
Temp °C	29	29	30	30	30	31	29	30	29	29	29	29	29	29	
Turbidity (NTU)	> 100				> 100		> 100				>100				clear
Phosphates (mg/l)	L	BDL	P	H	H-P	H	H-P	BDL	BDL	L	P-H	L	P	L	0.1
Copper (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05-1.5
Iron (mg/l)	L	P	L	P	L-P	L	H	L	L	P-L	L	H	L	L	0.3
Ammonia (mg/l)	1.2	0.6	1.2	0.6	0.8	2	0.6	0.4	0.8	1.8	0.6	0.6	1	0.6	0.5
Fluorides (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.5
Total Alkalinity (mg $CaCO_3$ /l)	420	420	490	490	490	490	280	420	420	420	560	420	420	420	200
Chlorides (mg/l)	140	70	210	70	1610	2100	210	140	300	140	140	140	140	70	200-250
DO (mg/l)	**2**	**2**	**2.8**	**0.8**	**3.2**	**3.2**	**1.6**	**2.4**	**4.4**	**1.6**	**3.2**	**3.6**	**3.2**	**3.6**	4-6
COD (mg/l)	**840**	**320**	**700**	**820**	**840**	**600**	**260**	**60**	**620**	**NA**	**920**	**800**	**620**	**680**	4-10
Chromium (mg/l)	BDL				BDL		BDL				BDL				0.05

C= colourless; G=green; Br= brown; R=red; B=Black; LG=light green; DG=dark green; GBr=greenish brown

O=odourless; U=unpleasant; F=fishy; E=faecal; S=sweetish; Sp=soapy

L=low; P=permissible; H=high; C=critical; BDL=below detection limit; NA=not available

COD=chemical oxygen demand; DO=dissolved oxygen

NTU=Nephelometric Turbidity Units; Cl=clear

Chemical concentration range followed for colour grid:

Pollutants	L –low (mg/l)	P-permissible (mg/l)	H-high (mg/l)	C-critical (mg/l)
Phosphates	Below 0.1	0.1	0.1-1.0	Above 1
Copper	Below 0.05	0.05 to 1.5	1.5- 10	Above 10
Iron	Below 0.3	0.3	0.3-1.0	Above 1.0
Chromium	Below 0.05	0.05	0.05-0.5	Above 0.5

SEASON: WINTER (January 2005)

DATE OF SAMPLING: 27th January 2005

DATE OF ANALYSIS: 28th January 2005

CLIMATIC CONDITIONS: Bright and pleasant

TOTAL NO. OF WATER BODIES STUDIED: Four (3→ freshwater and 1 →creek)

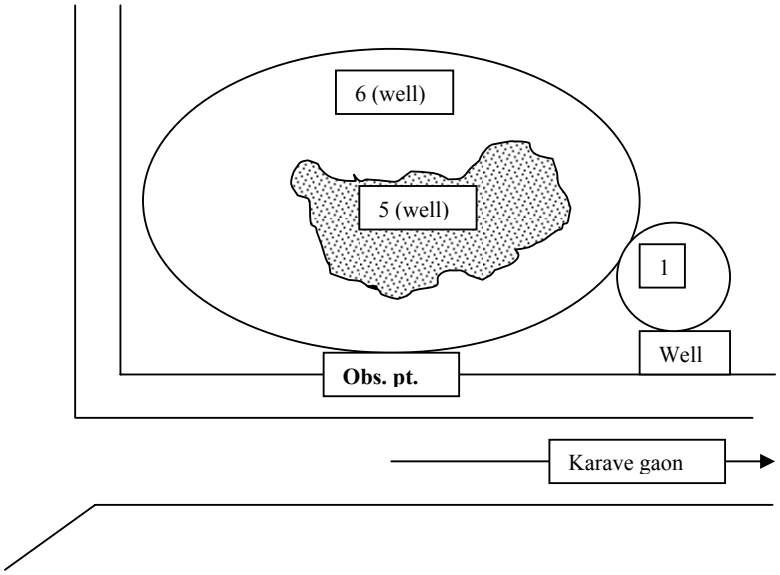
NO. OF WATER SAMLPLES COLLECTED: 12 samples (3/4 /fresh water bodies & 1 from the creek

Sampling site I: Ganesh talab, Sector 32/38 (fresh water body) : Fig.10

General observations: In this season, the water mass in the open water body had been pumped out/dried, hence sampling pts. 2, 3 and 4 (as in monsoon) were not available for sampling. There were a few huts of construction workers working on the boundary wall, etc. The water samples were collected from (pt. 1) the major well from which villagers draw water, and pts. (5) (6), the two small wells which were visible /approachable in this season. (These were immersed in the main water body in monsoon.)

The major well (pt. 1) was clean and clear. The square well (pt. 5) was densely covered with vegetation: the water sample was collected from a narrow strip of water (not covered with vegetation); the round well (pt. 6) appeared clean and its water was being used for construction purposes.

Fig. 10



Sampling site II: Creek, Opp. Chanakya, Palm Beach Road (creek water) : Fig.7

General observations: At the gross level, in this season, the site appeared dirty, brown and muddy. Several inlets with sewage water were observed to drain in this water body.

Sampling site III: Chincoli lake, Sector 8 (fresh water body) : Fig. 8

General observations:. The water body appeared dirty, brown and muddy with foul odour. Its surroundings were littered with waste of all sorts: a tempo (with large quantities of leftover food from a party organized on the occasion of the Republic Day on the previous day) was observed to empty its content in the water body. Washing of clothes and bathing was also observed. Water level had dropped to some extent.

Sampling site IV: Shiv Mandir lake, Sector 18 A (fresh water body): Fig. 9

General observations: At the gross level, the water body appeared dirty green with some odour. The concrete pockets at the corners of the water body contained food and floral waste; the water body was also littered with floral waste. Bathing and washing of clothes were observed. The water level had dropped to some extent.

NERUL (RESULTS)

Winter—January 2005

1. All the water bodies were dark green or brown and appeared dirty.
2. Turbidity was high in all water bodies, except in Ganesh *talao*.
3. Low pH (6) was recorded in pt. 5 of Ganesh *talao,* which was covered with vegetation.
4. High levels of iron were recorded in the three water bodies.
5. High levels of alkalinity were recorded in at pts. 5 and 6 of Ganesh *talao.*
6. High levels of chlorides were observed at all points in the Chincholi lake and at pt. 1 (main well) of Ganesh lake.
7. Low DO was recorded in all water bodies, though to varying extents.
8. The two well at Ganesh lake recorded DO of 3.6. However, pt. 5 recorded 0.8 DO, probably due to eutrophic conditions near that point.
9. High COD were recorded in Ganesh *talao* and the creek sample.
10. The main well (pt. 1 of Ganesh *talao*) contained relatively clean water in terms of DO, iron and other parameters.

***Table: Winter Nerul:* Physical and chemical characteristics of water samples**

NERUL	Water body I			Water body II		Water body III				Water body IV				Stds.
Name	Ganesh *talao* (Karave *gaon*-- sec.32/38)			Creek (opp. Chanakya, Palm Beach Rd)		Chincholi lake (sec. 8)				Shiv Mandir lake (sec.18A)				
Sample No. →	1 * (main well)	5 (sq. well)	6 (rd. well)	1	2(NA)	1	2	3	4	1	2	3	4	
Parameters ↓														
Colour	DG	G	DG	DBr		Br	Br	Br	Br	DG	DG	DG	DG	C
Odour	O	O	O	O		U	U	U	U	U	U	U	U	O
pH	7	6	7	8-9		7	7	7	7	7	7	7	7	6.5 to 8.5
Temp ^{o}C	29	29	30	29		30	30	30	30	30	30	30	30	
Turbidity (NTU)	Clear			>100		>100				>100				No Turbidity
Phosphates (mg/l)	BDL	L	L	P		BDL	BDL	BDL	BDL	BDL	L	P	L	0.1
Copper (mg/l)	BDL	BDL	BDL	L		BDL	BDL	BDL	BDL	BDL	BDL	BDL	L	0.05 to 1.5
Iron (mg/l)	P	H	H	H		BDL	H	H	H	H	H	H	P	0.3
Ammonia (mg/l)	0.4	0.2	0.2	0.8		0.2	0.2	0.2	0.8	0.2	0.2	0.4	0.4	0.5
Fluorides (mg/l)	0	0.2	0	0.5		1.5	0.2	0.2	0	0.2	0.2	0.5	0.5	1.5
Total Alkalinity (mg $CaCO_3$ /l)	220	340	370	90		160	170	190	140	140	140	90	150	200
Chlorides (mg/l)	390	170	170	30000		390	400	360	420	170	160	170	160	200-250
DO (mg/l)	**3.6**	**0.8**	**3.6**	**3.6**		**0.8**	**0.4**	**2.4**	**BDL**	**0.8**	**1.6**	**1.6**	**0.8**	4-6
COD (mg/l)	**600**	**1100**	**600**	**1350**		**NA**				**NA**				4-10
Chromium (mg/l)	BDL			BDL		BDL				BDL				0.05

*Pts. 2,3, 4 of water body I not available in January, 2005

C= colourless; G=green; Br= brown; R=red; B=Black; LG=light green; DG=dark green; GBr=greenish brown; O=odourless; U=unpleasant; F=fishy; E=faecal; S=sweetish; Sp=soapy ;L=low; P=permissible; H=high; C=critical; BDL=below detection limit; NA=not available;COD=chemical oxygen demand; DO=dissolved oxygen; NTU=Nephelometric Turbidity Units; Cl=clear

Chemical concentration range followed for colour grid:

Pollutants	L –low (mg/l)	P-permissible (mg/l)	H-high (mg/l)	C-critical (mg/l)
Phosphates	Below 0.1	0.1	0.1-1.0	Above 1
Copper	Below 0.05	0.05 to 1.5	1.5- 10	Above 10
Iron	Below 0.3	0.3	0.3-1.0	Above 1.0
Chromium	Below 0.05	0.05	0.05-0.5	Above 0.5

SEASON: SUMMER (April 2005)

DATE OF SAMPLING: 14th April 2005

DATE OF ANALYSIS: 15th April 2005

CLIMATIC CONDITIONS: Hot and humid

TOTAL NO. OF WATER BODIES STUDIED: Four (3→freshwater and 1 →creek)

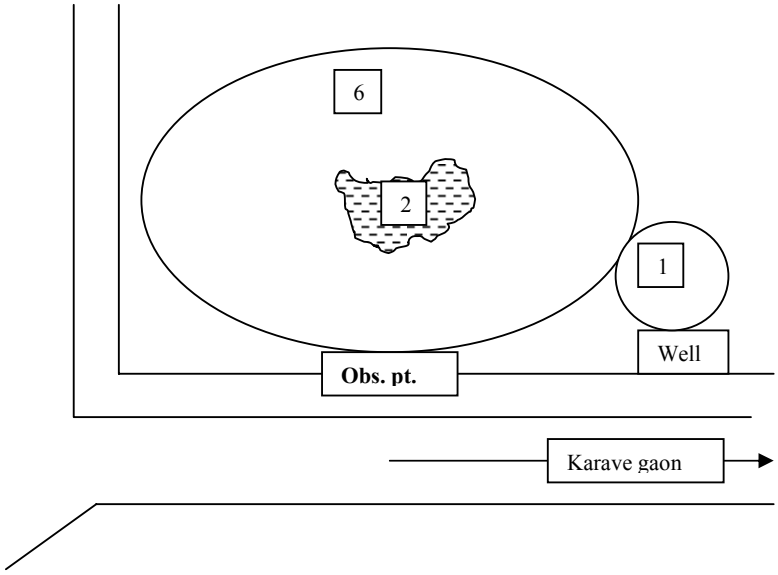
NO. OF WATER SAMLPLES COLLECTED: 11 samples (2 to 4/fresh water bodies & 1 from the creek

Sampling site I: Ganesh talab, Sector 32/38 (fresh water body) : Fig. 11

General observations: In this season, the water samples were collected from the main well (sampling pt. 1), and from the centre of the sprawling water body (sampling pt.2) as this open water body had dried up considerably. (Only one point of sampling –pt. 2-- was available.) Even at this point, there was vegetation (grass) and women were observed to wash clothes. Both sampling points 5 and 6 (as in winter) were inaccessible in this season.

While the main well appeared grey/black with no odour, the centre point (pt. 2) appeared colourless.

Fig.11



Sampling site II: Creek, Opp. *Chanakya*, Palm Beach Road (creek water): Fig. 7

General observations: At the gross level, this site appeared grey - blue with no odours. There was no shrinkage of water body or drop in water levels. One could see several inlets with *nullah* water gushing in this water body.

Sampling site III: Chincholi lake, Sector 8 (fresh water body): Fig.8

General observations: At the gross level, the water body appeared dirty and green/ brown, with slight movement of water. The water level had reduced to a perceptible extent. Other observations were as follows: Municipal workers were cleaning the water body with nets but people continued to throw *puja* flowers contained in plastic bags, etc. Women were washing clothes and there was littering on the edges of the water body. There was also burning of litter at pt. 4; all the four in-built pockets for garbage were full of *puja* flowers and other litter.

Sampling site IV: Shiv Mandir lake, Sector 18 A (fresh water body): Fig.9

General observations: At the gross level, the water body appeared dark green with some odour. There was a continuous stream of water from an inlet at pt. 2 (near the main road), probably this being a sewage outlet from the surrounding buildings.

NERUL (RESULTS)

Summer—April 2005

1. High turbidity was observed in most of the water bodies.
2. High phosphate levels were observed in the creek water samples.
3. High iron content was observed in the Chincholi water body and at pt. 2 of Ganesh lake at Karave.
4. High chloride levels were observed at all sampling points of Chincholi water body.
5. Low levels of DO were observed in all water bodies in Nerul, though Ganesh *talab* samples recorded comparatively higher DO levels (2 to 3.2 mg/l vis-a-vis 0.4 to 1.6 mg/l at other sampling points).

Table: Summer : Nerul: Physical and chemical characteristics of water samples

NERUL	Water body I				Water body II			Water body III					Water body IV				
Name	Ganesh talab, sec.32/38				Creek, opp. Chanakya			Chincholi lake, sec. 8					Shiv Mandir lake, sec.18A				Stds.
Sample No. →	1	2	3,4, 5,6*		1	2		1	2	3	4		1	2	3	4	
Parameter ↓																	
Colour	Gr	Gr			Dirty Bl			Br	Br	Br	Br		G	G	G	G	C
Odour																	O
pH	8	8			8			6	7	6	7		7	6	7	6	6.5 to 8.5
Temp ^{o}C																	
Turbidity (NTU)	clear	>100			>100			>100					>100				No turbidity
Phosphates (mg/l)	P	P			H			P	L	L	P		P	P	H	L	0.1
Copper (mg/l)	L	BDL			L			L	BDL	BDL	BDL		BDL	BDL	L	L	0.05 to 1.5
Iron (mg/l)	L	H	NA		L			C	H	P	H		L	L	H	L	0.3
Ammonia (mg/l)	0.2	0.2			0.2			0.2	0.4	0.2	0.4		0.6	0.2	0.2	0.6	0.5
Fluorides (mg/l)	0	0			0.5			0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.2	1.5
Total Alkalinity (mg $CaCO_3$ /l)	210	170			100			110	90	80	90		90	90	110	110	200
Chlorides (mg/l)	250	400			24450			500	550	450	500		250	250	250	250	200-250
DO (mg/l)	**2**	**3.2**			**0.8**			**0.8**	**BDL**	**0.8**	**0.8**		**0.4**	**1.2**	**0.8**	**1.6**	4-6
COD (mg/l)	**NA**				**NA**			**550 (mix)**					**630 (mix)**				4-10
Chromium (mg/l)	BDL				BDL			BDL					BDL				0.05

C= colourless; G=green; Br= brown; R=red; Gr=grey; B=Black; LG=light green; DG=dark green; GBr=greenish brown

O=odourless; U=unpleasant; F=fishy; E=faecal; S=sweetish; Sp=soapy

L=low; P=permissible; H=high; C=critical; BDL=below detection limit; NA=not available

COD=chemical oxygen demand; DO=dissolved oxygen

NTU=Nephelometric Turbidity Units; Cl=clear

Chemical concentration range followed for colour grid:

Pollutants	L –low (mg/l)	P-permissible (mg/l)	H-high (mg/l)	C-critical (mg/l)
Phosphates	Below 0.1	0.1	0.1-1.0	Above 1
Copper	Below 0.05	0.05 to 1.5	1.5- 10	Above 10
Iron	Below 0.3	0.3	0.3-1.0	Above 1.0
Chromium	Below 0.05	0.05	0.05-0.5	Above 0.5

WATER SAMPLING BY THE STUDENTS OF SIES COLLEGE, NERUL

Water sampling at Ganesh *talao*, Karave *gaon*, Nerul.

Observe the full water level in Sept. 2004, with the main village well and euthrophic plants in the background (top left pic), in sharp contrast to the pic on the right of the same lake.

The two small wells submerged in Sept. 2004 were visible in Jan/April 2005, when the water levels were low/pumped out in the main water body (above).

Chincholi lake, sector 8 (above) and Shiv Mandir lake (right), sector 18A, Nerul.

Water sampling at the water holding pond, opposite *Chanakya*, Palm Beach Road, Nerul.

AREA OF STUDY: TURBHE

SEASON: MONSOON (September 2004)

DATE OF SAMPLING: 15th September 2004

DATE OF ANALYSIS: 16th September 2004

CLIMATIC CONDITIONS: Cloudy day with heavy rains.

TOTAL NO. OF WATER BODIES STUDIED: Three (2→ freshwater and 1 →*nullah*)

NO. OF WATER SAMLPLES COLLECTED: 11 samples (4 (5) /fresh water bodies and 1 from an industrial *nullah*.

Sampling Site I :Turbhe *gaon taloa* (near Ram Tanu Mandir, Sec. 22, Vashi: Fig.12

Type of water body: Fresh water

General observations: This is a big fresh water body built and maintained by the NMMC; it is enclosed by a wall with iron fencing; it is approached by steps on one side. The lake is in the midst of a residential area. There is a vegetable market and shops, a temple, a municipal school (crèche-type), and residential quarters around the water body. Shape of the water body is rectangular.

At the gross level, the water body was greenish, but had no prominent odour. *Nirmalya* and plastic bags were observed at the corners, with women washing clothes; bathing/swimming activities were also observed. There is a small eutrophic well (covered with algal blooms, sampling pt. 4) next to this big water body. The well was full of plastic bags and other garbage.

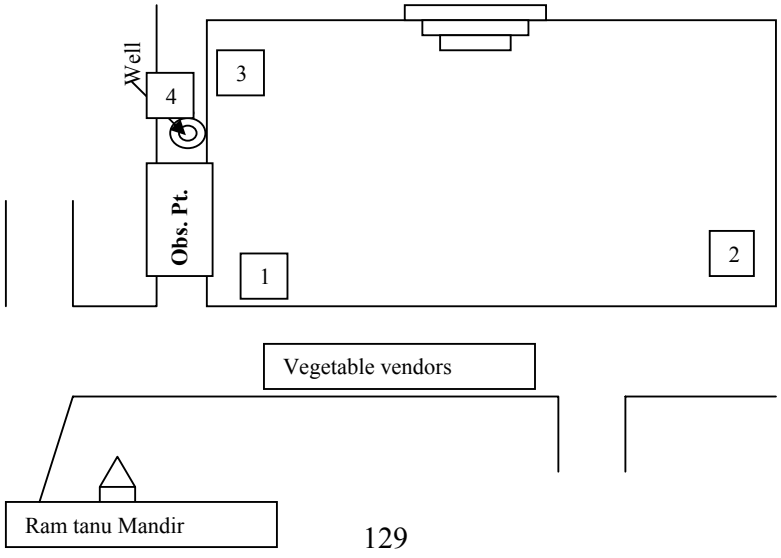


Fig.12

Sampling Site II : Turbhe *nullah* on the Thane Belapur Road, flanked by Zydus Industries, Polyrub, Buds Clothing Co., etc. : Fig. 13

Type of water body: Industrial waste water *nullah*

Outlets/Inlets: This *nullah* is a major outlet for industrial liquid waste.

General observations: Going towards Airoli, the eastern side of the Turbhe zone is flanked by different industries. The water sample was collected from an industrial *nullah*. It carries the liquid industrial waste (partially treated) from surrounding industries; the *nullah* water travels through Vashi and Kopar Khairane zones, via storm water drains and also via open surface water drains, and finally pours its contents into the Thane creek regions of Vashi and Kopar Khairane. This *nullah* (like several others) is not properly structured; it is lined with big stones, gravel, etc. A pipe line carrying clean municipal water is situated on the roadside. This pipeline had a leak just above the *nullah,* where people bathed and washed clothes.

At the gross level, the *nullah* water appeared dark reddish /black/brown. Thick white foamy lather was seen over the water surface. The entire region had a strong fishy odour of chemicals.

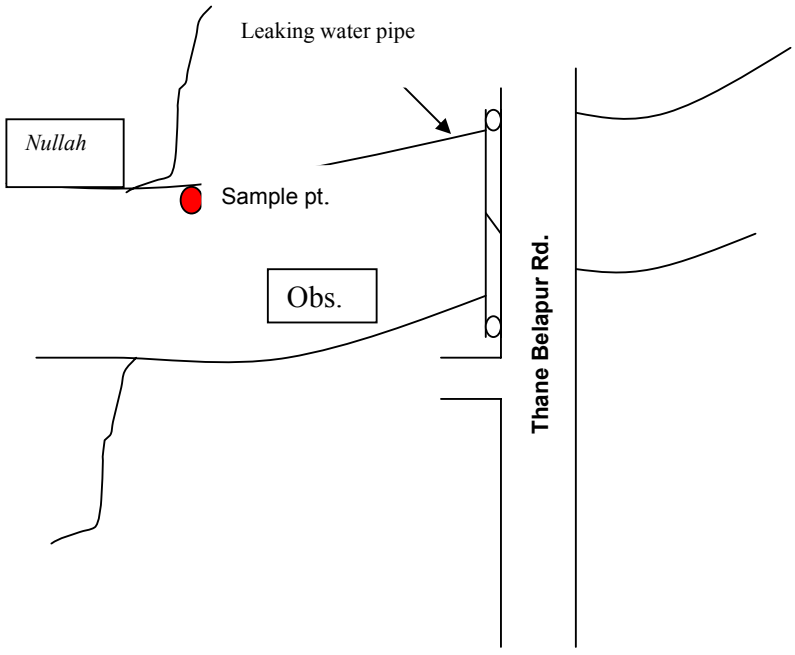


Fig. 13

Sampling Site III : Ganesh *talao*, Kopri *pada*, Sector 26 of Vashi: Fig.14

Type of water body: Fresh water; **Outlets/Inlets:** Nil

General observations: Square shaped, fairly big fresh water body, constructed and maintained by the NMMC; enclosed by boundary walls with iron fencing on all four sides; steps are provided on one side to access the water body. It is located north of Vashi and is accessed by a village-like locality (*pada*). A temple is located on one corner of the water body, while the opposite side is occupied by by transit slum dwellers. The side parallel to the Thane Belapur road was littered with human excreta.

At the gross level, the water body appeared dirty, dark green, with no perceptible odour. It was not maintained well by the NMMC in this season. *Nirmalya*, plastics, etc., were found at the periphery, especially at the corners. Women and children were observed washing clothes and also swimming.

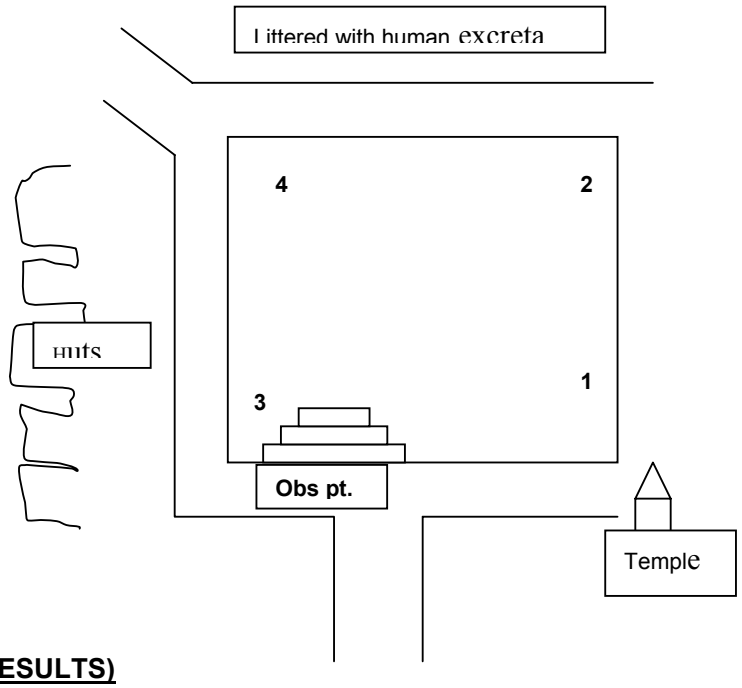


Fig.14

TURBHE (RESULTS)

MONSOON: September 2004

1. High alkalinity, ammonia and COD was detected in all the water bodies.
2. Water sample from the well located near the water body I (Turbhe *gaon*) had high levels of phosphates and very low DO.
3. Water sample from the *nullah* had high/critical levels of phosphates and iron, and low DO (below detection limit).

***Table : Monsoon Turbhe:* Physical and chemical characteristics of water samples**

	Water body I					Water body II		Water body III					Stds.
Name	Turbhe gaon talao (sec. 22)					Turbhe *Nullah*		Ganesh talao (Kopri *pada,* sec. 26)					
Sample No. →	**1**	**2**	**3**	**4 (well)**		**1**		**1**	**2**	**3**	**4**	**5**	
Parameters ↓													
Colour	DG	DG	DG	DG		R		G	G	G	G	G	**C**
Odour	U	U	U	U		S		O	O	O	O	O	**O**
pH	7	7	7	7		7		7	7	7	7	7	**6.5 to 8.5**
Temp °C													
Turbidity (NTU)	NA			NA		NA		NA					**No turbidity**
Phosphates (mg/l)	BDL	BDL	L	H		C-H		L	L	C	L	L	**0.1**
Copper (mg/l)	BDL	L	BDL	BDL		BDL		L	L	BDL	BDL	L	**0.05 to 1.5**
Iron (mg/l)	L	C	L-P	L-P		C		P	P-L	L	C	P	**0.3**
Ammonia (mg/l)	1.6	1	1.4	1.2		1.4		1.4	1.4	1.4	1	1	**0.5**
Fluorides (mg/l)	0	0	0	0		0		0	0	0	0	0	**1.5**
Total alkalinity (mg $CaCO_3$ /l)	300	300	100	300		600		600	600	300	600	300	**200**
Chlorides (mg/l)	90	90	90	30		180		30	60	30	30	30	**200-250**
DO (mg/l)	**5.6**	**5.6**	**5.2**	**0.8**		**BDL**		**5.6**	**5.6**	**5.2**	**6**	**5.6**	**4-6**
COD (mg/l)	**1420**	**1320**	**NA**	**220**		**1780**		**900**	**990**	**NA**	**NA**	**850**	**4-10**
Chromium (mg/l)	BDL					BDL		BDL					**0.05**

C= colourless; G=green; Br= brown; R=red; B=Black; LG=light green; DG=dark green; GBr=greenish brown

O=odourless; U=unpleasant; F=fishy; E=faecal; S=sweetish; Sp=soapy

L=low; P=permissible; H=high; C=critical; BDL=below detection limit; NA=not available

COD=chemical oxygen demand; DO=dissolved oxygen

NTU=Nephelometric Turbidity Units; Cl=clear

Chemical concentration range followed for colour grid:

Pollutant	L –low (mg/l)	P-permissible (mg/l)	H-high (mg/l)	C-critical (mg/l)
Phosphates	Below 0.1	0.1	0.1-1.0	Above 1
Copper	Below 0.05	0.05 to 1.5	1.5- 10	Above 10
Iron	Below 0.3	0.3	0.3-1.0	Above 1.0
Chromium	Below 0.05	0.05	0.05-0.5	Above 0.5

SEASON: WINTER (January, 2005)

DATE OF SAMPLING: 18th January 2005

DATE OF ANALYSIS: 19th January 2005

CLIMATIC CONDITIONS: Bright and pleasant

TOTAL NO. OF WATER BODIES STUDIED: Three (2→ freshwater and 1 →*nullah*)

NO. OF WATER SAMLPLES COLLECTED: Nine samples (4 /fresh water bodies & 1 from the *nullah*.

Sampling Site I :Turbhe *gaon taloa* (near Ram Tanu mandir, Sector 22 of Vashi (fresh water body) : Fig.12

General observations: At a gross level, the water body appeared clean, though the sides were littered with *nirmalaya* and plastic waste. Women were washing clothes near the steps. The water body had no odour. As in monsoon, one water sample was collected from the adjoining well (pt. 4), which was again full of plastic bags with flowers, and other garbage.

Sampling Site II : Turbhe *nullah* on the Thane Belapur Road, flanked by Zydus Industries, Polyrub, Buds Clothing Co., etc (Industrial waste water *nullah*): Fig.13

General observations: At the gross level, the *nullah* appeared red/brown with foul chemical odour, which permeated the entire area. The situation was similar to that in monsoon.

Sampling Site III : Ganesh *talao*, Kopripada, Sector 26 of Vashi (fresh water body): Fig.14

General observations: At the gross level, the water body appeared light green with the usual activities of washing clothes and bathing by people. Litter was dominant at the periphery of the water body. There was no pronounced odour.

WINTER (JANUARY 2005) RESULTS

1. High levels of ammonia and somewhat low DO was detected in most of the sampling points of all water bodies and in the adjoining well.
2. Water bodies II—creek--and III (fresh water) had high alkalinity and chloride levels.
3. Water sample from the *nullah* had acidic pH and critical levels of iron.

Table: Winter:Turbhe: Physical and chemical characteristics of water samples

TURBHE	Water body I				Water body II	Water body III				Stds.
Name	Turbhe *gaon talao* (sec. 22)				Turbhe *Nullah*	Ganesh *talao* (Kopri *pada*, sec. 26)				
Sample No.→	1	2	3	4 (well)	1	1	2	3	4	
Parameters↓										
Colour	LG	LG	LG	G	R	LG	LG	LG	LG	C
Odour	O	O	O	U	S	O	O	O	O	O
pH	6-7	6-7	6-7	6-7	< 6	6-7	6-7	6-7	6-7	6.5 to 8.5
Temp ^{O}C	25-26				26	25-26				
Turbidity (NTU)	NA				NA	NA				Cl
Phosphates (mg/l)	BDL	BDL	BDL	P	L	L	BDL	P	H	0.1
Copper (mg/l)	BDL	BDL	BDL	BDL	L	L	BDL	BDL	BDL	0.05 to 1.5
Iron (mg/l)	BDL	L	L	BDL	C	L	L	L	L	0.3
Ammonia (mg/l)	0.5	1.4	0.8	1.6	2	1.3	0.6	1	1.2	0.5
Fluorides (mg/l)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.5
Total alkalinity (mg $CaCO_3$ /l)	120	130	140	220	500	370	320	320	320	200
Chlorides (mg/l)	90	100	110	110	700	920	850	990	940	200-250
DO (mg/l)	1.2	2.4	1.5	BDL	BDL	3.2	1.6	4.0	1.6	4-6
COD (mg/l)	NA				NA	NA				4-10
Chromium (mg/l)	BDL				BDL	BDL				0.05

C= colourless; G=green; Br= brown; R=red; B=Black; LG=light green; DG=dark green; GBr=greenish brown

O=odourless; U=unpleasant; F=fishy; E=faecal; S=sweetish; Sp=soapy

L=low; P=permissible; H=high; C=critical; BDL=below detection limit; NA=not available

COD=chemical oxygen demand; DO=dissolved oxygen

NTU=Nephelometric Turbidity Units; Cl=clear

Chemical concentration range followed for colour grid:

Pollutant	L –low (mg/l)	P-permissible (mg/l)	H-high (mg/l)	C-critical (mg/l)
Phosphates	Below 0.1	0.1	0.1-1.0	Above 1
Copper	Below 0.05	0.05 to 1.5	1.5- 10	Above 10
Iron	Below 0.3	0.3	0.3-1.0	Above 1.0
Chromium	Below 0.05	0.05	0.05-0.5	Above 0.5

SEASON: SUMMER (April 2005)

DATE OF SAMPLING: 12th April 2005

DATE OF ANALYSIS: 13th April 2005

CLIMATIC CONDITIONS: Hot and humid

TOTAL NO. OF WATER BODIES STUDIED: Three (2→ freshwater and 1 →*nullah*)

NO. OF WATER SAMLPLES COLLECTED: Ten samples (4 to 5 /fresh water bodies & 1 from the *nullah*.

Sampling Site I :Turbhe *gaon talao,* Sector 22 of Vashi, (fresh water body) : Fig.12

General observations: At the gross level, the water body looked clean except at the edges; it appeared parrot - green, with surface water movement at the centre and between pts. 3 and 4; the water body did not have any odour. There was no perceptible change in the level of water. The surface of the adjoining well was full of litter, but the drawn water sample appeared clear and clean.

Sampling Site II : Turbhe *nullah* (Industrial waste water *nullah*): Fig. 13

General observations: In this season, the *nullah* appeared purple-red with foul strong chemical odour. In the stagnated water area, an oily film was observed. Women were washing clothes at the leaking water pipe.

Sampling Site III : Ganesh *talao*, Kopri *pada*, Sector 26, Vashi (fresh water body): Fig. 14

General observations: At the gross level, the water body appeared dirty and light-green to brown with soapy smell. The water level had perceptibly lowered and the samples were drawn from the edge of the water body. Children were swimming by using thermocole pieces as floaters. Litter, as usual, was observed.

TURBHE (RESULTS)

1. In this season, all the water samples had foul characteristic odours.
2. High COD and low DO were detected in all the water bodies.
3. High levels of phosphates and iron were detected in almost all water samples.
4. High chloride levels were detected in Ganesh *talao* (fresh water body).
5. The *nullah* and the well (turbhe village) were equally polluted.

Table: Summer: Turbhe: Physical and chemical characteristics of water samples

TURBHE	**Water body I**					**Water body II**		**Water body III**				**Stds.**
Name	**Turbhe gaon talao (sec. 22)**					**Turbhe *Nullah***		**Ganesh talao (Kopri *pada*, sec. 26)**				
Sample No.	**1**	**2**	**3**	**4**	**Well**	**1**		**1**	**2**	**3**	**4**	
Parameters												
Colour	G	G	G	G		R		G	G	G/B	G/B	**C**
Odour	F	F	F	F	U	Chem.		Sp.	E	E		**O**
pH	6	6	6	6	8	6		7	7	8	7	**6.5 to 8.5**
Temp ^{O}C	NA					NA		NA				
Turbidity (NTU)	>100					>100		>100				**No turbidity**
Phosphates (mg/l)	P	L	C	H	P	C		L	H	BDL	P	**0.1**
Copper (mg/l)	BDL	L	BDL	BDL	BDL	BDL		BDL	BDL	BDL	L	**0.05 to 1.5**
Iron (mg/l)	BDL	H	H	BDL	C	C		C	C	L	L	**0.3**
Ammonia (mg/l)	0.2	0.2	0.2	0.6	0.6	1.4		0.2	0.4	0.6	0.6	**0.5**
Fluorides (mg/l)	1	0.5	0	0.5	0	1.5		1	1	0.5	1	**1.5**
Total alkalinity (mg $CaCO_3$ /l)	200	100	200	200	40	20		400	400	400	400	**200**
Chlorides (mg/l)	200	150	150	600	170	750		2050	2000	2000	2200	**200-250**
DO (mg/l)	**1.6**	**NA**	**0.8**	**1.2**	**BDL**	**0.4**		**0.8**	**1.2**	**1.6**	**1.6**	**4-6**
COD (mg/l)	**580 (mix)**				**NA**	**NA**		**850 (mix)**				**4-10**
Chromium (mg/l)	BDL											

C= colourless; G=green; Br= brown; R=red; B=Black; LG=light green; DG=dark green; GBr=greenish brown

O=odourless; U=unpleasant; F=fishy; E=faecal; S=sweetish; Sp=soapy

L=low; P=permissible; H=high; C=critical; BDL=below detection limit; NA=not available

COD=chemical oxygen demand; DO=dissolved oxygen

NTU=Nephelometric Turbidity Units; Cl=clear

Chemical concentration range followed for colour grid:

Pollutant	**L –low (mg/l)**	**P-permissible (mg/l)**	**H-high (mg/l)**	**C-critical (mg/l)**
Phosphates	Below 0.1	0.1	0.1-1.0	Above 1
Copper	Below 0.05	0.05 to 1.5	1.5- 10	Above 10
Iron	Below 0.3	0.3	0.3-1.0	Above 1.0
Chromium	Below 0.05	0.05	0.05-0.5	Above 0.5

WATER SAMPLING AND ANALYSIS BY THE STUDENTS OF K.B. PATIL (MODERN) COLLEGE AT TURBHE

Water sampling at Turbhe *gaon talao* (near RamTanu Mandir), sector 22, Vashi.

The small well adjacent to Turbhe *gaon talao* (above).

Turbhe *nullah* on the Thane Belapur road (right).

Water sampling at Ganesh *talao*, Kopri *pada*, sector 26, (Vashi), Turbhe.

Students of K. B. Patil College, Vashi, carrying out chemical analysis of water samples at HBCSE laboratory.

AREA OF STUDY: VASHI

SEASON: MONSOON (September 2004)

DATE OF SAMPLING: 4th September 2004

DATE OF ANALYSIS: 5th September 2004

CLIMATIC CONDITIONS: Cloudy day

TOTAL NO. OF WATER BODIES STUDIED: Four (1 freshwater and 3 creek)

NO. OF WATER SAMLPLES COLLECTED: Ten samples (4 /fresh water bodies & 4 (1) from creek.

Sampling Site I: Mini seashore (water holding pond), Sector 10 : Fig.15

Type of water body: Creek water

Outlets/Inlets: One large inlet-outlet manned by gates (between pts. 3 and 4) allows sea water into the holding pond; this opening also allows an out flow of collected water into the creek. Thus the water levels in the holding pond are maintained. An inlet point (near pt. 2) with gates pours storm and waste water from Vashi city side into this holding pond on a continuous basis. There is also seepage of sewage water from an open area (adjacent to a sewage plant).

General observations: This is a large recreational water holding pond maintained by the NMMC, with boating and restaurant facilities. The area is flanked by residential blocks in the east, continuing creek shoreline with denuded mangroves to the north, creek side again with mangroves on the west and a sewage treatment plant with an open sludgy area in the south.

At the gross level, mini seashore (*chowpatty)*, appeared light green; fishy odour was present. Plastic bags, *puja* flowers, tyres and a film of oil (especially, near the boat house) dotted the entire periphery. Fishing and boating activities were present.

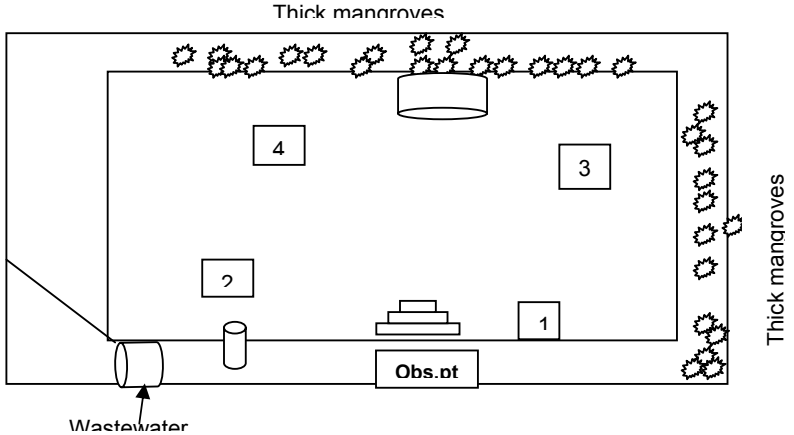


Fig.15

Sampling Site II: Shiv Mandir lake, sector 7 : Fig.16

Type of water body: Fresh water body

Outlets/Inlets: None

General observations: Shape of this water body is an irregular polygon, maintained by the NMMC. The lake is surrounded by residential quarters. Steps are built at four points of the pond to approach the water body. A temple is located at one corner. There are two wells located close to the lake, but it was not possible to collect water samples from these wells, as they were full of plastic bags containing *nirmalaya.*

Bathing and washing clothes was observed near the steps. Considerable amount of litter, especially in the form of plastic bags with *puja* flowers, was scattered all around the lake. Cooked food was also being thrown by people in the lake side to feed the fish. At the gross level, the lake appeared light green with no odour.

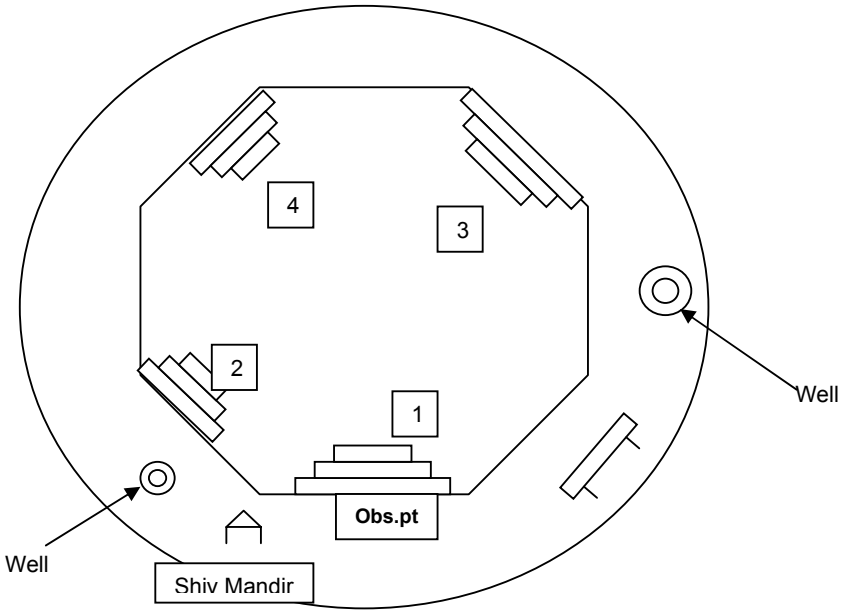


Fig. 16

Sampling Sites III and IV: (i) Vashi creek (sec 12) and (ii) Vashi *gaon*, sec 31 : Fig.17 and 18.

Type of water body: Creek water

General observations: (i) The entire creek side north of the mini shore was denuded of mangroves. Cut mangroves tied up in bundles were seen at several points. One could see and smell the continuous flow of raw sewage/industrial waste into the creek at this point. The entire area emitted a foul odour.

Chemically, the water samples recorded pH 6, with DO below detection limits, along with high COD, alkalinity and phosphates.

(ii) The area north of Vashi *gaon* was also denuded and one could observe haphazard cutting of mangroves. Illegal slumdwellers were engaged in making clay pottery items. The resulting waste (dyes, clay, damaged moulds, etc) from this occupation was littered around and in the water body.

Chemically, the water samples recorded high phosphates and high COD.

At the gross level, both these creek sites presented an ugly view of marshy land, with human faeces and other waste and black- brown water and foul dirty odour.

Water samples were collected from these two areas along the creek.

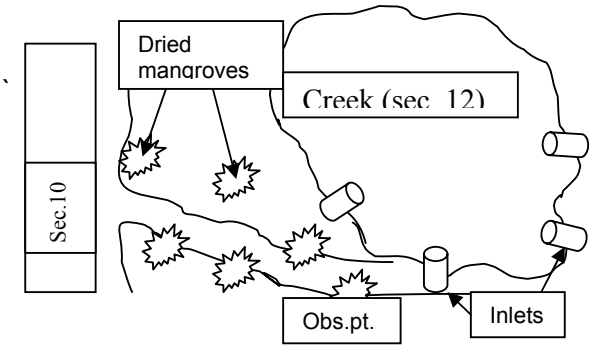


Fig. 17

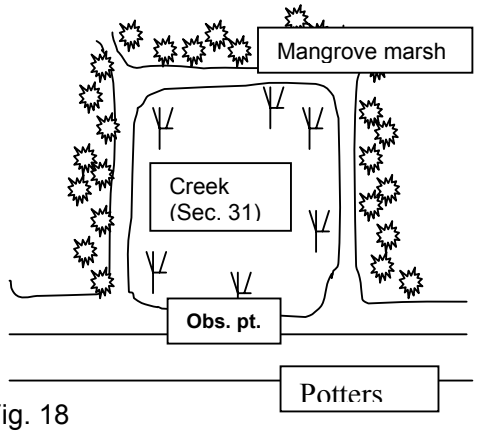


Fig. 18

VASHI (RESULTS)

Monsoon—September 2004

1. High levels of alkalinity and COD were observed in water bodies I and II.
2. DO levels within the standards were observed for water body I.
3. High chlorides were recorded for water body II.
4. The creek waters near the crematorium (sector 12) and the Vashi *gaon* had the semblance of waste *nullahs* rather than being parts of Thane creek, with pH 6, low DO, along with high COD, alkalinity and phosphates.

Table: Monsoon: Vashi: Physical and chemical characteristics of water samples *(results of creek samples are given in the text portion.)*

VASHI	**Water body I**				**Water body II**				**Stds.**
Name	**Mini seashore (sector 10)**				**Shiv Mandir lake (sector 7)**				
Sample No. →	1	2	3	4	1	2	3	4	
Parameters ↓									
Colour	C	C	C	C	C	C	C	C	**C**
Odour	O	O	O	O	F	F	O	O	**O**
pH	7	7	7	8	7	7	7	7	**6.5 to 8.5**
Temp ^{o}C	30	31	32	32	31	32	32	31	
Turbidity (NTU)	>100				90				**Clear**
Phosphates (mg/l)	L	P	P	L	BDL				**0.1**
Copper (mg/l)	BDL				BDL				**0.05 to 1.5**
Iron (mg/l)	L	H	L	P	C/H	L	P	L	**0.3**
Ammonia (mg/l)	0.4	0.2	0.3	1.4	0.4	>2	0.6	>2	**0.5**
Fluorides (mg/l)	-	-	1	1	0.5	-	1	-	**1.5**
Total alkalinity (mg $CaCO_3$ /l)	4200	2400	1200	1200	1400	1400	1400	1400	**200**
Chlorides (mg/l)	7200	7200	4800	4500	700	700	700	350	**200-250**
DO (mg/l)	**5.6**	**4.8**	**4.5**	**6.4**	**5.6**	**2.4**	**1.6**	**2.8**	**4-6**
COD (mg/l)	**1720**	**640**	**440**	**1380**	**200**	**500**	**500**	**420**	**4-10**
Chromium (mg/l)	BDL				BDL				0.05

C= colourless; G=green; Br= brown; R=red; B=Black; LG=light green; DG=dark green; GBr=greenish brown

O=odourless; U=unpleasant; F=fishy; E=faecal; S=sweetish; Sp=soapy

L=low; P=permissible; H=high; C=critical; BDL=below detection limit; NA=not available

COD=chemical oxygen demand; DO=dissolved oxygen

NTU=Nephelometric Turbidity Units; Cl=clear

Chemical concentration range followed for colour grid:

Pollutant	**L –low (mg/l)**	**P-permissible (mg/l)**	**H-high (mg/l)**	**C-critical (mg/l)**
Phosphates	Below 0.1	0.1	0.1-1.0	Above 1
Copper	Below 0.05	0.05 -1.5	1.5- 10	Above 10
Iron	Below 0.3	0.3	0.3-1.0	Above 1.0
Chromium	Below 0.05	0.05	0.05-0.5	Above 0.5

SEASON: WINTER (January 2005)

DATE OF SAMPLING: 7th January, 2005

DATE OF ANALYSIS: 8th January, 2005

CLIMATIC CONDITIONS: Bright and pleasant day

TOTAL NO. OF WATER BODIES STUDIED: Four (1freshwater and 3 creek)

NO. OF WATER SAMLPLES COLLECTED: Nine samples (4 /fresh water body & 3 (1) from creek

Sampling Site I: Mini seashore, Sector 10 (creek) : Fig.15

General observations: At the gross level, the water body appeared dirty/green. Sampling pts. 1 and 2 were covered with algal scum. At pts. 3 and 4, the water body appeared clean. Plastic bags with flowers and other litter were observed at the periphery.

Sampling Site II: Shiv Mandir lake, sector 7: Fig. 16

General observations: At the gross level, the water body appeared green, with fishy odour. *Puja* flowers in plastic bags were littered at all four sampling points. Women were washing clothes at sampling pts.1 and 3.

Sampling Sites III and IV: (i) Vashi creek near crematorium (sector 12) and (ii) Vashi gaon—creek side, sector 31 : Fig.17 and 18

General observations: (i) The entire area was filthy, with human faeces all along the road. The creek water was black; and the area had a foul odour. Only one sample was collected from this site. Chemically, the creek sample was highly polluted with high iron, phosphates, ammonia, and alkalinity levels.

(ii) The area north of Vashi *gaon* was also denuded and one could observe destruction of mangroves. The potter families continued to abuse the creek area. The water body appeared brown-black and unpleasant. Chemically, the water sample had critical/high levels of iron and alkalinity, and low DO levels. At the gross level, both these creek sites presented an ugly view of once mangrove-covered land.

VASHI (RESULTS)

Winter—January 2005

1. High alkalinity and iron levels, with low DO were observed in most of the water samples of Vashi.

Table : Winter: Vashi: Physical and chemical characteristics of water samples

VASHI	**Water body I**				**Water body II**				**Stds.**
Name	**Mini seashore (sector 10)**				**Shiv Mandir Lake (sector 7)**				
Sample No. →	1	2	3	4 (NA)	1	2	3	4	
Parameters ↓									
Colour	C	C	C		Br	Br	Br	Br	**C**
Odour	O	O	O		F	O	O	O	**O**
pH	NA	NA	NA		7	7	7	7	**6.5 to 8.5**
Temp ^{o}C	28	28	27		26	26	29	29	
Turbidity (NTU)	Clear				Clear				**Nil**
Phosphates (mg/l)	P	L	BDL		L	L	L	P	**0.1**
Copper (mg/l)	L	BDL	L		BDL	BDL	BDL	BDL	**0.05 to 1.5**
Iron (mg/l)	H	H	H		L	L	H	H	**0.3**
Ammonia (mg/l)	BDL	>2	1.2		0.6	>2	0.4	1	**0.5**
Fluorides (mg/l)	2	1	2		0.5	1	1	0.5	**1.5**
Total alkalinity (mg $CaCO_3$ /l)	1000	1600	1000		7000	1700	400	180	**200**
Chlorides (mg/l)	420	3100	2600		50	40	40	50	**200-250**
DO (mg/l)	**BDL**	**2.8**	**1.6**		**3.6**	**1.2**	**0.4**	**0.8**	**4-6**
COD (mg/l)	**NA**				**NA**				**4-10**
Chromium (mg/l)	BDL				BDL				0.05

C=colourless; G=green; Br= brown; R=red; B=Black; LG=light green; DG=dark green; GBr=greenish brown

O=odourless; U=unpleasant; F=fishy; E=faecal; S=sweetish; Sp=soapy

L=low; P=permissible; H=high; C=critical; BDL=below detection limit; NA=not available

COD=chemical oxygen demand; DO=dissolved oxygen

NTU=Nephelometric Turbidity Units; Cl=clear

Chemical concentration range followed for colour grid:

Pollutant	**L –low (mg/l)**	**P-permissible (mg/l)**	**H-high (mg/l)**	**C-critical (mg/l)**
Phosphates	Below 0.1	0.1	0.1-1.0	Above 1
Copper	Below 0.05	0.05 -1.5	1.5- 10	Above 10
Iron	Below 0.3	0.3	0.3-1.0	Above 1.0
Chromium	Below 0.05	0.05	0.05-0.5	Above 0.5

SEASON: SUMMER (March/April 2005)

DATE OF SAMPLING: 4th April 2005

DATE OF ANALYSIS: 5th April 2005

CLIMATIC CONDITIONS: Hot and humid

TOTAL NO. OF WATER BODIES STUDIED: Three (1 freshwater and 2 creek)

NO. OF WATER SAMLPLES COLLECTED: Eight samples (4 /fresh water body & 1 to 4 from creek.)

Sampling Site I: Mini seashore, Sector 10 (creek): Fig 15

General observations: At the gross level, the water body appeared clean with good water level, light green with no odour. The litter was minimal, though there was an oil film on the water near the observation point.

Sampling Site II: Shiv Mandir lake, sector 7 : Fig. 16

General observations: At the gross level, the water level had slightly reduced; there was some litter at the periphery. The water body appeared parrot green with no odour. Washing of clothes was observed.

Sampling Sites III and IV: (i) Vashi creek (sec. 12) and (ii) Vashi *gaon* (sec. 31) : Fig. 17 and 18.

General observations: No water sample was collected from Vashi creek (sector 12) as it was unapproachable due to strong odours and the surrounding filth.

(ii) The situation at this site near Vashi village was worse than in the earlier seasons and hence only one water sample was collected. The site resembled a *nullah* with a pH of 9.

Chemically, high COD (3,150 mg/l), phosphates and alkalinity levels were detected in the water sample from creekside at Vashi village, sec. 31.

VASHI (RESULTS)

Summer—April 2005

1. In many water samples from Vashi, high COD and phosphate levels were detected.
2. High iron and low DO were detected in some samples of water bodies I and II.
3. High alkalinity was observed in most of the water samples.

Table: Summer: Vashi: Physical and chemical characteristics of water samples

VASHI	Water body I				Water body II				Stds.
Name	Mini seashore (sector 10)				Shiv Mandir lake (sector 7)				
Sample No. →	1	2	3	4	1	2	3	4	
Parameters ↓									
Colour	LG	C	G	G	G	G	G	G	C
Odour	O	F	O	F	O	O	O	O	O
pH	7	6.5	7	6-7	7	7	7	7	6.5 to 8.5
Temp ^{o}C	NA				NA				
Turbidity (NTU)	>100				>100				
Phosphates (mg/l)	H	H	H	P	L	L	H	BDL	0.1
Copper (mg/l)	L	BDL	BDL	BDL	BDL	BDL	L	BDL	0.05 to 1.5
Iron (mg/l)	H	L	L	H	H	L	P	H	0.3
Ammonia (mg/l)	0.1	0.2	0.4	0.4	0.4	0.4	0.2	0.1	0.5
Fluorides (mg/l)	1.5	1	1	1	0.5	0.5	0.5	0.5	1.5
Total alkalinity (mg $CaCO_3$ /l)	2000	800	400	400	160	440	560	160	200
Chlorides (mg/l)	36000	32200	9100	7500	110	150	250	60	200-250
DO (mg/l)	1.2	1.6	1.6	2.4	1.2	0.4	0.4	0.4	4-6
COD (mg/l)	7,500 (mix)				900 (mix)				4-10
Chromium (mg/l)	BDL				BDL				0.05

C= colourless; G=green; Br= brown; R=red; B=Black; LG=light green; DG=dark green; GBr=greenish brown

O=odourless; U=unpleasant; F=fishy; E=faecal; S=sweetish; Sp=soapy

L=low; P=permissible; H=high; C=critical; BDL=below detection limit; NA=not available

COD=chemical oxygen demand; DO=dissolved oxygen

NTU=Nephelometric Turbidity Units; Cl=clear

Chemical concentration range followed for colour grid:

Pollutant	L –low (mg/l)	P-permissible (mg/l)	H-high (mg/l)	C-critical (mg/l)
Phosphates	Below 0.1	0.1	0.1-1.0	Above 1
Copper	Below 0.05	0.05 -1.5	1.5- 10	Above 10
Iron	Below 0.3	0.3	0.3-1.0	Above 1.0
Chromium	Below 0.05	0.05	0.05-0.5	Above 0.5

WATER SAMPLING BY THE STUDENTS OF ICLES' M.J. COLLEGE AT DIFFERENT POINTS ALONG THE W ATER HOLDING POND (SEC. 10A), VASHI

Open lagoon of waste/sewage water adjacent to the water holding pond (sec.10A) and the pumping station (right).

On the way to the creek side near crematorium, sector 12, Vashi. This stretch is highly deteriorated with rampant mangrove cutting (right).

Water sampling at the creek side of sector 12, Vashi. This site was the exit point of major sewage pipes and hence the water was highly polluted with minimal mangrove cover.

Discussion

In this study, water quality of several fresh water bodies and creek water in the Navi Mumbai region (Airoli, Kopar Khairane, Nerul, Turbhe and Vashi) was studied in three seasons: monsoon, winter and summer of 2004 and 2005. The water bodies studied under HEAL were all recreational water bodies (and hence the drinking water standards were relaxed when considering the water quality of ponds under study). However, for comparison, the standards for drinking water quality were considered for the least risk factor.

Results under HEAL are presented for fresh water and creek water samples from two different perspectives:
(i) On-site general observations;
(ii) Physico-chemical and microbiological properties

(i) On-site general observations of water bodies

Several general observations, including smell, colour, movement of water column, damage to mangroves or other vegetation and the general appearance of a water body give strong clues about the health of any water body. Rarely, the water bodies in Navi Mumbai appeared clean, and hence healthy.

Across seasons, across water bodies and at all sampling points, some variation in the chemical composition was observed. In the monsoon season, when water mixes to a great extent at both vertical and horizontal levels and with mixing / dissolving of atmospheric oxygen in the rain water, relatively high DO was recorded in this season vis a vis winter and summer.

Fresh water bodies:

(a) Navi Mumbai, which is a part of mainland of Maharashtra, has several fresh water wells from which drinking water was being drawn by original residents/villagers.

(b) After the CIDCO takeover and creation of the Navi Mumbai Municipal Corporation (NMMC), many of these have been converted into recreational ponds. In some cases, the original wells are still maintained by the villagers, as in Karave *gaon,* Nerul.

(c) Peripheries of all the fresh water bodies were extensively littered with *puja* flowers (often packed in plastic bags) and other solid wastes.

(d) In monsoon, the fresh water bodies appeared greenish and odourless, but in the other two seasons, they had a foul smell and appeared parrot green to brown.

(e) Several fresh water bodies had inlet/outlet pipes at corners or along the sides draining storm water in monsoon. At times, the drains contained foul-smelling water all round the year.

(f) The official map of Kopar Khairane shows a water body in sector 12. Our site visits revealed growth of abundant ground vegetation (castor--*Riccinus* sps. at the periphery with typha grass in abundance) at this site.

(g) The above site was surrounded on three sides by shanty huts, mostly dealing in dyeing and dry cleaning activities. The liquid waste from this settlement was being drained directly into the encroached water body in sector 12, Kopar Khairane.

(h) While the municipal workers were observed to clean the ponds with nets, etc., at regular intervals, people seemed to be unconcerned about the general cleanliness of the water body and littered them with a variety of garbage.

(i) Most of the fresh water bodies had steps on which women and children were observed to wash clothes. These women were from nearby villages which did not have regular tap water supply.

(j) Most of the fresh water recreational ponds were adjacent to the well used by villagers. These small wells were in a state of misuse and were full of garbage, often packed in plastic bags. The well at Karave village, Nerul, was the only exception.

Creek water:

(a) Creek water in the studied zones presented a dismal picture. Thane creek along Vashi (sectors 12 and 31) and Kopar Khairane (sector 14) appeared like stinking *nullahs*, rather than being a part of the Thane creek.

(b) At these points, raw sewage and industrial waste were being directly discharged and the entire water mass was brown/black with a foul odour. At times, even sample collection was difficult.

(c) Over the three seasons, systematic destruction/degradation of mangrove cover was observed to varying extents at sampling sites. For instance, the Airoli creek site (sector 10), lush with mangrove cover in monsoon, was devoid of this cover in summer due to construction activity.

(ii) Physico-chemical and microbiological properties

Physical, chemical and microbiological properties reflect an overall poor quality of water in the water bodies identified and studied.

Fresh water bodies:

(a) All the fresh water bodies studied recorded high COD in the three seasons. This could be due to dumping/presence of large volumes of domestic solid/liquid and industrial waste water in these water bodies.

(b) The waste materials use the dissolved oxygen in water to get oxidized. As the pollutant load increases, the demand for oxygen also grows totally depleting the available oxygen in the water bodies. This results in high chemical oxygen demand (COD). In fact, the high COD (especially, in summer and winter) is accompanied by low DO in most of the water samples.

(c) Low DO in most of the water bodies was observed in winter and summer. This could be attributed to the presence of organic pollutants in the water body contributed by sewage influx and large quantities of *puja* flowers.

(d) Whatever be the nature of waste in the water body, the layered garbage effectively blocks the entry of sunlight into the deeper layers of water, sunlight being necessary for the release of nascent oxygen (during photosynthesis) by the plankton community.

(e) Very low DO was observed in some water bodies : (i) Ganesh *talab* (Karave *gaon*), Nerul, at pt. 4 in monsoon, pt. 5 in winter and (ii) at the well of Turbhe *gaon talab* (opposite Ram Tanu Mandir) at Turbhe, in the three seasons. The low DO at these points could be attributed to eutrophication (i.e., excessive vegetative growth on the water surface due to high nutrients in the form of phosphates and nitrates is contributed by domestic sewage. Indeed, high phosphate concentration was observed at pt. 4 of Ganesh *talab* in monsoon, with the possibility of seepage of sewage from the surrounding settlement.)

(f) However, DO levels were good in monsoon in all other water bodies. This could be due to mixing of atmospheric oxygen with the inflow of large volumes of rain water and also due to turbulence in the water body.

(g) High levels of iron were observed at certain points, especially in monsoon. This could be due to surface runoffs of soil entering into the lakes during monsoon. Geologically, this region of Maharashtra is known to be rich in iron (laterite soil), which often gets detected in deep water samples, even if the solubility of iron oxides in soil is low.

(h) The water sample drawn from ground water via a hand pump in summer at Airoli (Ganapati *talao*, sector 1) also showed high iron content. (The tested water samples from the open water bodies were from a depth of about 30 cms, and still many of them recorded high iron concentrations. This could be attributed to water turbulence in monsoon leading to vertical mixing of water.)

(i) No fixed pattern was observed for other pollutants like phosphates, alkalinity, copper, fluorides, and ammonia, though high levels of phosphates and ammonical nitrogen were observed at points where washing and bathing activities were underway or where inlets were observed.

(j) High levels of chlorides were observed in several fresh water bodies (Diva lake in Airoli, Kopri *pada* at Thurbhe, Chincholi *talao* at Nerul), suggesting intrusion of creek water into these water bodies.

(k) Microbiological analysis (Most probable number—MPN) carried out in summer revealed excessively high load of *Escherichia coli (E.coli)* in all water samples. This was a strong indication of sewage contamination.

Creek water:

The highly polluted creek water status was reflected by the chemical analysis of the samples. The creek samples had very low DO and high COD in all the three seasons, indicating the presence of high organic matter.

The above discussion brings out the following:

1) Efforts should be made to preserve all fresh water bodies. Attempts to fill these up or occupy them, should be discouraged.
2) Ways will have to be found to keep these water bodies free of litter, especially after festivals.
3) Sewage treatment and its scientific disposal need to be enhanced. Treatment and disposal of liquid waste — both domestic and industrial — need to be thoroughly overhauled.
4) Mangrove cover is under great threat along Navi Mumbai shoreline. All efforts should be made to conserve these plants along the creek side, which act as natural filters and barriers to high waves and are also breeding sites for marine organisms.

GREEN COVER

Green cover refers to any natural vegetation in an area. It includes both ground cover (grass, herbs and shrubs) and canopy cover of trees [this canopy could be narrow (and hence limited) as in Ashoka tree (*Polyalthia longfolia*) or arching (and wide) as in banyan tree]. Green cover is an integral part of our environment. The percentage of green cover in an area is considered by city planners and this percentage is an indicator of the overall environment of a place. While 30% and more green cover is targeted in several cities in the developed countries, the situation varies in different cities of India. For planned cities like Navi Mumbai, 20 to 10 green cover is considered as reasonably good.

Under HEAL, several activities were planned around the study of quality and quantity of green cover in the study sites. These activities were:

- Observation and measurement of canopy cover;
- Observation and measurement of ground cover;
- Qualitative and quantitative measurement of green cover (trees and shrubs) at ground level;
- Qualitative and quantitative measurement of green cover (herbs and grass) at ground level;
- Measurement of tree circumference and height;
- Measurement of grass biomass;
- Qualitative characteristics of green cover

This is an exhaustive activity and students (with their teachers) found it difficult to carry out all the activities despite detailed training. However, they collected limited data about the above for the different studied areas. Students monitored municipal gardens in their respective zones and did not extend their observations to other green stretches, like mangrove cover or green areas between and around different residential blocks.

Observations of students are as follows:

1. The different studied zones have several gardens developed by the NMMC.
2. These gardens were reasonably well maintained to varying extents by the NMMC. Gardeners were observed in a few of the gardens, especially in Airoli.
3. While the green open areas are marked out as gardens in maps, several of these areas are undeveloped and hence target of abuse (garbage/building material collection points, meeting place for anti-social elements, etc.) (e.g., big gardens in sector 10A, Vashi, Kopar Khairane and Nerul).
4. The gardens have trees, shrubs and grass cover. However, in most of the gardens there is a dominance of ground (grass) cover.
5. There is a limited variety of trees and shrubs in several gardens, with the trees (often *casurina*) and shrubs of *crotons* confined to the peripheries or along pathways.
6. Exceptions to the above are present, such as, the Tata Garden in Sector 9A, Vashi, which has a variety of trees and shrubs.
7. The marked out green areas (in the CIDCO maps) in the form of gardens developed by the NMMC consist of ground cover, canopy cover and built up areas in the form of pathways and playing areas for children.
8. In several gardens, the green areas were reduced by built-up stages (erected for performances and religious/political functions), as in Ambedkar garden in Sector 10A, Vashi.
9. The green areas were also reduced to provide for cricket pitch in some gardens.
10. One observed encroachments on the green areas; these were in the form of buildings, sheds and other built-up structures (in the last six months, a new two-storied structure—library--has come up in the Tata Garden in Sec. 9A, Vashi).
11. Overall, Vashi appeared to have maximum number of big and small gardens (1.6 % green area), which were reasonably well maintained.

12. Airoli (0.98%) and Nerul (0.63%) followed Vashi in the total number of green gardens, and hence in the per cent green cover.
13. Besides the fact that there are few gardens in Kopar Khairane, these were not well maintained or developed.
14. Turbhe zone (which is a part of Vashi node) had small green patches (also marked out in the CIDCO map). However, the areas with high density of population, such as the Turbhe *gaothan (village)*, Kopri *pada* and Hanuman Nagar had no green areas.
15. Turbhe Stores, a major slum-like area, had only one small open patch of land. This open ground, completely devoid of all green cover, according to local residents was being used as a playground and /or for political meetings.

Table: % Green area (only gardens as marked out in CIDCO maps) in studied zones (NMMC Env. Report, 2003-04).

Studied Zone	**Total Area of the zone (sq. km)**	**No. of gardens**	**Area under gardens (sq. km)**	**% Green area**
Airoli	7.75	18	0.076	0.98
Kopar Khairane	32.25	10	0.038	0.11
Nerul	14.90	23	0.095	0.63
Turbhe	15.85	7	-	-
Vashi	8.50	29	0.138	1.6

It was observed that the mangrove cover was being systematically destroyed in different zones of Navi Mumbai, and this continues till today. The pics. below are those from Vashi, Sectors 10 and 12.

.

Students of ICLES' M.J. College, Vashi, taking green cover measurements.

Plants on road dividers, as on T.B.R., provide valuable green cover and block the glare of vehicular head lights from the opposite direction. Within six months of our observations, entire stretches of road - dividers were paved by removing the green cover.

DOMESTIC SOLID WASTE

In all societies, scientific disposal of wastes is an important issue. Urban planners make provisions for waste-disposal after taking into consideration the long-term growth potential of a city and the sites and technologies available for safe disposal. Generally, wastes are classified into gaseous, liquid and solid generated by domestic and industrial sectors. Proper management of all wastes is reflected in the overall environment of a site and health of the population.

Study of domestic solid waste was considered under HEAL. The different activities as given in the Protocol Guide are:

- Type of waste generated;
- Waste segregation in medical setups;
- Waste collection at different sites;
- Safety norms as practiced by rag pickers;
- Waste degradation;
- Disposal methods for medical waste;
- Site observation of waste dumps and pests.

Students did not carry out the above detailed activities due to a variety of reasons, such as, uncooperative attitude of medical practitioners, even in big municipal hospitals, and their own hesitation due to social reasons. However, certain observations regarding domestic solid waste emerged over the three seasons in all the study zones during health surveys. These were:

1. Open garbage bins:
    a. In September 2004 (monsoon season) these bins were located at several strategic points in all sectors in all zones. Several of these bins were overflowing with garbage causing resultant unhygienic conditions.
    b. Garbage was also found to be strewn along road sides and gardens, especially in Kopar Khairane and Turbhe.

c. Stray dogs in large numbers were always found around or in close vicinity of these bins.
d. In January 2005 (winter season) open garbage bins were removed from several areas of Vashi and Nerul zones.
e. A new system of garbage collection was started by the local municipality in the form of introduction of "*Ghanta gadi*" (Bell van).
f. By March-April 2005 (summer season), most of the open garbage bins were removed from all the study zones and the bell van system was introduced for garbage collection.
g. The garbage collection van was observed to come daily on time and collect household solid waste.
h. However, the van is badly designed and small. The garbage is all mixed up inside the small enclosed area of the van exposing the men (2-3) at work to great health risks. Minimal protective gear (gloves, spade, etc.) was provided to them and majority of them worked with bare hands. (Only one man directly handling the garbage was sometimes observed to wear long rubber gloves.)

These points need immediate attention of the NMMC.

2. <u>Waste segregation:</u>
    a. Examination of domestic solid waste at several collection points (garbage bins in Sept. 2004) revealed that residents were not segregating their domestic waste. This was observed in all the studied zones.
    b. Unsegregated domestic waste was also observed when vans were observed to collect this waste in January and April 2005.
    c. Residents were not segregating waste at source.

3. <u>Waste handling:</u>
    a. Rag pickers were found at waste collection points in September 2004 in all studied zones. Men, women and young children were deft at sorting out waste into different categories, such as, glass, coconut shells, metal, thermocole, etc.

b. They worked with bare hands without any protective gear. However, some of them carried a metal stick with a hook to pick up waste items like cloth pieces, plastic, etc.

4. Medical waste:
    a. In September 2004, there was no segregation of medical waste in hospitals and smaller dispensaries.
    b. This situation changed in January and April 2005, when enquiries revealed that differently coloured plastic bags (blue and yellow, according to the MCI) were provided to all medical setups in Vashi, Kopar Khairane and Turbhe, and in some areas in Nerul.
    c. By April 2005, medical waste segregation was quite standardized in these areas, and it had started in Airoli too.
    d. This medical waste was being collected daily or three/four times in a week (depending on the volume) by separate vans and taken to a centralized facility for treatment, followed by safe disposal.

5. Resultant absence or presence of pests, especially stray dogs and rats
    a. Stray dogs and other pests abound near and around domestic garbage collection points as they get their food from these bins. It was observed that the number of stray dogs decreased dramatically with the removal of open garbage bins in all zones, especially in January 2005.
    b. However, now, nearly a year later, many of these canines are back and their numbers are again increasing. They are now found at points where there are food hawkers, marriage halls or religious places where free food is being served or discarded.

Domestic solid waste management: In September 2004, it was observed that domestic solid waste was being collected in open garbage bins and sorted out by rag pickers and their young children.

This situation started to change in 2005, when *ghanta gadis*—garbage collection bell vans--were introduced in Navi Mumbai.

However, these vans are small and badly designed; unsegregated garbage is being handled by unprotected workers in a cramped van area.

HEALTH

Introduction

Understanding and finding out the health status of a society /population is an extremely complex concept, even with supportive epidemiological studies. One of the main reasons for this complexity lies in the multi-factorial nature of health-related exposure vectors. Some of these factors are nutrition, psychological and social conditions and the overall indoor and outdoor environmental conditions of the population under study. Considerable literature exists on the effects of these factors on human health based on which the exposure response functions have been evaluated.

The above argument implies that promoting health of people or improving their quality of life goes hand-in-hand with their interactions with immediate environment. In turn, improvement of environment (indoor and outdoor) leads to prevention of environment-related diseases and thus good health of a populace. In the long run, good health of a population has a direct effect on the economy and educational status of a society. This brings out the importance of a clean environment with investments in public health and science education as part of good governance.

Under HEAL, attempts were made to assess the quality of environment (specially air and water) of specific study sites in Navi Mumbai and also assess the pollution-related health impairment / risks among residents in and around the study sites through personal interviews using specially designed questionnaires. These health problems are mainly in the realm of respiratory, gastro-intestinal and vector borne diseases like malaria, dengue and rabies. These latter vector-borne diseases could partly be attributed to the unhygienic environment with stagnant pools of water and open garbage dumping practices, which lead to presence and proliferation of mosquitoes, rodents and stray dogs.

The effects of individual air and water pollutants and other endemic contaminants, more specific to human health, are well documented. These health effects could broadly be classified under respiratory and gastro-intestinal problems, besides other problems like allergies, skin rashes, uveititis (general inflammation of the eyes), etc. Attempts were made under HEAL to ascertain the prevalence of the above health-related impacts by conducting questionnaire based surveys. This indirectly formed part of the provisional diagnosis of diseases among residents of the study sites.

Lung function tests (LFT) or pulmonary function test was also carried out in the summer season among a limited number of residents (~35 in each of the study sites; total number subjected to the test -159). This was done in collaboration with the Occupational Health and Safety Centre (OHSC), Mumbai. Broadly, this test gives the lung volume of each individual or the amount of air the lungs can hold, how quickly the air moves in and out of the lungs and how well the lungs supply oxygen to the blood circulation process. Hence, the LFT helps to diagnose or give indications about breathing problems or lung diseases and also the severity of several lung diseases plaguing an individual. A portable ventilometer or spirometer was used for the lung function test to evaluate the lung volume /capacity of the subjects tested which directly or indirectly relates to the observed respiratory deficiencies in the population studied.

For HEAL, two parameters of LFT were considered: (i) Forced Expiratory Volume (FEV1), the volume of air exhaled forcefully in the first second after deep inhalation and (ii) Forced Vital Capacity (FVC). The formulae and questionnaire used for calculating these parameters were from the work of Dr. S. R. Kamat, Retd. professor and Head, Dept. of Chest Medicine, KEM Hospital, Mumbai (refs). FEV1 is affected due to polluted air (when it is recorded as 80% below predicted values) resulting in asthma, byssinosis (chronic industrial disease, associated especially with inhalation of cotton or any other fibrous dust over a long period of time and characterized by chronic bronchitis and often complicated by emphysema or asthma) and other obstructive breathing problems. FVC gets affected (when it is below 80% of the predicted value), with more serious problems like lung fibrosis or extensive obstruction of airways.

Under HEAL, the LFT test was undertaken at different study sites in small camps involving participating colllege students and the medical group, during collection of the health data. Our attempts were to find out whether there were any significant numbers of residents /subjects under study in the five zones of Navi Mumbai who were affected by FEV1 or FVC, thereby giving indications about the health status of residents. Different aspects of results are given in the Results and Discussion section.

Approach and execution of study perspectives

Under HEAL, health status of the residents, especially in the context of environment-based diseases, was monitored over three seasons in a year, using the questionnaire. Medical students along with teachers and program co-ordinators accompanied the participating students in these health surveys. Provisional diagnosis was provided by the doctors based on the symptoms recorded on the data sheets.

Sampling details:

- Health surveys were carried out at five zones (Airoli, Kopar Khairane, Turbhe, Nerul and Vashi) in Navi Mumbai.
- Map of each zone was studied and the zone was divided among 5-6 groups of students to get a random representation of the population.
- Attempts were made to cover all the sectors of the studied zones.
- Where this was not possible due to non development of sectors or permission being denied to enter the buildings, the zone was then geographically demarcated into four regions (north, south, east, and west).
- Thirty plus houses per sector were surveyed. They were randomly selected on different streets and consisted of residents with mixed socio-economic status.
- Four members per house [or family] were assumed, when the exact number of family members could not be ascertained.

- Attempts were made to keep the sectors and sampling method uniform/constant during the three seasons (Monsoon--September, 2004; winter—January 2005 and summer---April 2005).
- The demographic profile of the population in Navi Mumbai is largely uniform in all the studied zones, with residents living in J1, J2, J3, J4 houses built by CIDCO, and others living in privately built houses. Local (original) residents either lived in *chawl*-like structures or in well defined areas, often called as *gauthans/gauns* (villages).
- Turbhe zone has a different demographic profile. Its population is highly mixed, the zone being largely dominated by the Agricultural Produce Market Confederation (APMC) and the Thane Belapur Industrial belt. The people surveyed resided in Turbhe *gaon*, Kopri *pada*, BRIT (BARC) colony, Turbhe Stores and Hanuman Nagar. The latter two are official slum-like settlements in Navi Mumbai.

Survey sheets:

- The details provided in the different survey sheets, as given in the Protocol Guide, were followed.
- These were prepared in consultation with the public health officials of the NMMC and with the doctors of L. T. Medical College, Sion, Mumbai.
- Every season, the participating students were briefed and trained for systematic collection of health data just before the health surveys.
- Printed instruction slips (given in brief to each student group) further guided the students about questions to be asked to residents in the field.
- These questions spanned the different symptoms under different heads – such as, problems due to polluted air affecting the upper respiratory tract (URT) and the skin and the eyes (category--Others), problems of the gastro-intestinal (GI) tract and confirmed cases of the vector-based diseases.
- Symptoms of URT were probed extensively.
- Allergies, eye burning, along with skin rashes were specifically probed separately. These could be due to air pollution.

- Inclusion of gastro-intestinal problems needs some explanation here. These problems arise with drinking / eating contaminated water or food. This phase of HEAL did not cover analysis of drinking water or food served in food stalls/hotels. (Though it was acknowledged that detection of large scale GI problems concentrated in one specific area should prompt us to carry out microbial analysis of drinking water in that area. This situation of concentrated GI problems was not encountered at any time).
- It was emphasized that students should intensively probe into the prevalence of collateral or overlapping clinical symptoms, such as fever, head ache, etc., to ascertain the cause of these symptoms.
- *'Other'* health category problems, which included dog-bites, hearing problems, skin and eye allergies, headache and fever (due to inexplicable reasons) were also recorded.
- The questionnaire covered collation of data about the prevalence or otherwise of confirmed cases of tuberculosis, malaria and other vector-borne diseases which were directly addressed to residents by students.
- All these questions were accompanied by the caveat to the residents that the symptoms/diseases should have occurred in the past one month. The logic here was that the air monitoring was carried out in the immediate past and health problems, if any, should manifest themselves immediately or within a few weeks.
- Students' responses were collated to give the results as given below.
- At several places, residents complained about breathing problems due to air pollution during specific hours of the day and night. Such reactions are mentioned separately in the results section.

Results and Discussion

Tables given in the following pages show the number of people affected with different health problems during the three seasons under study. This provisional diagnosis is based on the symptoms as reported by residents of the studied sites.

September 2004 (MONSOON)

ZONES →	Airoli	Kopar Khairane	Nerul	Turbhe	Vashi
No. of houses surveyed	672	120	159	144	355
No. of Residents	**4055**	**520**	**617**	**656**	**1478**
No. of Residents sick	**327**	**47**	**110**	**173**	**206**
% sick members	8	9	18	26	14
No. of URT cases	195	28	64	71	62
% URT cases among surveyed	5	5	10	10	4
% URT cases among Sick	60	60	51	41	30
No. of GI cases	28	3	11	4	66
% GI cases among surveyed	1	1	2	1	4
% GI cases among sick	8.5	6.3	10	2.3	32.03
No. of malaria cases	8	7	13	47	18
% malaria among surveyed	0.2	1	2	7	1
% malaria among sick	2	15	12	27	8
Other health problems	96	10	22	51	60
% of other problems among surveyed	2	0.2	4	8	0.4
% of other problems among Sick	29.36	21.2	20	29.4	29.12

House-to-house health surveys in monsoon brought out the following results:

a. The highest percentage of **sick residents** was reported in Turbhe (26%), followed by Nerul (18%), in this season.
b. The percentages of residents with **URT** problems were high, varying from 30 to 60% in all the five zones.
c. The percentages of residents with **GI** problems in different zones were low, with an exception of Vashi zone (32%).
d. Confirmed **malaria** cases were reported in all zones, with Turbhe having the highest percentage (27%).
e. Other problems, which included **dog bites, hearing problems, allergies, etc**., were prevalent in all the five zones, ranging from 20 to 30%.

JANUARY 2005 (WINTER)

ZONES →	Airoli	Kopar Khairane	Nerul	Turbhe	Vashi
No. of houses surveyed	600	210	527	48	283
No. of members surveyed	**2482**	**915**	**2277**	**224**	**1264**
No. of members sick	**310**	**201**	**315**	**183**	**170**
% sick members	12	22	14	81	13
No. of URT cases	212	126	200	116	72
% URT cases among surveyed	9	14	9	52	6
% URT cases among sick	68	63	63	63	42
No. of GI cases	30	23	38	24	69
% GI cases among surveyed	1	3	2	11	5
% GI cases among sick	10	11	12	13	41
No. of malaria cases	17	17	23	15	4
% malaria among surveyed	0.7	2	1	7	0.3
% malaria among sick	5	8	7	8	2
Other health problems	40	35	54	28	25
% of other problems among surveyed	2	4	2.3	13	2
% of other problems among sick	13	17	18	15	15

House-to-house health surveys in winter brought out the following:

a. The highest percentage of sick residents was again reported in Turbhe (81%).
b. The percentages of residents with URT problems were high in all zones, reaching a high of 68% in Airoli.
c. The percentages of residents with GI problems in different zones were fairly high, ranging from 10 to 13%. Again Vashi zone was an exception where 41% reported GI-based problems.
d. Confirmed malaria cases were reported in all zones.
e. Other problems, which included dog bites, hearing problems, allergies, etc., were widely prevalent in the five zones, ranging from 13 to 18%.

March-April 2005 (SUMMER)

ZONES ⟶	Airoli	Kopar Khairane	Nerul	Turbhe	Vashi
No. of houses surveyed	428	253	703	357	362
No. of members surveyed	1990	1162	2751	1661	1487
No. of members sick	308	113	398	148	206
% sick members	15	10	14	9	14
No. of URT cases	173	68	271	88	132
% URT cases among surveyed	8	6	10	5	9
% URT cases among sick	56	60	68	59	64
No of GI cases	9	6	10	5	9
% GI cases among surveyed	0.5	0.5	0.4	0.3	0.6
% GI cases among sick	3	5	3	3	4
No of malaria cases	11	2	24	4	7
% malaria among surveyed	0.5	0.2	0.9	0.2	0.5
% malaria among sick	4	2	6	3	3
Other health problems	88	33	89	48	53
% of other problem among surveyed	4	3	3	3	4
% of other problem among sick	29	29	22	32	26

House-to-house health surveys in summer brought out the following:

a. The percentage of sick was nearly uniform in all the zones.
b. The percentages of residents with URT problems were again high in all zones, ranging from 56 to 68%.
c. The percentages of residents with GI problems in different zones were very low, ranging from 0.3 to 0.6%.
d. Confirmed malaria cases were reported in all zones, though in small numbers.
e. Other health problems, which included dog bites, hearing problems, allergies, etc., were again widely prevalent in the five zones, ranging from 26 to 32%.

Table : Environment-related health problems (based on symptom-based provisional diagnosis) in five zones of Navi Mumbai across three seasons in 2004-2005

ZONES →	Airoli			Kopar Khairane			Nerul			Turbhe			Vashi		
Seasons	M	W	S	M	W	S	M	W	S	M	W	S	M	W	S
% sick members	8	12	15	9	22	10	18	14	14	26	81	9	14	13	14
% URT cases among sick	60	68	56	60	63	60	51	63	68	41	63	59	30	42	64
% GI cases among sick	9	10	3	6	11	5	10	12	3	2	13	3	32	41	4
% malaria among sick	2	5	4	15	8	2	12	7	6	27	8	3	8	2	3
% of other problem among sick	29	13	29	21	17	29	20	18	22	29	15	32	29	15	26

M=monsoon; W=winter; S=summer

Discussion

These health surveys were carried out by young students not necessarily belonging to science disciplines, and of a large population of about six to eight thousand over a residential area of about 29 sq. kms (NMMC Report, 2002-2003). Such surveys have possibility for errors at several levels, despite the many precautions/care taken (such as, the presence of young medical students during health surveys, providing printed supporting material to students, etc). Despite these precautions and inherent weaknesses in such surveys, the results of HEAL have clearly highlighted the prevalence of certain environment-based diseases in Navi Mumbai.

The health surveys evoked varied type of responses from citizens. While many wanted to know the details of the survey and showed great interest/enthusiasm in answering the questions (so that a cleaner environment and better health could result, perceptibly articulated by these residents), others expressed hopelessness at the prevailing situation. Majority expressed surprise when they were questioned in detail about the occurrence of symptoms like cough and cold. Often their responses ranged from: "…what is there to complain about/report? Or, "…cough and cold should not be taken seriously…" , or "…cough and cold are of no consequence…" and such remarks.

Several residents in Airoli, especially of the buildings in Sector 4, facing the Thane Belapur Road, complained of irritating fumes at night round the year, and the resultant continuous bouts of coughing and throat irritation.

The general health scenario at Turbhe, with its concentration of industries, heavy traffic, vicinity to hill quarrying and congested living conditions as in slums, needs special mention. As commented by a doctor (and there are entire lanes of doctors in Hanuman Nagar), people here largely suffer from watery red eyes leading to cataract and an entire range of respiratory problems. Not surprisingly, five to six cases of tuberculosis were detected in just one lane (1-1-2410) in Turbhe Stores.

Further, people living in residential units behind Sulphur Mills Ltd. (located on the main Thane Belapur Road, in Hanuman Nagar, Turbhe), complained of constant problems of suffocation, cough, cold, burning of the eyes and scaly (peeling) skin. (An exposure of a few seconds of one of the HEAL co-ordinators (BSM) in one of these dwelling units brought about a strong bout of coughing and suffocation.)

More specifically, the tables in this section reveal the widespread presence of upper respiratory tract (URT) and other related problems (which predominantly included allergies of eyes and skin and head ache) among the residents of all the studied zones in the three seasons. Many of these problems could be attributed

to polluted air from proximity to industries, heavy traffic, road dust, and hence considered as air borne environment-related problems.

Several respiratory diseases and other problems (along with diarrhoeal diseases) and malaria are known to claim millions of lives in India. These diseases occupy the top positions in the list of diseases in terms of DALY (disability-adjusted life years loss) loss (appendix 2).

Malaria incidence in Navi Mumbai needs special mention. In monsoon and winter mon ths, recorded malaria percentages were higher than in the summer months. Nerul and Turbhe recorded higher percentages, the reasons being that both these zones have a high construction activity with a large floating population of labourers.

Lung Function Tests:

The results of LFT on 159 residents living in studied zones are presented below. Calculations have taken into consideration smokers and non smokers and those on medication, especially for asthma and other respiratory problems. As the inhalation/exhalation act is a 'learned/practiced' act, two to three attempts were tried out on each individual, prior to obtaining two consistent readings. Results consider that persons having values below 80% of the predicted value are affected with some respiratory problems. LFT data were analysed and provided by V. Kanhere of OHSC, Mumbai.

Overall results of LFT using different parameters

Parameter ↓	Affected (below 80% of the predicted value)		Not affected	
	Frequency	%	Frequency	%
FEV1	40	25.2	119	74.8
FEV1/FVC	66	41.5	93	58.5
FVC	20	12.6	139	87.4

Comparison of FEV1 values in the five zones of Navi Mumbai

ZONES ↓	Affected (below 80% of the predicted value)	Not affected	Total
Airoli	9	25	34
Kopar Khairane	3	28	31
Nerul	8	24	32
Turbhe	9	22	31
Vashi	11	20	31
Total	40	119	159
Total %	25%	75%	-

Frequencies of smokers and non smokers among the surveyed population for LFT in the studied zones of Navi Mumbai

Scores* of smokers	Frequencies	%
Score < 100 (smoker)	42	26.4
Score > 100 (chronic smoker)	19	11.9
Score = 0 (non smoker)	98	61.6

*Smoking score is calculated by:

No. of cigarettes smoked in a day × no. of years of smoking

The data obtained from the LFT reveal the following:

(a) 25% of those surveyed (159) for the LFT in the studied zones were affected by a decrease in FEV1. This decrease in the FEV1 values could be attributed to air pollution in the studied zones. This number should be taken note of.

(b) 41% of those surveyed (159) for the LFT were affected by a decrease in FEV1/FVC. This could be again attributed to air pollution in the studied zones.

(c) 12.6% of those surveyed were affected by a decrease in FVC. This group of individuals could suffer from problems associated with obstruction of respiratory passages or fibrosis of lungs.

(d) Results of LFT reveal the presence of respiratory malfunctions in the surveyed populace, thus giving strong indications about air pollution in the area.

The above discussion brings out the following:

- The upper respiratory tract problems have acquired chronic proportions in the study zones in Navi Mumbai.

- The results obtained by the lung function tests further confirm that a substantial proportion of population is afflicted with respiratory problems (since FEV1 is affected).

- Vector-borne diseases are also widely prevalent in the study sites.

Health surveys, along with lung function tests, at Kopar Khairane.

In every season, health surveys were started with intensive training of participating students (below left). Doctors assembled at J.V. Mandal College, Airoli (below right) before the surveys.

Health surveys at Turbhe Stores and Hanuman Nagar, Turbhe, by the students of ICLES' M. J. College and K.B. Patil College, both at Vashi.

The above picture is taken at the exact site in Hanuman Nagar, behind the Sulphur Mills Ltd., TBR. Here the residents complained of constant irritation of eyes/skin, besides problems of URT.

GENERAL CONCLUSIONS

Achieved goals and recommendations

Educational Implications

Both health and environment are complex issues and today they occupy the centre-stage in our overall development and education. Several approaches at different levels are being tried out to improve our environment and health. Larger public participation and awareness, combined with a more proactive educational approach are vital to a clean environment with healthy populace. HEAL attempted to do just that and was set up as a MODEL to be replicated.

- HEAL involved a large number of college students, nearly one thousand students, associated with the National Service Scheme (NSS) of the University of Mumbai. These students came from different disciplines (science, commerce, computer science and arts) from five colleges spread over five zones of Navi Mumbai. Hence, HEAL could **sensitise** a large number of students about the important and complex issues of health and environment.
    - Interestingly, months after the formal completion of this phase of HEAL, the students of the SIES College at Nerul and the Karamaveer Bhaurao Patil College (Modern College) at Vashi, took the initiative to carry out noise pollution studies during the 2005 *Diwali* and *Ganapati* festivals. Further, preparations are underway for a 'health and hygiene' programme in Airoli, July 2006, by students of Jnan Vikas Mandal, Airoli, and to generate the geographical information system (GIS) maps of the studied zones by using HEAL-generated data by computer students from the SIES College at Nerul. Here the important point is that the teachers and students are getting sensitized about the links between health and environment and are undertaking many studies on their own. HEAL can take some credit in this regard for catalyzing this proactive approach.

- This programme could be followed as a **model for replication** at other places, at any time, from primary school to college levels. Depending on the expertise and motivation of teachers, the programme / model could be carried out at different scales of operation The replication of this model has become a strong possibility today with the introduction of environment science in the school curriculum, where teachers could first refer to the HEAL Protocol Guide and decide at what level he/she wants to introduce the different activities.
    - For instance, at the primary level, emphasis could be put on general observations, say of a nearby water body—river, lake, well or the nearby sea stretch. In the process, students could be trained to keep records of the odour and other features of the general appearance of the water body —e.g., litter around it, size (big or small and its depth) -- with dates and timings. Introduction of the concepts of pH, temperature, turbidity, along with observations of different algae, fish and other life forms could follow in the middle school level. These could be linked to the scientific concepts of chemical constituents of waste and the resulting degradation (or not) in the water, role of light, and the continuous changes taking place in the water body.
    - At the high school or at the college levels, students could next be exposed to the different tests for chemical analysis of water samples, or identification of different life forms.
    - Health, as associated with the water body, more so if its water is used for drinking purpose, and hence microbiological studies, could be another aspect of the study.
    - This entire exercise could be carried out on a small or large scale, depending on the logistics of the educational organization.

- HEAL students were exposed to how science works in day-to-day life, as the programme emphasized hands-on experience. College students actually collected data over three seasons about different environmental factors and their effects on our health. In the process, they used different scientific methods, involving experiments, fieldwork, graph making and analysis of

their results; thus they were exposed to the intricacies of science and also the fact that science is all around us.

- The different scientific concepts normally taught in the classrooms, were actually carried forward to the field. Students' understanding of different scientific concepts (pH, dilutions, solubility, settling velocities of particulates, microorganisms and their reservoirs, plant diversity, to name only a few) in several disciplines was clarified with their experiences in the field and in the laboratory.
- Students learnt how to collect and analyse data and use different statistical techniques; even mathematical modeling was suggested to them by programme co-ordinators. Besides inculcating a culture of data collection (widely absent in India), HEAL took scientific knowledge to the common people, thus 'bridging the *know-do gap'* -- knowledge leading to action/doing.
- It is important to remember that the data under HEAL have been collected over just one year. These limited data are not sufficient to make any definitive conclusions about environment or health in Navi Mumbai. But these data certainly denote some trends. Besides validation of the current data, there is an urgent need to collect more comprehensive and extensive data at least for a three year period, which could have important implications for policy changes by policy makers in conjunction with stake holders.
- The data collected over time could be put on the website by the project leaders of different educational institutes to be accessible to all. In this regard, HEAL data will soon be processed to be uploaded on the HBCSE website. The availability of databases would promote transparency, validation and exchange of ideas between different groups working in the subject per se.
- HEAL being a multi-disciplinary programme, the participating students soon realized the many perspectives / dimensions involved in health and environment. The study gave a true picture of complexities in the context of both environment and health, as it existed at the grass roots level.
- HEAL with its scientific analysis provoked students to think of alternatives / possible solutions to the present health and environment problems in their respective areas.

- HEAL encouraged students towards adopting sustainable development methods in their homes, localities and colleges.

It is hoped that HEAL, a science education programme, can help in the efforts to prevent further deterioration of our environment and reduce the related disease-burden.

Implications on public health policy

The preliminary results under HEAL about the quality of air and water of recreational water bodies, along with limited data about domestic solid waste disposal facilities and green cover, on one hand, and results of health status of residents of study sites in Navi Mumbai, on the other hand, howsoever limited, indicate definite trends. The high prevalence of respiratory ailments could be attributed to the air quality, especially the prevalence of higher concentration levels of Respiratory Suspended Particulate Matter (RSPM). Detailed epidemiological studies showing the cause-effect relationship is urgently warranted. The observed environmental quality trends also highlight the need for steps to be taken to clean up the environment and thus improve the environment and health status of citizens of Navi Mumbai. This could be done by committed involvement of individuals, educational institutions, NGO's and by the NMMC. The Maharashtra Pollution Control Board (MPCB), scientists, along with the industries in the area, also have an important role to play in making Navi Mumbai a better place to live in.

For improving air quality:

1. There is an urgent need for continuous monitoring of air quality in different zones of Navi Mumbai, especially in view of the heterogenous terrain of the area and location of the TTCIA (Trans Thane Cree Industrial Area) and large swathes of residential townships. This should help in establishing point and mobile sources of air pollutants. Experts/scientists in this field could be consulted.
    a. The air monitoring stations should effectively communicate to the general public the quality of air in a given area (this is NOT true of

the monitoring station at Vashi fire station installed on 26th January, 2005, by the NMMC).

   b. Indicators, such as the AQI (using different colours), could also be displayed to warn/inform the citizens about the quality of air in a given area.
   c. This should be preceded by proper information campaigns in the print and visual media (till date there has been no mention/news in the media about the air monitoring station at Vashi).

2. Air emissions from industries in the vicinity of major residential areas (such as Turbhe Stores and Hanuman Nagar, both in Turbhe) should be stringently monitored to safeguard the health of people. Failure to adopt cleaner emission technologies should be penalized. (Recall the unhealthy environs of dwelling units in Hanuman Nagar during health surveys.)
3. Source inventory details of point source emissions (from both large and small scale industries) need to be upgraded and not left solely to the industrial sector.
4. HEAL surveys brought out the somewhat mixed siting of different types of industries in the TTCIA (this component was not included formally in the programme at this stage). This has potential for major disasters--in fact, two major accidents occurred in the said area in early 2005.
5. Mobile emission sources could be regulated by better traffic management.
6. Emphasis on public transport facilities, with proper maintenance of bus depots/stations, roads, etc. has great scope for improving air quality of an area.
7. Vehicles, such as, auto rickshaws and taxis to be fitted with CNG-powered engines.
8. All construction activities, especially on public lands, should have protective barriers in the form of high/tall metal barricades or curtains, to minimize the spread of dust and other particulates over a large area.
9. Hill quarrying should be regulated scientifically. City planners should identify, notify and protect hills affecting the climate and put up the data in public domain. The authorities should also take preventive steps to stop settlements on the hill slopes.

For preservation of open water bodies, green cover and scientific management of waste:

1. Corporate sector, educational institutions and non governmental organizations (NGOs) could adopt water bodies and open areas meant for gardens in their respective areas. Besides development and maintenance, this would involve regular monitoring of the water body/green spaces and its immediate environs, and educating the public about the importance of an overall clean environment.
2. Monitoring of liquid waste (both domestic and industrial) by first tracking the entire path of this waste from its origin to exit points, and then chemical analysis (at source, midpoint and exit points) could be undertaken. These steps could yield important insights about the management of liquid waste, especially in the context of functioning /non functioning of sewage treatment plants and its disposal.
3. Municipalities and city development authorities to pay added emphasis on waste management at all levels by being vigilant, uncompromising and stringent, and devising ingenious methods—at source, at collection points and at final disposal points.
4. Green cover could be enhanced in different areas, especially in areas of high population density and air pollution (Kopar Khairane, Turbhe and TTCIA).
5. Mangrove cover and Thane creek could be monitored for possible encroachments / pollution / degradation due to construction, drainage and other allied activities.
6. In all this, citizens including scientists, teachers, students, along with non governmental organizations and industries have an important role to play.

HEAL should prompt students to reflect and imbibe scientific knowledge about these issues and take cognizant about how their many actions (including those associated with different religious and social practices) impact on health and environment. This should prompt them to act in a proper manner so essential for our survival and life on earth.

***

REFERENCES

Acharya, S. (2002), How Sick are we? *The Economic Times*, 4 April

Botkin, D. Keller (1995), *Environmental Science: Earth as a Living Planet,* John Wiley and Sons, Inc.

Brandon, C. (2000-2001), *Environment Matters*: *Annual Review*; July 2000-June 2001

Central Pollution Control Board (http://cpcb.nic.in)

Clesceri, L.S. Greenberg, A.E. Eaton, A.D.(1998), *Standard Methods for the Examination of Water and Wastewater,* American Public Health Association, Washington

Das Gupta, M. Chen, L.C. and Krishnan, T.N. (1996), *Health Poverty and Development in India,* Oxford University Press, New Delhi

De, A.K. (1990), *Environmental Chemistry,* Wiley Eastern Ltd.

Down to Earth: Survival Primer (2004), Society for Environmental Communication, New Delhi

Environmental Status Report --2001-2002: Navi Mumbai Municipal Corporation, India

Environmental Status Report --2002-2003: Navi Mumbai Municipal Corporation, India

Environmental Status Report --2003-2004: Navi Mumbai Municipal Corporation, India

Environmental Health Indicators: Development of a Methodology for the WHO European Region-Interim Report (2000)

High Level Conference on: Strategies for Control of Air Pollution in Mumbai (2005), organized by Maharashtra Pollution Control Board and National Environment Engineering Research Institute

Kamat, S.R. and Athavale, A. U. (2005), Mumbai Air Pollution Study, in *High Level Conference on: Strategies for Control of Air Pollution in Mumbai* (2005), organized by Maharashtra Pollution Control Board and National Environment Engineering Research Institute

Kumar, M.S. and Ravindranath, S. (1998), *Water Studies: Methods for Monitoring Water Quality,* Centre for Environment Education, Ahmedabad

Lvovsky, K. (2001), *Health and Environment*, Environment Strategy Paper 1. World Bank

Mahajan, Bakhtaver S. (1996), *Microbes and Disease,* Oxford University Press, India

Mahajan, Bakhtaver S., Chunawala S. N., Deshmukh N.and Shitut, S. (1996*), Health Education Programme: Technical Report No. 27*, Homi Bhabha Centre for science Education, Mumbai

Mahajan, Bakhtaver S. and Chunawala. (1999), "Indian Secondary Students' Understanding of Different Aspects of Health", *Int. J. Science Education.*, Vol. 21, No. 11, pp.1155-1168.

Mahajan, Bakhtaver S. and Nair Suma, *Protocol Guide*-Health and Environment: Action-based Learning (HEAL) (2004), Homi Bhabha Centre for Science Education, Mumbai

Maharashtra Pollution Control Board (http://www. mpcb.mah.nic.in)

Monitoring Ambient Air Quality for Health Impact Assessment (1999), WHO Regional Publications, European Series, No.85

Morgan, M.T., et al (2003), *Environmental Health*, Wadsworth/ Thomson Learning, USA

Mukerjee, B. (1997), *Environmental Biology,* Tata McGraw-Hill Company Ltd.

National Environment Policy–2004, Ministry of Environment and Forests, Government of India, New Delhi (http:// envfor.nic.in/nep.htm)

Pang, T. (2003), "Filling the gap between knowing and doing", *Nature,* Vol. 426, pp. 383

Particulate Matter Reduction Action Plan for Greater Mumbai: Draft Interim Report-II (2002), Mumbai Metropolitan Regional Development Authority and National Environment Engineering Research Institute

Patil, R.S. (2005), Exposure Assessment as Tool to Understand Health Risks, in *High Level Conference on: Strategies for Control of Air Pollution in Mumbai* (2005), organized by Maharashtra Pollution Control Board and National Environment Engineering Research Institute

Price-Smith A.T. (2002), *The Health of Nations: Infectious Disease, Environmental Change, and their Effects on National Security and Development Health and Environment*

Ramteke, D. S. and Moghe C. A. (1988), *Manual on Water and Wastewater Analysis,* National Environmental Engineering Research Institute, Nagpur

Report on Inter Agency Project: Assessment and Management of Health and Environmental Risk from Industries in Trans Thane Creek Area (Indian case study) (1998)

Sachs, J. D. (2002), "Health for all is Wealth", *The Economic Times*, 16 February

Sharma, Mukesh, et al, (2000), Air Quality Index and its Interpretation for City of Delhi, presented in the International Conference, CSE, June 6-8, 2000

Sharma, Mukesh, et al, (2003), Design of a Website for Dissemination of Air Quality Index in India, in *"Environmental Modelling and Software* XX".

Sita, K.and M.Ray (2001), The Land Use Pattern, in *Issues in Urban Development: A Case of Navi Mumbai*, Eds. R. N. Sharma and K. Sita, Rawat Publications, India

The GLOBE Program—Teacher's Guide (1997), Available: http//: www.globe.gov

World Development Report: Investing in Health (1993), Oxford University Press, USA

The World Health Report: Fighting Disease, Fostering Development (1996), World Health Organization, Geneva

The World Health Report: Life in the 21st Century—A Vision for All (1998), World Health Organization, Geneva

World Health Report: Reducing Risks, Promoting Healthy Life (2002), Available: (www.who.int/whr/2002/en)

APPENDIX 1

Names of participating colleges, principals and teachers:

1. Jnan Vikas Mandal's College of Arts, Science & Commerce, **Airoli,** Navi Mumbai

   Principal: Dr. Madhusudan Raje
   Mr. Satyajit Kamble
   Ms. Rajani Mishra

2. F.G. Naik College of Arts, Science & Commerce, **Kopar Khairane**, Navi Mumbai

   Principal: Ms. Yogini Ghare
   Ms. Preeti S. Zade
   Mr. Ganesh Patil

3. S.I.E.S (Nerul) College of Arts, Science & Commerce, **Nerul,** Navi Mumbai

   Principal: Dr. G.V. Subramaniam
   Ms. Komal V. Tembulkar
   Ms. Swati P. Vitkar

4. Rayat Shikshan Sanstha's Karmaveer Bhaurao Patil College of Arts, Science & Commerce, **Vashi**, Navi Mumbai

   Principal: Dr. B.A. Patil
   Vice-Principal: Dr. H. V.Jadhav
   Mr. Rajesh J. Kavade
   Ms.Rajeshree Ghorpade

5. ICLES' Motilal Jhunjhunwala College of Arts, Science & Commerce, **Vashi,** Navi Mumbai

   Principal: Dr. S. N. Shetty
   Ms. Aruna Sharma
   Mr. Hiren M. Dekate
   Dr. Sadhana Phadnis
   Ms. Usha Anilkumar

APPENDIX 2

Distribution of DALY+ loss due different factors in some regions of the world, 1990 (in %)

	SUB.S AFRICA	INDIA	CHINA	F.S.C.	M.D.C.
Population	510	850	1134	346	798
Total DALY Loss(m)	293	292	201	58	94
Communicable diseases	71.3	50.5	25.3	8.6	9.7
TB	4.7	3.7	2.9	0.6	0.2
STD/HIV	8.8	2.7	1.7	1.2	3.4
Diarrhoea	10.4	9.6	2.1	0.4	0.3
Vaccine-prevented childhood infections	9.6	6.7	0.9	0.1	0.1
Malaria	10.8	0.3	0.05	-	-
Worm infection	1.8	0.9	3.4	-	-
Resp. infection	10.8	10.9	6.4	2.6	2.6
Maternal diseases	2.7	2.7	1.2	0.8	0.6
Perinatal diseases	7.1	9.1	5.2	2.4	2.2
Other	4.6	4.0	1.4	0.6	0.5
Non-communicable diseases	19.4	40.4	58.0	74.8	78.4
Injuries	9.3	9.1	16.7	16.6	11.9

+DALY= Disability- Adjusted Life Year

APPENDIX 3

Distribution of DALY loss in some regions of the world, with emphasis on per capita health and public sector health expenditures

	SUB-S AFRICA		INDIA		CHINA		FSC		MDC	
Total Population (m)	510		850		1134		346		798	
Total DALY Loss (m) (1990)	293		292		201		58		94	
DALD* loss/Person/Year	210		125		65		61		43	
Days	*150	#60	*63	#62	*16	#49	*5	#56	*4	#39
Per capita health expenditure ($)	**24**		**21**		**11**		**142**		**1860**	
Public sector health expenditure (%)	**55**		**22**		**59**		**71**		**60**	

* Due to Communicable Diseases # Due to Non-communicable Diseases/Accidents

DALY = Present value of the future years of disability-free life that are lost due to:

(i) **premature deaths; and**

(ii) **disability occurring in a particular year**.

*DALD = Disability-Adjusted Life Day

DALD/Person/Year ≡ DALY/ Total population × 365