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Environmental Health Assessment: Respiratory Disease in relation to Air Pollution in Kanpur, Uttar Pradesh

India-Norwegian cooperation project
(Project no. O-106082, Ref. nr. IND3025 05/51)

Alena Bartonova [1)] and Hai-Ying Liu [1)] (eds)

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Preface

This report is a summary of a project ‘Environmental Health Assessment: Respiratory Disease in relation to Air Pollution in Kanpur, Uttar Pradesh’. The project was funded under Royal Norwegian Embassy New Delhi, Project no. O-106082, Ref. nr. IND3025 05/51. The aim of this project is to build up a methodology for environmental health impact assessment. The specific aims are:

- To assess population-wide health effect of air pollution in the city of Kanpur;
- To lay further basis for environmental health and air quality monitoring at Kanpur and Agra;
- To disseminate the findings and sampling procedures for adoption at other sampling locations in India.

The project contains seven partners:

- Norwegian Institute for Air Research (NILU)
- Indian Institute of Technology Kanpur (IITK)
- GSVM Medical College in Kanpur
- Central Pollution Control Board (CPCB) in Agra
- State Pollution Control Board in Kanpur

The project was structured into the following tasks:

- Task 1: Verification of measurement methods in relationship to the European CEN/EN12341 standard on PM10 monitoring in Kanpur and Agra.
- Task 2: Health effect assessment attributable to air pollution in the city of Kanpur.
- Task 3. Dissemination (workshops) and administration.

This report summarizes the main results from this project, first, to verify the measurement methods in relationship to the European CEN/EN12341 standard on PM10 monitoring in Kanpur; second, to examines the associations between respiratory disease and outdoor air pollution in Kanpur. The results showed that (i) the monitoring equipment for PM10, often used in the Indian monitoring network, provide 20% lower results than both high volume sampling equipment and the European reference method. (ii) the variable PM is most strongly correlated with SO_2 and NO_X; (iii) the degree of air pollution is significantly relevant to the landscape patterns; and (iv) there are strong association between respiratory disease as measured by the total number of patients and outdoor air pollution.

For more information, please contact the project coordinator Dr. Alena Bartonova, E-mail: aba@nilu.no.

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1. Executive Summary

This report summarizes all activities of the whole period for the project.

The project is a collaboration between Indian Institute of Technology Kanpur (IITK), GSVM Medical College in Kanpur, Central Pollution Control Board (CPCB) in Agra, State Pollution Control Board in Kanpur, and Norwegian Institute for Air Research (NILU), Kjeller.

Project activities were somewhat delayed, and started for full first in August 2006. The first task, *Verification of measurement methods,* deployed the European reference instrumentation. The Indian staffs prepared standard operating procedures and were trained in sampling and gravimetric methods with emphasize on quality control and quality assurance methods. Parallel sampling was done for the European reference sampler Kleinfiltergeraet, the Indian make standard PM sampler RDS, and a high-volume sampler Packwill. The concentrations measured by Packwill and the Kleinfiltergeraet did not significantly differ. The concentrations measured by RDS were 22% lower than concentrations measured by the Kleinfiltergeraet. There was no significant difference in weighing between NILU and the Indian institutions.

The second task, *Health assessment*, had three parts: 1) establishment of an emission database, 2) assessment of health effects, and 3) statistical analysis. A comprehensive emission database for Kanpur was established, covering particulate matter (PM_{10}), SO_2 and NOx. In the Kanpur area, point sources, area sources and line sources were all considered and investigated by a combination of methods (direct inspections, statistical data collection, satellite data collection). In a 2x2 kilometre grid, areas of the city were classified into four categories (1 – least emissions, 4 – highest emissions), and coupled with population and with patient register of the participating hospital. Respiratory symptoms and illnesses showed clear positive association with emission intensities, demonstrating that deteriorated air quality due to high emissions is a clear precursor for higher risk for respiratory disease.

In the Task 3, *Dissemination*, the project team held an inception workshop, but did not manage to hold a final workshop. At the present time, publications detailing the results from the project are being prepared, and ways how to hold the final workshop are being investigated.

During the project period, the tasks were carried out mostly as planned (except dissemination), but there were lapse on reporting. Therefore, the project was extended until 31. August 2008.

2. Introduction

The project is building upon results and achievements of a previous project "Indoor and Ambient Air Exposure of PAHs and Fine Particulate to Women and Children: Health Impacts in terms of Morbidity", performed by the collaborating partners during the period February 2002 to July 2005, which concluded that there are observable health effects that can be attributed to air pollution.

In addition to those important findings, it put the infrastructure necessary for such investigations in place; it enabled the IITK to run efficiently a high-quality air pollution monitoring, and to perform the required chemical analyses, with the help of a quality assurance/quality control system, and established a relation with the GSVM Medical College in Kanpur, enabling GSVM to collect and supervise collection of high-quality data on respiratory health outside their usual clinical practice.

Within the previous project, information was disseminated to the public through two workshops, attended by professionals and other stakeholders. The final workshop in its recommendations pointed out that the established collaboration of the three institutions can further build on the project achievements, both in terms of more accurate assessments of health damages and in terms of contributions towards improvements of air quality, using elements of integrated air quality management system.

3. Objectives and Scope of the Cooperation Project

The purpose of the project is to further develop expertise of all the participating institutions, and at the same time, provide necessary quantitative pollution-health linkage, for use by the health and environment authorities in India and to the scientific community elsewhere. In line with scientific and regulatory advancements, it is also the view of the current team that information on environmental health is one of the most important inputs to air quality management.

Specifically, four issues are addressed that underpin the main objective:

- Further work on enabling the IITK laboratory to serve as a quality control and quality assurance expertise centre in support of monitoring;
- Putting in place procedures in support of air quality management, especially related to emission inventories and assessment of population exposures;
- Further developing information on relation between respiratory health to air pollution, in support to air quality management;
- Dissemination of information and knowledge relevant to air quality management.

The main aim of the project is build up a methodology for environmental health impact assessment. The specific aims are:

- To assess population-wide health effect of air pollution in the city of Kanpur;
- To lay further basis for environmental health and air quality monitoring at Kanpur and Agra;
- To disseminate the findings and sampling procedures for adoption at other sampling locations in India.

4. Activities taken up and completed

The project was structured into the following tasks:

- Task 1: Verification of measurement methods in relationship to the European CEN/EN12341 standard on PM10 monitoring in Kanpur and Agra.
- Task 2: Health effect assessment attributable to air pollution in the city of Kanpur.
- Task 3. Dissemination (workshops) and administration.

The implementation of these tasks was done through separate work of the Indian and Norwegian teams, many electronic and several telephone communications, technical visit and an inception workshop.

4.1 Task 1 Verification of measurement methods

The Indian team started preparations for this task by identifying project staff at the IITK and by selecting and preparing the monitoring sites. This included several technical preparations. In order to secure power supply at the Kanpur sites, backup power systems were deployed and on-site installations were performed. The Norwegian team supervised deployment of the equipment and provided training during the first technical visit on the operation of the samplers, and on quality assurance and control procedures for the samplers, for filter handling and weighing.

Parallel monitoring was done according to a plan, with three instruments in Kanpur and two instruments in Agra. The output of sampling consists of weight of filters before they were exposed and after. Furthermore, the total volume of air blown through the filter was known and used for evaluating the average concentration of dust in air in samplers' surrounding. In most cases, the 16-hour average was available although there were few observations where sampling was shorter or were not carried out due to e.g. damage of filter.

The main task was to assess the difference in outputs from Indian samplers compared to reference Leckel sampler. As the tool for providing this, the evaluated concentration and the relative difference in concentration were used.

A concern regarding the equality of outputs coming from various samplers was raised, although it was already shown that the procedure of filter weighing in India laboratories usually meets with the systematic positive error. To overcome this obstacle, the assessment of the accuracy of Leckel' filters weighing procedure in India was done. First, the filters were weighed in NILU and sent to India to exposition. In India, the laboratory staff reweighed the unexposed filters before the very sampling started. After the sampling was done the filters were weighed in India, sent back to Norway and reweighed again. The resulting differences between weighing in India and NILU showed significant difference in exposed filter weight in about 0.16mg and furthermore the evaluated concentration differed in mean in 3.9µg/m^3.

Nevertheless, assuming that the weighing of filters exposed using all three filters was done in the same condition in Indian laboratories, we still are able to compare the results coming from these three samplers. Here the question arises, if the different filters used in all three samplers tend to behave in same matter with regards to the unknown potentially influencing effects as is the level of humidity in laboratory etc.

4.1.1 Statistical analysis

The difference Δc in concentration c from the reference of Leckel was calculated as follows:

$$\Delta c(Leckel, RDS) = c(Leckel) - c(RDS) \quad (1)$$

$$\Delta c(Leckel, Packwill) = c(Leckel) - c(Packwill) \quad (2)$$

Furthermore, the relative difference Δc_r in concentration was obtained as follows:

$$\Delta c_r(Leckel, RDS) = \frac{c(Leckel) - c(RDS)}{c(Leckel)} \quad (3)$$

$$\Delta c_r(Leckel, Pckwill) = \frac{c(Leckel) - c(Packwill)}{c(Leckel)} \quad (4)$$

To assess the differences between outputs of reference sampler and other two samplers, the two-tailed parametric paired two-sample t-test and also non-parametric Wilcoxon signed-rank test were used. The testing was provided on the 0.05 significance level.

4.1.2 Results

The sampling was provided within September 9th 2006 and May 1st 2007 in Kanpur, Uttar Pradesh. The total number of observations was 339 from which 112 derived from Leckel, 118 from Packwill and 109 from RDS. There were a few days in which various arrangements of machines were provided and as a consequence, the observations were not performed with all three samplers. Furthermore, as mentioned earlier, several failures caused by filter damage appeared. The final number of valid observations to compare the two investigated samplers to the reference sampler was 217, from which 115 and 102 were from Packwill and RDS respectively.

In the following tables the basic descriptive statistics are displayed. The differences between reference sampler and remaining Indian samplers Packwill and RDS were in mean 5.44µg/m^3 and -105.93µg/m^3, respectively. Especially the RDS sampler strongly underestimated the concentration of dust in air, if assuming that the measurements by reference sampler Leckel were done properly. Furthermore, the differences between the samplers vary from hundreds of µg/m3 below and above zero, which indicate huge errors.

The basic descriptive statistics of relative difference in concentration may be seen in Table 3. As it may be expected, the mean relative difference from Packwill sampler is with the value 0.02 close to zero; however the variability represented by the values 0.32 of standard deviation is enormous. The RDS sampler results pose in addition to huge variability also huge negative bias with the mean value of -0.22.

Table 1 Descriptive statistics of the evaluated concentrations on the basis of measurements obtained by two Indian samplers (Packwill, RDS) and reference sampler Leckel.

Sampler\Concentration [μg/m^3]	**Min**	**Mean**	**Max**	**Standard deviation**
Leckel	68.94	300.03	838.77	166.49
Packwill	65.14	297.43	786.97	168.78
RDS	48.14	201.02	529.32	80.73

Table 2 Descriptive statistics of the differences in evaluated concentrations between two Indian samplers (Packwill, RDS) and reference sampler Leckel.

Sampler\Differences in concentration [μg/m^3]	**Min**	**Mean**	**Max**	**Standard deviation**
Packwill	-321.01	5.44	261.16	84.28
RDS	-548.45	-105.93	196.16	133.82

Table 3 Descriptive statistics of the relative differences in evaluated concentrations between two Indian samplers (Packwill, RDS) and reference sampler Leckel.

Sampler\Relative differences in concentration	**Min**	**Mean**	**Max**	**Standard deviation**
Packwill	-0.71	0.02	1.54	0.32
RDS	-0.71	-0.22	2.00	0.43

The calculated differences between Packwill or RDS machine and reference Leckel sampler are also displayed on the Figure 1 and Figure 2. The differences for Packwill are mostly uniformly spread around the zero except 13 observations from 22th to 28th of April 2007. These last cases were mentioned as being done with the Packwill substrate for PM_{10} sampling. Further, please notice the serious variation of values which exceeds the ±100ug/m^3 imaginary horizontal lines.

The second plot represents the results from RDS sampler. As it may be seen the levels of concentration of dust in air obtained from RDS outputs are considerably lower as the resulting differences with reference sampler are far below zero. Again the variability of data is particularly huge.

Figure 3 and Figure 4 show the evaluated relative differences in concentration between Indian samplers and Leckel. The patterns of points mostly copy the behavior seen in absolute differences in concentration.

4.1.3 Summary of findings

Packwill:

1. There is **non-significant difference between concentration level** obtained by Packwill and reference Leckel sampler equal **5.44ug/m^3.** The two-tailed significance level is 0.49 from paired two-sample *t*-test and 0.11 from Wilcoxon test.
2. There is **non-significant difference in relative concentration** obtained by Packwill and reference Leckel sampler equal **2%.** The two-tailed significance level is 0.51 from paired two-sample *t*-test and 0.04 from Wilcoxon test.

RDS:

1. There is **significant difference between concentration level** obtained by RDS and reference Leckel sampler equal **-105.93ug/m^3**. The two-tailed significance level is < 0.001 from both paired two-sample t-test and Wilcoxon test.
2. There is **significant difference in concentration level** obtained by RDS and reference Leckel sampler equal **-0.22.** The two-tailed significance level is < 0,001 from both paired two sample t-test and Wilcoxon test.

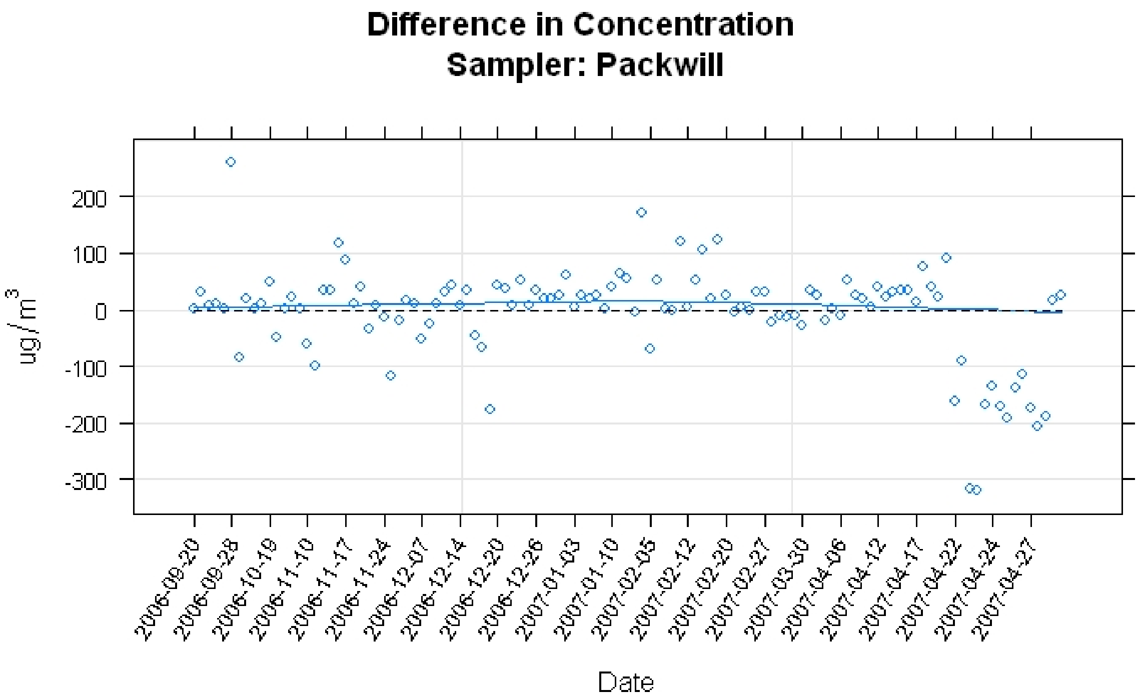

Figure 1 The differences between the concentration of dust in air obtained by Packwill and Leckel are displayed. The smoothed line mirroring the mean tendency is drawn in solid blue line. The dashed black line represent the desired zero level.

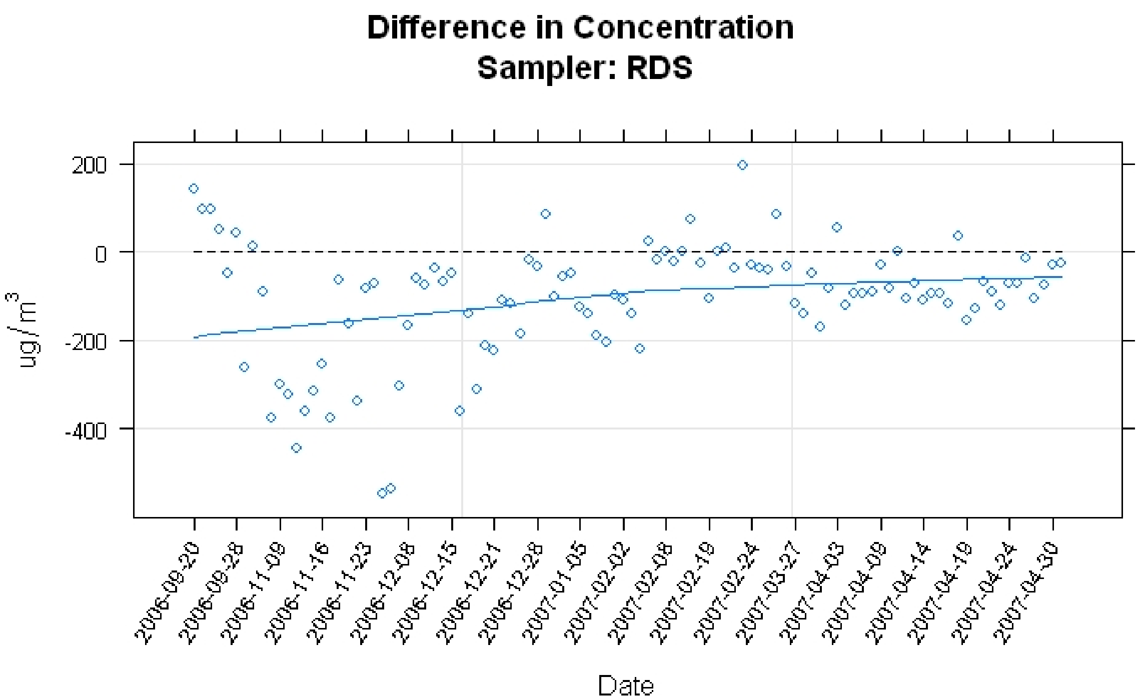

Figure 2 The differences between the concentration of dust in air obtained by RDS and Leckel are displayed. The smoothed line mirroring the mean tendency is drawn in solid blue line. The dashed black line represent the desired zero level.

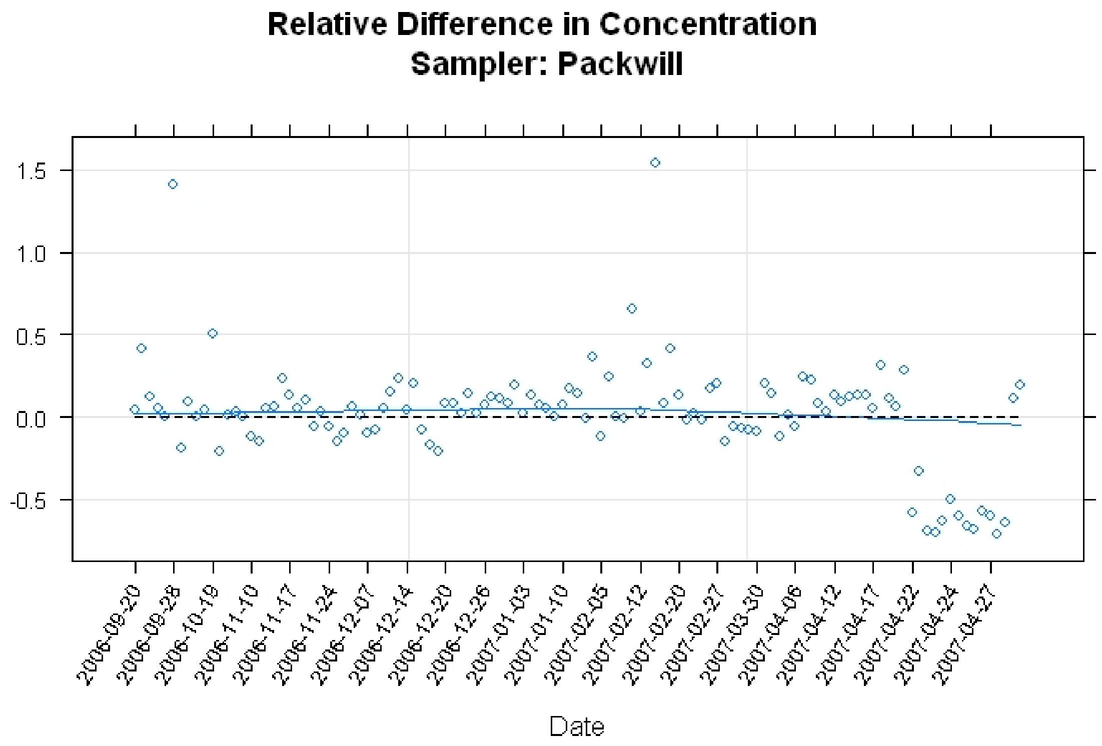

Figure 3 The relative differences in concentration of dust in air obtained by Packwill and Leckel are displayed. The smoothed line mirroring the mean tendency is drawn in solid blue line. The dashed black line represent the desired zero level.

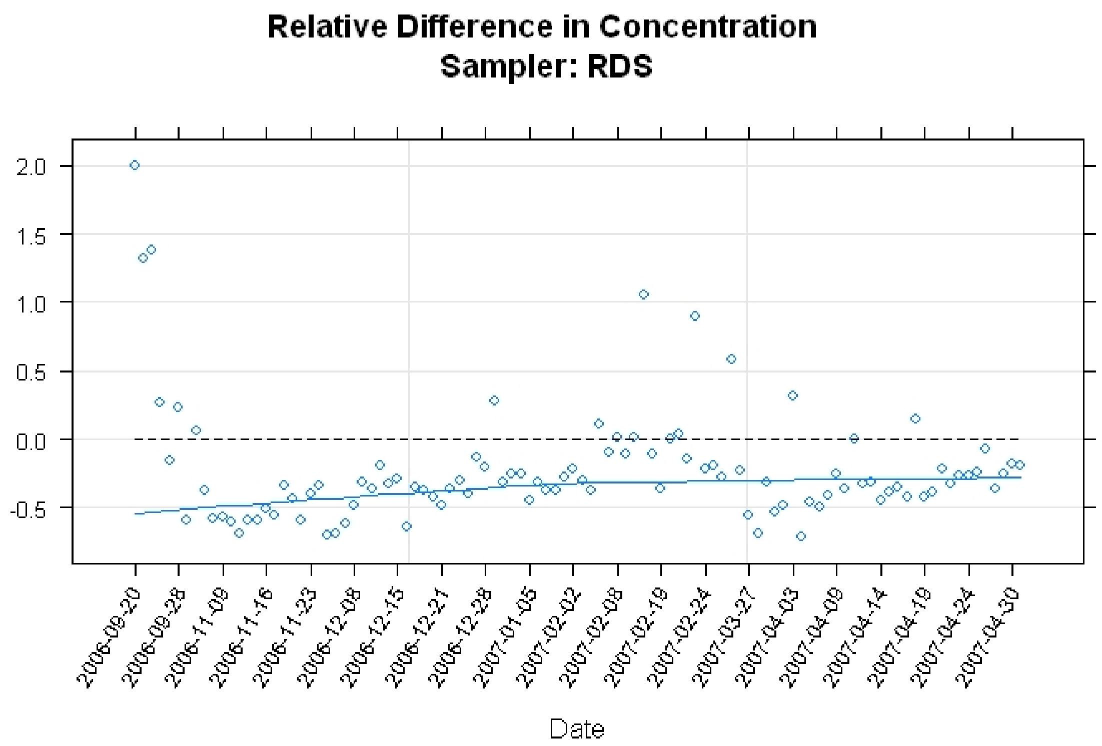

Figure 4 The relative differences in concentration of dust in air obtained by RDS and Leckel are displayed. The smoothed line mirroring the mean tendency is drawn in solid blue line. The dashed black line represent the desired zero level.

Difference in concentration

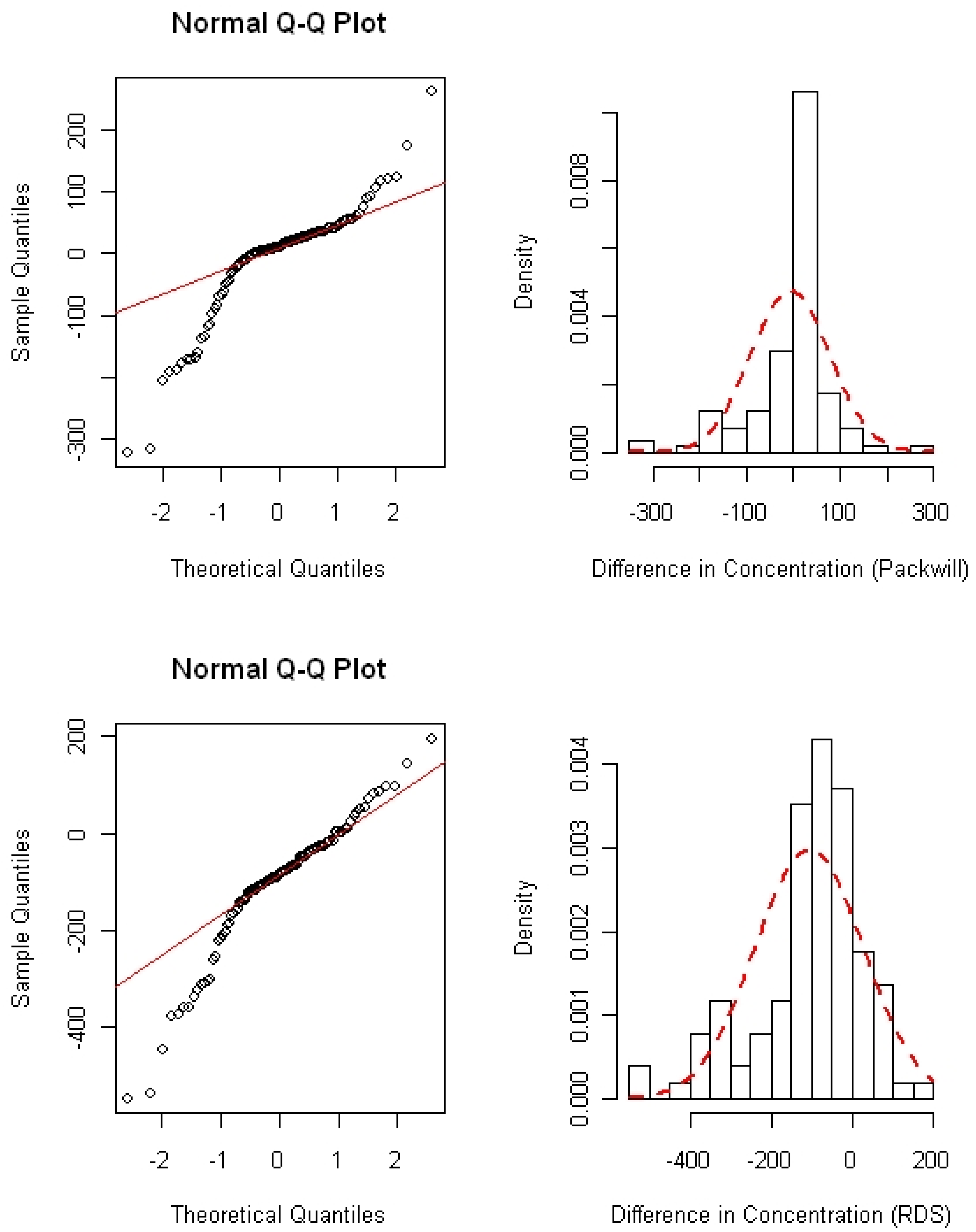

Figure 5 Difference in concentration from Packwill and RDS compared to Leckel: Plots assessing the belonging to normal distribution (Q-Q plot: sample quantiles vs. theoretical, histogram with normal distribution density curve in red line).

Relative Difference in concentration

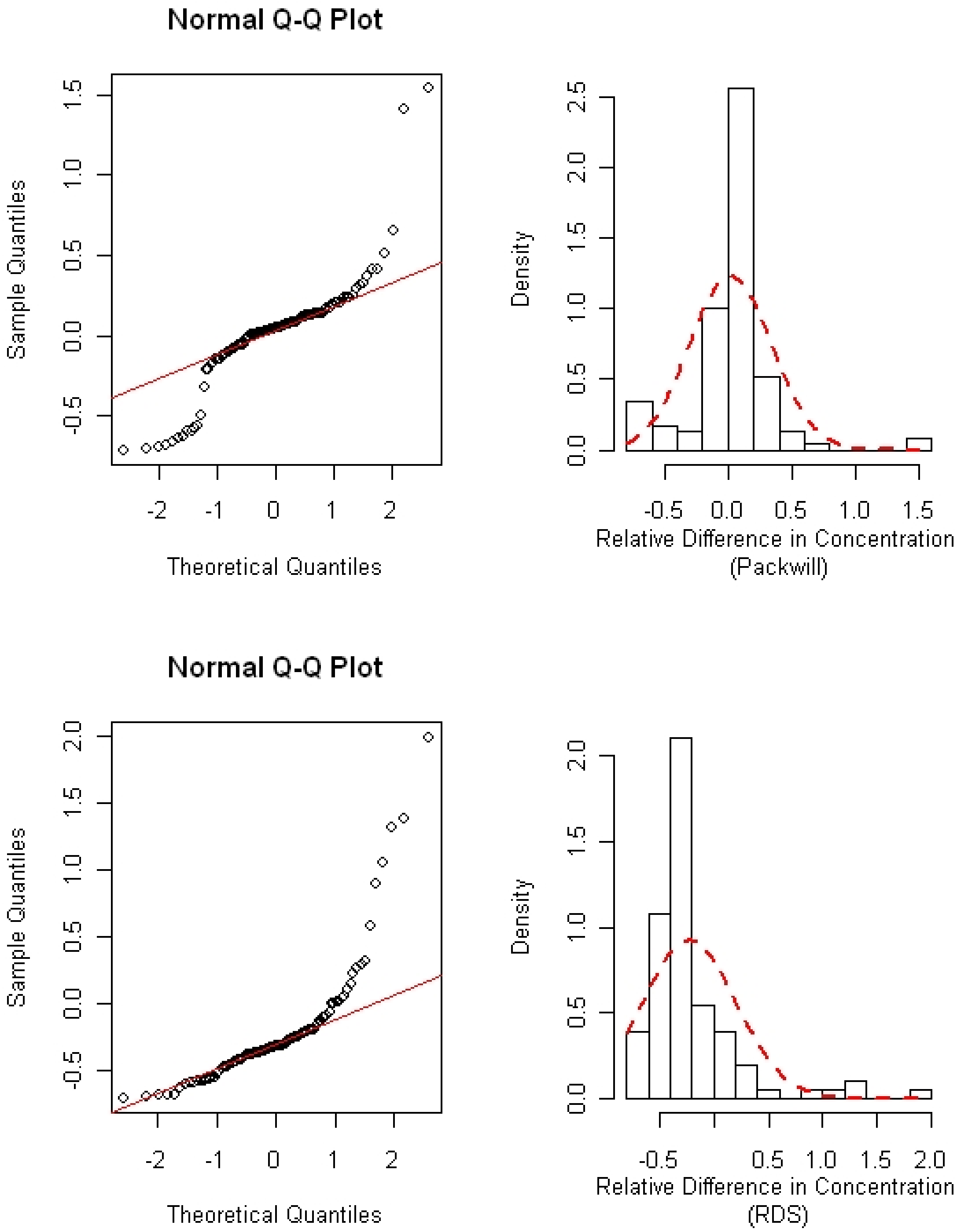

Figure 6 Relative Difference in concentration from Packwill and RDS compared to Leckel: Plots assessing the belonging to normal distribution (Q-Q plot: sample quantiles vs. theoretical, histogram with normal distribution density curve in red line).

4.2 Task 2 Assessment of population burden of disease due to air pollution

4.2.1 Emission inventory

4.2.1.1 Sampling centres

There are 7 centres in the city where the sampling was done (Figure 7). At each of the centres, the coordinates of the centre point were plotted with the help of GIS. The coordinates recorded by the GPS were in UTM (WGS 84). This database file including the point number, name of station, landscape pattern and its coordinates is shown in Table 4.

Table 4 Database file for sampling stations.

ID	Station name	Latitude	Longitude	Landscape pattern
1	**Sidbi**	26.51	80.23	Institutional
2	**Vikas Nagar**	26.49	80.29	Residential
3	**Dadanagar**	26.47	80.34	Commercial
4	**Colonel Ganj**	26.47	80.34	Commercial
5	**Pared**	26.45	80.29	Industrial
6	**Ramadevi**	26.44	80.32	Residential
7	**Juhilal Colony**	26.41	80.39	Residential

4.2.1.2 Sampling grids

The data collected was in an area of 2 km × 2 km square grid around the sampling centres mentioned in above section. Thus, 7 square grids were created which represented the area of sampling in the city as shown in Figure 7. The whole city was divided into 154 grids of 2 km ×2 km (Figure 7). The environmental and health data were collected and analyzed grid-wise.

4.2.1.3 Point source

There are a total of 20 point source which were surveyed. A detail of 20 point source industries with stack height above 25 m is shown in Figure 7 and Table 5.

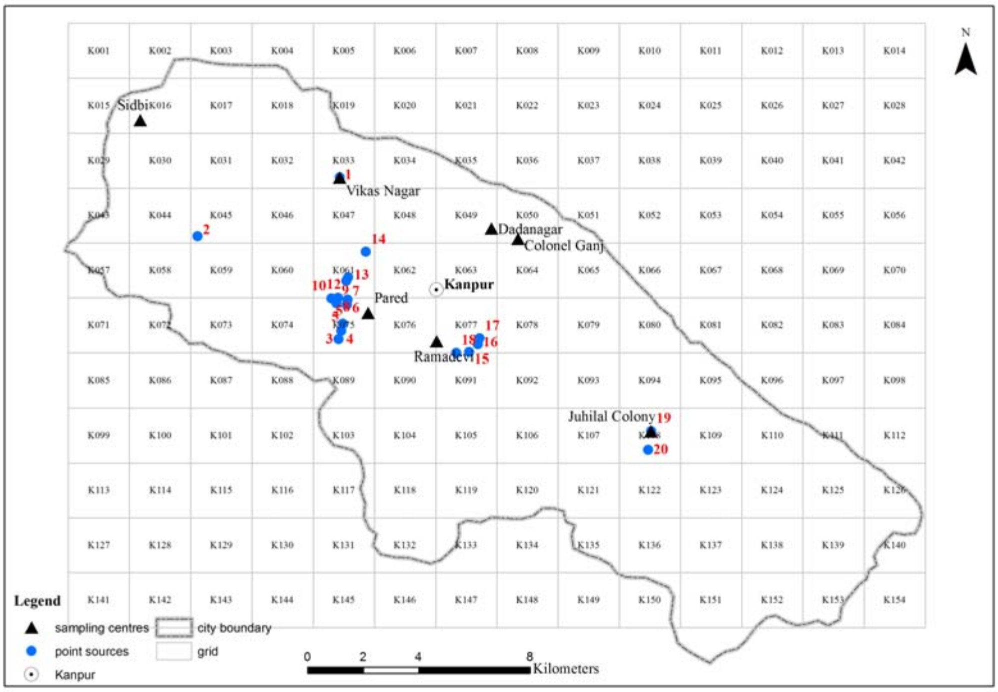

Figure 7 Sampling centers, sampling grids and point source locations in Kanpur.

Table 5 Information for point source industries in Kanpur.

Source No.	Grid No.	Industry	Capacity	Fuel Consumption	Stack Height (m)	Latitude (N)	Longitude (E)
1	**K033**	Rice Mill	48 T/d	640 Kg/d coal	30 m	26 º 29'40.18"	80º 7'11.45"
2	**K045**	Thermal Power Plant	2×110 MW	2030 T/d coal	120 m	26º28'31.08"	80º14'25.878"
3	**K075**	Iron and Steel Industry	31.59 T/d	2.2 T/d coal	30 m	26º26'30.26"	80º17'10.073"
4	**K075**	Textile Industry	7 T/d	700 L/d diesel	60 m	26º26'40.24"	80º17'13.043"
5	**K075**	Rice Mill	150 T/d	2 T/d coal	35 m	26º26'48.34"	80º17'15.035"
6	**K075**	Iron and Steel Industry	20 T/d	20 L/d diesel & 18 T/d coal	25 m	26º27'10.66"	80º17'20.076"
7	**K075**	Iron and Steel Industry	50 T/d	4.5 T/d coal	30 m	26º27'11.628"	80º17'20.016"
8	**K061-K075**	Iron and Steel Industry	28 T/d	3 T/d Coal	25 m	26º27'18.762"	80º17'9.732"
9	**K061-K075**	Oil Industry	2 T/d	2 T/d coal	25 m	26º27'12.56"	80º17'07.662"
10	**K061-K075**	Textile Industry	5 T/d	1 T/d coal	55 m	26º27'17.95"	80º17'1.87"
11	**K075**	Rice Mill	25 T/d	375 kg/d coal	30 m	26º27'16.44"	80º17'20.35"
12	**K061**	Textile Industry	5.5 T/d	1 T/d coal	60 m	26º27'38.632"	80º17'19.481"
13	**K061**	Leather Industry	5 T/d	960 L/d diesel	35 m	26º27'42.745"	80º17'21.312"
14	**K061**	Iron and Steel Industry	11 T/d	10 L/d diesel & 1 T/d coal	25 m	26º28'12.745"	80º17'42.131"
15	**K077-K091**	Oil Industry	7.5 T/d	750 L/d diesel	30 m	26º26'15.542"	80º19'42.236"
16	**K077**	Rice Mill	36 T/d	480 kg/d coal	35 m	26º26'24.356"	80º19'52.423"
17	**K077**	Leather Industry	5 T/d	5 T/d Coal	35 m	26º26'31.256"	80º19'54.581"
18	**K077-K091**	Rubber Industry	10 T/d	2 T/d coal	30 m	26º26'14.334"	80º19'27.184"
19	**K108**	Textile Industry	12 T/d	1.2 T/d coal	80 m	26º24'43.152"	80º23'14.361"
20	**K108**	Rice Mill	35 T/d	425 kg/d coal	35 m	26º24'21.285"	80º23'11.186"

4.2.1.4 Environmental data

Emission inventory includes emission of SO_2, PM, NO_X and CO from various sources, e.g. vehicles domestic, garbage burning, restaurant, medical-waste incinerator, funeral burning, etc. The detail databases are shown in Appendix 2.1-2.4, respectively.

4.2.2 Health parameter selection and data extraction

The two teams identified the relevant health parameters and extracted data from the medical records. Several types of data were recorded in the unit of 2 km×2 km grid from the period 10 January 2006 to 25 May 2007.

The sources in priority order for manual entry are:

- Outdoor patient
- Indoor patient
- Respirator patients (Intensive Care Unit–ICU or those on non-invasive respirator)
- Lung patients

The description of the health parameter and database is shown in Table 6. The total number of patients for outdoor, indoor, ICU and lung are shown in Appendix 3.

Table 6 The description of health parameter and database in Kanpur, India.

Type of patients	Record period	Record item	Patients number
Outdoor	10.1-29.12.2006	Age, sex, smoking, occupation, address, symptom	8557
Indoor	28.3-25.5.2007	Age, sex, smoking, occupation, address, symptom, diagnosis	2273
ICU	3.4-21.5.2007	Age, sex, smoking, occupation, address, symptom, diagnosis	77
Lung	14.7-21.8.2007	Age, sex, smoking, occupation, address, symptom, diagnosis, FVC (forced vital capacity), FEV (forced expiratory volume), FEV/FVC	718

4.2.3 Outdoor pollution assessment

4.2.3.1 Correlation between SO_2, NO_X and PM

The variables SO_2, NO_X and PM are highly correlated. The variable PM is the one most correlated with the remaining pollutants variables, SO_2 and NO_X (Table 7).

Table 7 Correlation between variables SO_2, NOX and PM.

Variable	NO_X	PM	SO_2
NO_X	1.0000000	0.9002302	0.8427640
PM	0.9002302	1.0000000	0.9561169
SO_2	0.8427640	0.9561169	1.0000000

One-way anova analysis (Kirk 1995) of variance between groups or Kruskal-Wallis test (Kruskal and Wallis 1952) showed that the degree of emissions was significantly dependent upon the factor 'land use types' (Table 8 and Figure 8).

Table 8 Kruskal-Wallis test for dependence of variables SO_2, NOX and PM on factor 'land use types'**.**

Variable\test	Kruskal-Wallis chi-squared	Degrees of freedom	P-value
NOx	30.1228	4	4.621e-06
PM	39.8352	4	4.682e-08
SO_2	54.0952	4	5.027e-11

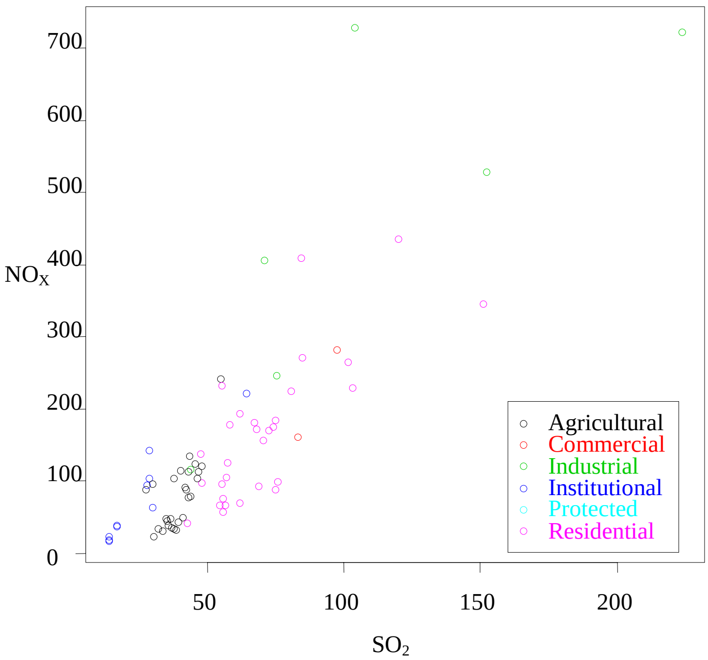

Figure 8 Correlation between NOX and SO_2 based upon six land use types.

From Figure 8, we can see that the values of SO_2 and NO_X are much higher in the industrial region than in the institutional regions.

4.2.3.2 Clusters of emissions

Four levels of emissions of SO_2, NO_X and PM, based upon all the emission sources excluding stacks higher than 25 m, were divided by using cluster analysis on the three-dimensional data (Figures 9-10).

The representation of emissions from each variables SO_2, PM and NO_X in each cluster is shown in Table 9. The division of the 78 grid-cells into four distinct groups is shown in Figure 10.

Table 9 Emissions of SO2, PM and NOX in each cluster.

Cluster	SO_2 (kg/day)	PM (kg/day)	NO_X (kg/day)
1	36.08	44.57	39.00
2	46.57	75.72	104.23
3	62.19	134.76	194.15
4	120.16	259.34	434.97

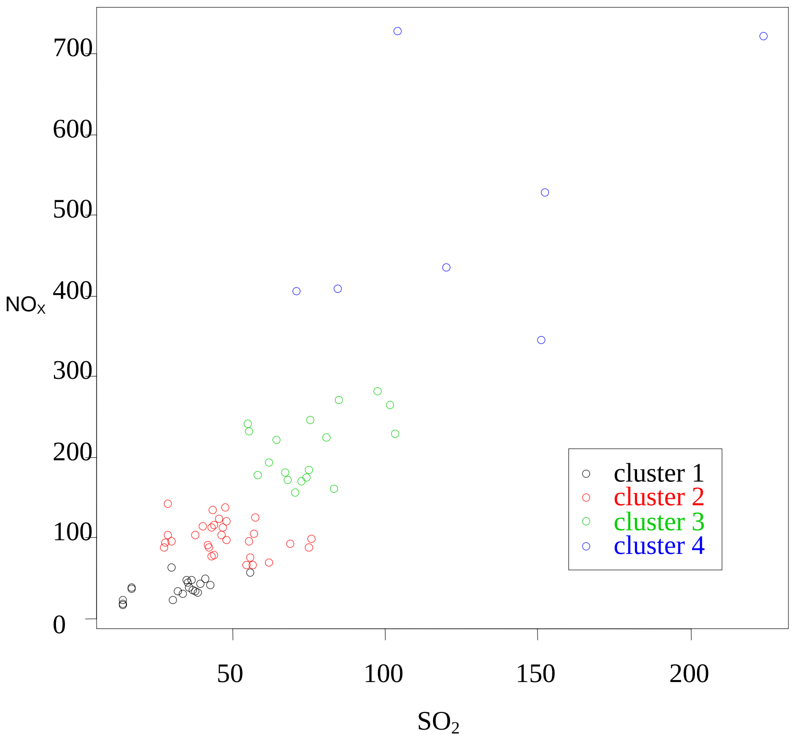

Figure 9 SO_2 and NO_X of the clusters based upon all the sources excluding stacks higher than 25 m.

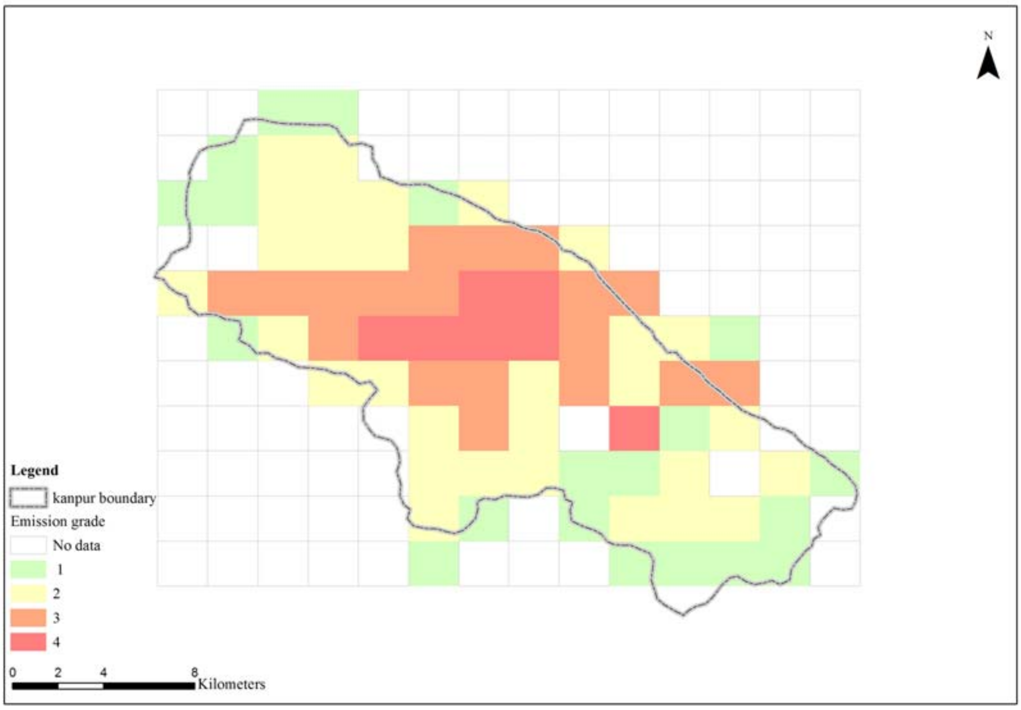

Figure 10 Four clusters of total emission (kg/day) from various sources in the city (1-less polluted, 2-polluted, 3-highly polluted, and 4-very highly polluted).

4.2.4 Statistical analysis

For all data analysis, the R freeware, version 2.7.1 (Anonymous 2004a, 2004b), packages '*cluster*' and '*rgl*' (Oksanen 2007, Oksanen et al. 2007), were used. For clustering *R*-functions '*kmeans*' and '*pam*' from package '*cluster*' were used.

ArcGIS 9.0 (ESRI, http://www.esri.com) was used for all the illustration maps.

4.2.4.1 Analysis of hospital visits

The total population of all grids was incorporated into this analysis of hospital visits. Pearson's chi-square test for independence in the contingency table of number of people coming and not coming to the pulmonary clinic classified by the clusters, showed that the morbidity is much high in the higher polluted regions (clusters 3 and 4, see Table 10 and Figure 11).

Table 10 Number of inhabitants coming and not coming to the clinic in each cluster.

cluster / patient	1	2	3	4
Yes	466	1274	1553	781
No	448863	747183	448925	231443

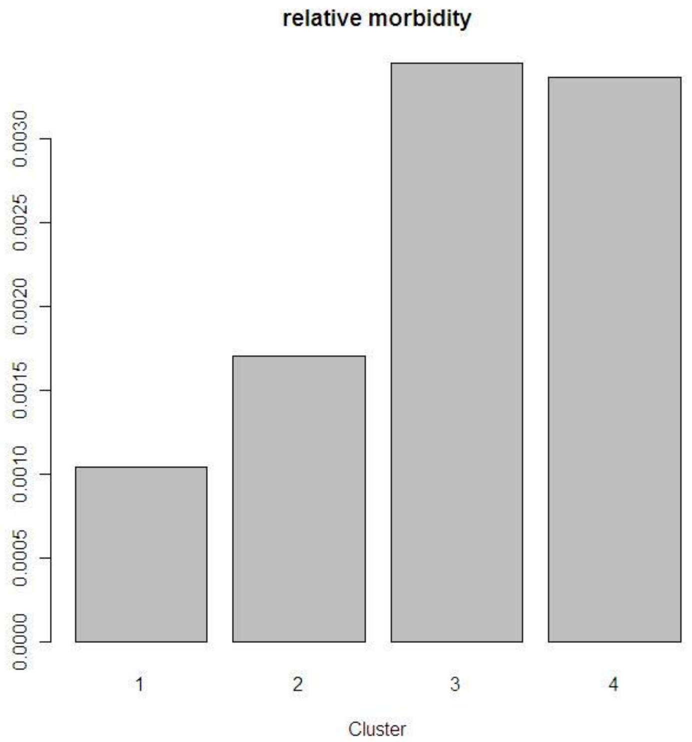

Figure 11 The relative morbidity (inpatients/total population) in the clusters.

Furthermore, we considered a logistic regression model where we modeled an occurrence of a person in the pulmonary clinic in dependence on the cluster (level of pollution) of the home grid. People not coming to the clinic played the role as the control group.

Independent of the cluster variable type (e.g. nominal, ordinal or quantitative), the conclusion was that the level of pollution significantly influence the morbidity on any reasonable level.

The computation of the 95% simultaneous confidence interval for the difference of effect of all the pairs of levels of factor cluster, indicated that the morbidity significantly differs for every pair except between the clusters 3 and 4 (Figure 12), where no difference was found.

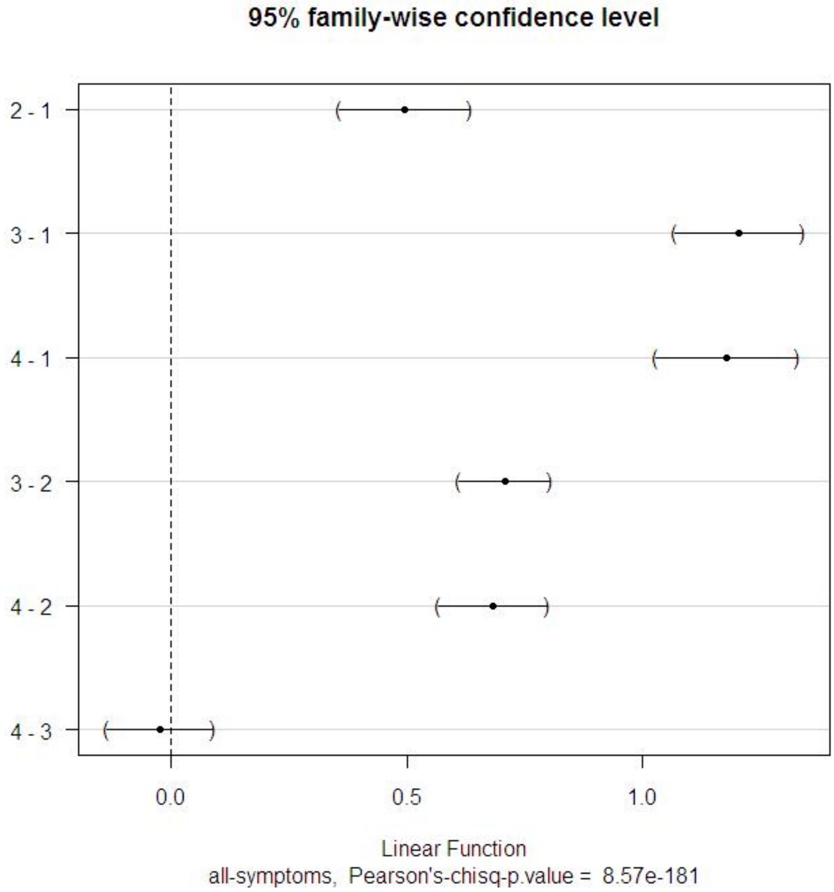

Figure 12 Difference of the effects of the clusters on the morbidity.

Table 11 shows the estimated coefficients for the differences of the effects of the levels of emission (factor cluster), 95% confidence interval (CI), odds ratios (the value by which the relative risk of having pulmonary problems is multiplied when we moved from one cluster to another), and the 95% confidence interval of the odds ratios. The latter two indicators are just the exponentials of the estimates and the confidence intervals.

Similarly, we got the same results by analysing the twelve classified symptoms individually, not simultaneously. In fact, cluster 1 and 3 differed significantly for all the symptoms and cluster 3 and 4 were not different for any of the twelve symptoms' classes (Figure 13).

Table 11 Comparison of the effects of the factor cluster (emission level) with simultaneous confidence intervals and the odds ratios with their simultaneous confidence intervals.

Contrasts	Estimate	95% CI of estimate	Odds ratio	95% CI for odds ratio
2 - 1	0.50	(0.36, 0.63)	1.64	(1.43, 1.89)
3 – 1	1.20	(1.07, 1.34)	3.33	(2.91, 3.81)
4 – 1	1.18	(1.03, 1.33)	3.25	(2.80, 3.78)
3 – 2	0.71	(0.61, 0.80)	2.03	(1.84, 2.24)
4 – 2	0.68	(0.57, 0.80)	1.98	(1.76, 2.22)
4 – 3	-0.02	(-0.14, 0.09)	0.98	(0.87, 1.09)

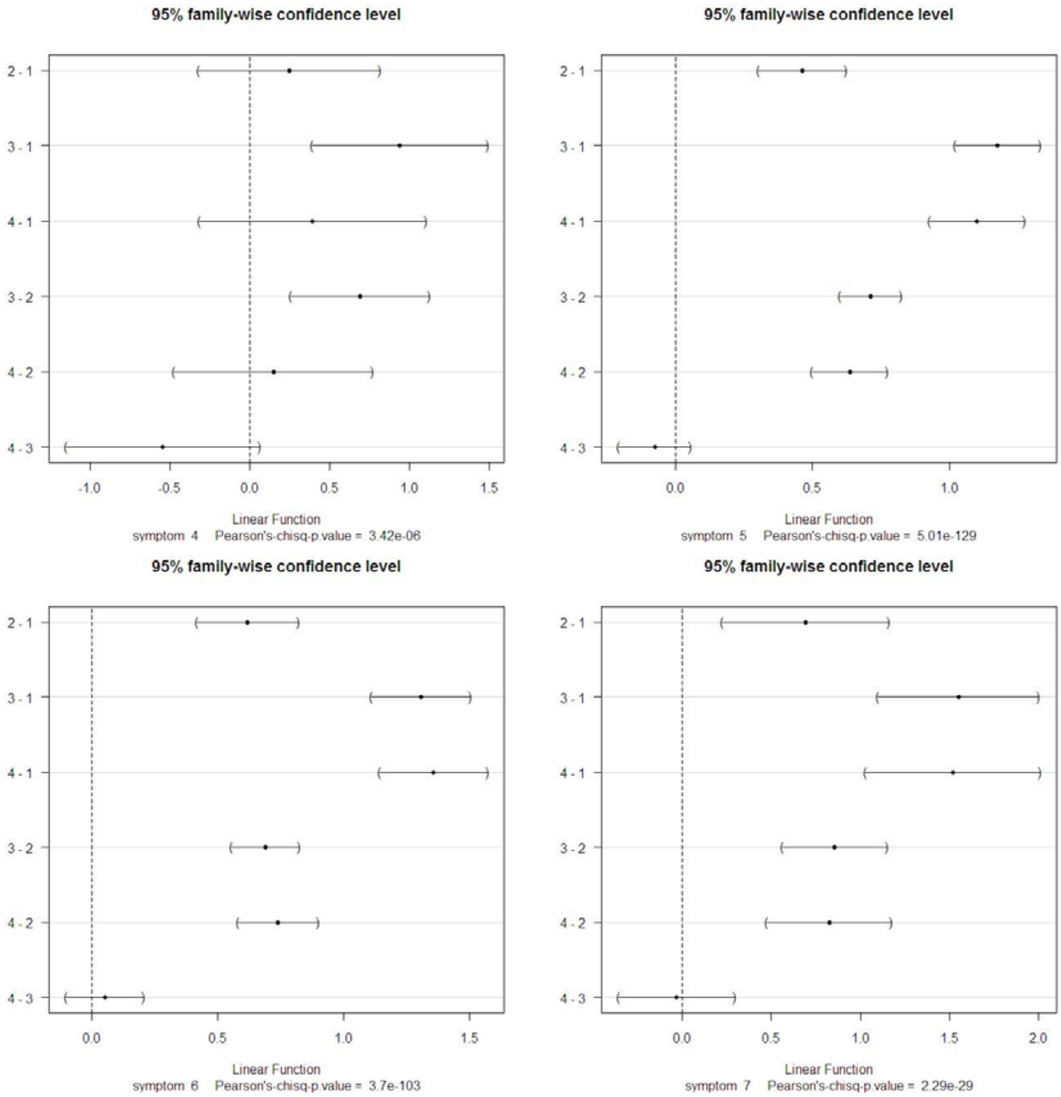

Figure 13 Effects of clusters for symptoms common cold, cough, fever and hemoptysis.

4.2.4.2 Time Analysis

The aim of time analysis is to assess an effect of time on the distribution of the morbidity in the four clusters and on the hospital visits.

First, we looked at the total number of patients for each cluster in each of the twelve months of the year 2006. Table 12 shows absolute values of the patients and the 3D-barplots on Figure 14 shows the relative morbidity in each cluster and month.

Table 12 Number of patients in the four clusters and twelve months.

Cluster / Month	1	2	3	4
1	30	95	129	57
2	44	99	128	71
3	45	111	161	66
4	44	106	139	55
5	45	98	121	73
6	36	107	131	71
7	32	106	133	75
8	47	126	127	69
9	29	119	131	77
10	28	71	109	62
11	48	113	117	52
12	19	70	88	38

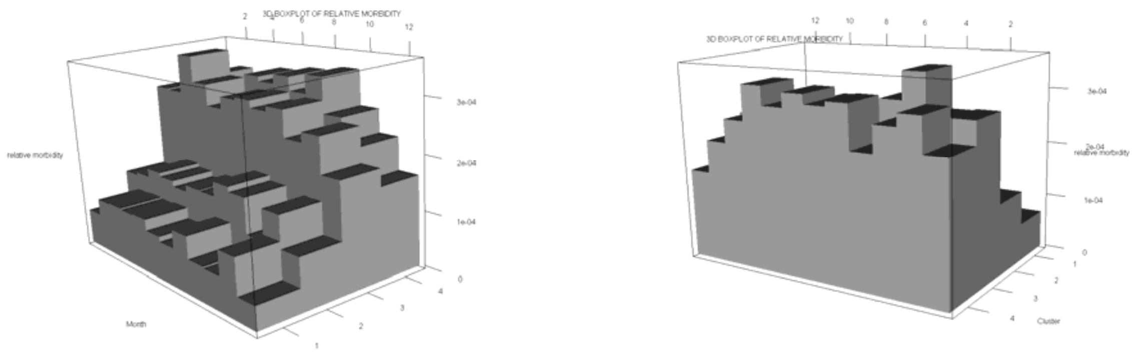

Figure 14 Relative morbidities as a function of cluster and month.

To study the influence of the time (months) on the distribution of hospital visits in the clusters or the effect of the clusters (level of pollution) on the distribution of the morbidity during the year, we performed the Pearson's chi-squared test for independence in the contingency. *P*-value of this test was, however 0.29, so we did not reject on the 5% level of significance the hypothesis that there is no relationship between the variables month and cluster. The evidence strong was not enough to claim that the distribution of the morbidity in the clusters depends on the time of the year or that the distribution of the morbidity during the year depends on the variable cluster.

Another question we can ask is: Does the morbidity vary during the year regardless of the variable cluster? We collapsed Table 12 to get the marginal sums for the months. Adding the patients without the information about the grid we get the following Table 13.

Table 13 Number of patients coming to the clinic in each month.

Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Number of patients	555	684	738	680	747	784	772	837	768	581	732	462

Dividing the twelve months into two samples, we employed a two-sample test for difference in location. The first sample consisted of the summer months (April to September) and the second sample of the remaining winter months. The Wilcoxon two-sample test resulted in a rejection (on 5% level) of the hypothesis of no difference (*P*-value 0.015) and hence we concluded that there is a difference in the hospital visits for summer and winter months.

4.2.4.3 Analysis of occurrence of an symptom

This part of analysis will only take into account the patients who came to the clinic with pulmonary problems. We took symptoms one by one. For each symptom we assigned to the patient "1" if he or she suffered from the symptom or "0" if he or she did not. Thus, here, the control group consisted of the patients who did not suffer the specific symptom, but suffered at least one other possibly worse symptoms.

We considered a logistic regression model with the occurrence of the symptom as the response and the variables cluster, sex, smoke and age (in years) and possibly their interactions as the regressors. We found out that only the symptoms 4, 5, 6 and 7 were significantly influenced by the ordered factor "cluster". The less serious symptoms, e.g. common cold and cough were less frequent in the higher polluted clusters, whereas the more serious symptoms, e.g. fever and hemoptysis, were more likely to occur in the higher polluted clusters of the grids.

Next, we took a closer look at the four symptoms. First we found the best model for each of the symptoms for the set of all patients (e.g. setting cluster equal to zero for the patients without any grid number, where most of these patients came from outside the city), then for the patients with grid information. We gave the estimated coefficients of the best models and their interpretation including their confidence interval. We used a stepwise backward selection procedure (Kleinbaum 1994) to find the best model.

4.2.4.3.1 Common cold

For the set of all patients the factor cluster was not significant when the other variables were included. We gave the set of the explanatory variables from the final model we found. We presented the estimates of the corresponding coefficient, its 95% confidence interval, its effect (e.g. odds ratio) and the 95% confidence interval of the odds ratio.

Table 14 Significant explanatory variables for the occurrence of common cold, for all the patients.

Common cold – all patients	**Smoke (Yes)**	**Age**	**Sex (Male)**
Estimate	-0.40	-0.016	0.42
95% CI of estimate	(-0.71, -0.10)	(-0.022, -0.0096)	(0.20, 0.65)
Odds ratio	0.67	0.9845	1.5
95% CI of odds ratio	(0.49, 0.90)	(0.9785, 0.9904)	(1.2, 1.9)

Further, we analyzed only the patients with the grid information. For cluster being an ordered factor (i.e. with the orthogonal polynomial contrasts), the linear trend was significant with a negative estimate of the coefficient, although the overall effect of cluster was not significant on the 5% level. To better interpret the effect of cluster, we treated cluster as a numeric (quantitative) variable.

Table 15 Significant explanatory variables for the occurrence of common cold, for the patients with a known grid.

Common cold – known grid	**Cluster**	**Age**	**Sex (Male)**
Estimate	-0.15	-0.015	0.34
95% CI of estimate	(-0.31, 0.018)	(-0.024, -0.0068)	(0.026, 0.66)
odds ratio	0.86	0.9848	1.4
95% CI of odds ratio	(0.73, 1.0)	(0.9764, 0.9932)	(1.0, 1.9)

4.2.4.3.2 Cough

The strucplot display in Figure 16 shows the histograms for sex, smoke, cluster and cough on the diagonal and the empirical distribution for all of the pairs. We can see that, as expected, relatively few female smokers, which in turn can cause estimation problems.

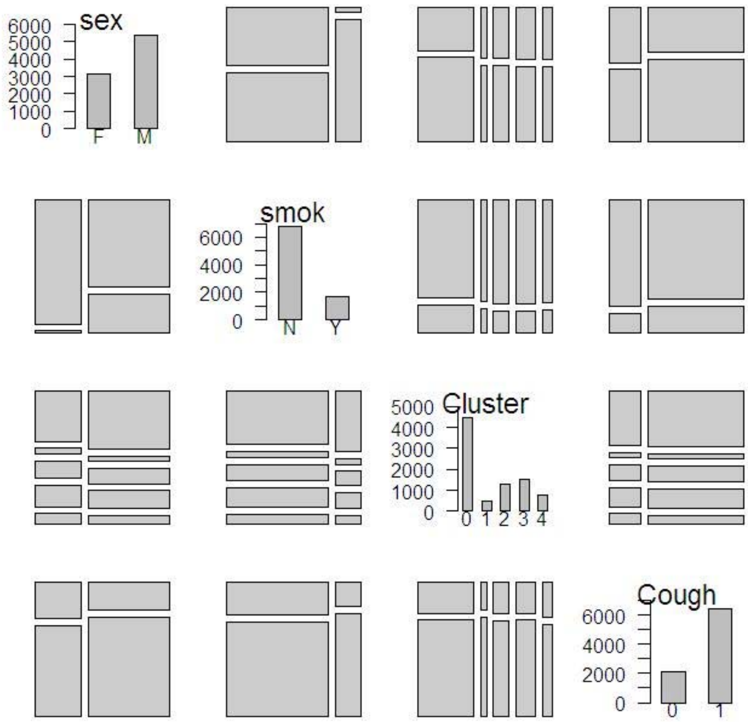

Figure 16 Matrix of strucplots for cough.

For the symptom cough, both best models we found included variable I (cluster = 4) which equals to “1” if the cluster is 4 and “0” otherwise. Both models also included interaction term I (cluster = 4): sex, which made it more difficult to assess the effects of these two regressors. In the model, for all patients the interaction term had a coefficient estimate 0.71, and in the smaller model, 0.73.

Table 16 Significant explanatory variables for the occurrence of cough, all the patients.

Cough–all patients	**I(cluster=4)**	**Smoke (Yes)**	**Age**	**Sex (Male)**
Estimate	-0.56	0.17	0.0053	0.21
95% CI of estimate	(-0.81, -0.31)	(0.021, 0.32)	(0.0024, 0.0082)	(0.095, 0.33)
Odds ratio	0.57 (sex=F) 1.2 (sex=M)	1.2	1.005	1.2 (cluster<4) 2.5 (cluster=4)
95% CI of odds ratio	(0.45, 0.74) (sex=F) (0.90, 1.5) (sex=M)	(1.0, 1.38)	(1.002, 1.008)	(1.1, 1.4) (cluster<4) (1.8, 3.5) (cluster=4)

If cluster is an ordered factor (in a model containing only the patient with a known grid), its linear trend is significant. However, we found a better model containing only the term I (cluster = 4).

Table 17 Significant explanatory variables for the occurrence of cough, for the patients with a known grid.

Cough–known grid	**I(cluster=4)**	**Age**	**Sex (Male)**
Estimate	-0.63	0.0021	0.24
95% CI of estimate	(-0.90, -0.37)	(0.0022, 0.010)	(0.065, 0.40)
odds ratio	0.53 (sex=F) 1.1 (sex=M)	1.006	1.3 (cluster<4) 2.6 (cluster=4)
95% CI of odds ratio	(0.41, 0.69) (sex=F) (0.84, 1.4) (sex=M)	(1.002, 1.010)	(1.1, 1.5) (cluster<4) (1.9, 3.7) (cluster=4)

4.2.4.3.3 Fever

Similarly, the strucplot display for fever is shown in Figure 17. Although the interaction terms smoke: age, and age: sex were slightly significant, we excluded it from the final model to keep it simple for both sets of patients.

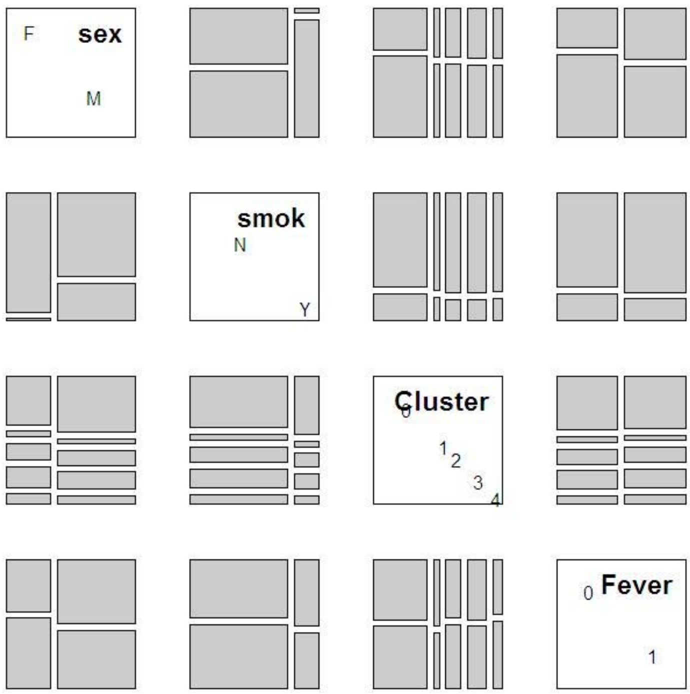

Figure 17 Matrix of strucplots for fever.

Table 18 Significant explanatory variables for the occurrence of fever, for all patients.

Fever–all patients	**I(cluster=1)**	**Age**	**Sex (Male)**
Estimate	-0.28	-0.011	-0.36
95% CI of estimate	(-0.48, -0.082)	(-0.013, -0.0082)	(-0.46, -0.27)
Odds ratio	0.76	0.9895	0.70
95% CI of odds ratio	(0.62, 0.92)	(0.9871, 0.9918)	(0.63, 0.76)

Table 19 Significant explanatory variables for the occurrence of fever, for the patients with a known grid.

Fever–known grid	**I(cluster=1)**	**Smoke**	**Age**	**Sex (Male)**
Estimate	-0.31	0.21	-0.012	-0.46
95% CI of estimate	(-0.51, -0.10)	(0.023, 0.39)	(-0.016, -0.0089)	(-0.61, -0.32)
Odds ratio	0.74	1.2	0.9876	0.63
95% CI of odds ratio	(0.60, 0.90)	(1.0, 1.5)	(0.9841, 0.9911)	(0.55, 0.72)

4.2.4.4 Hemoptysis and similar

There was a weak linear trend of ordered factor cluster with a positive estimate of the coefficient on the occurrence of the hemoptysis, but the final models did not include it.

Table 20 Significant explanatory variables for the occurrence of hemoptysis, for all patients.

Hemoptysis – all patients	**Age**	**Sex (Male)**
Estimate	-0.0064	0.22
95% CI of estimate	(-0.010, -0.0025)	(0.064, 0.37)
Odds ratio	0.9936	1.24
95% CI of odds ratio	(0.9897, 0.9975)	(1.1, 1.45)

Table 21 Significant explanatory variables for the occurrence of hemoptysis, for the patients with a known grid.

Hemoptysis – known grid	Age
Estimate	-0.0012
95% CI of estimate	(-0.016, -0.0089)
Odds ratio	0.9936
95% CI of odds ratio	(0.9880, 0.9992)

4.3 Task 3 Dissemination and management

Due to the course of the academic year, the activities in India could not be started before August 2006. Activities of the Norwegian partner (preparation of instruments for shipping, detailed planning for the measurement campaigns, planning of the health impact assessment including air quality assessment) progressed only with minor delays. As a consequence, a re-scheduling of several tasks was necessary, and the teams agreed upon a revised time plan.

Minor difficulties were encountered with regards to custom duty on the instrumentation. The Indian partner tried to recover the paid duty by invoking the agreements in place for IITK in relation to scientific equipment. To date, the instrumentation has not been returned to NILU, and is incurring additional costs to the Norwegian partner.

Due to staff changes and changes in project portfolio of the Norwegian partner, significant delays in reporting have occurred.

Regarding dissemination, a seminar was held on issues of air quality management for students and staff at IITK. Furthermore, an article on the project was published in Times of India (Kanpur local edition). Other dissemination work was restricted in order to prepare results for publishing scientific papers. An article on ‘verification of measurement methods in relation to CEN standard EN12341 on PM10 monitoring in Kanpur, India’ has been submitted to ‘Environmental Monitoring and Assessment’. Another article on ‘respiratory disease in relation to outdoor air pollution in Kanpur, Uttar Pradesh, India’ has been finalized and will be submitted to ‘Achieves of Environmental Health’. In addition, possibilities for a scientific workshop will be investigated.

5. Degree of achievement of the goals and objectives of the project

The goals of activity 1 and 2 were achieved fully. The goals of Activity 3 were achieved to a low degree, as the final workshop took place in March 2010.

6. Sustainability of the cooperation between the participating institutions

IIT Kanpur, GSVM Medical College and NILU have been collaborating since 2003, while the CPCB Agra only joined the project team in 2006. For the current project, the three Indian institutions have been collaborating for a long time. The collaboration was efficient. A number of visits were executed, for technical and scientific purposes:

- Inception workshop and technical visit in Kanpur and Agra
- Technical visits by NILU staff in Kanpur and Agra
- Scientific visit by the Indian team to Norway.

These visits were essential for the functioning of the project, and to achieve the same understanding of the project and implementation issues by the teams.

Future collaboration of the teams is dependent on being able to find suitable sustainable financing. Such sources include the Framework Programs for Research and development of the European Commission (FRP), the national funding agencies and authorities in India (including the State and Central Pollution Control Board), and other national and international funding agencies. Common applications for funds to the 7th FRP have already been sent, but have not been successful. The teams are complementary in their skills and have similar professional interests. For these reasons we believe that future collaboration is very likely.

7. Arrangement for institutionalisation of benefits

At NILU, the project is among important reference projects. It contributes to the institutional knowledge on environmental health impact assessment. On the technical side, the project is relatively routine, but with high demands on the quality control and quality assurance systems and technical knowledge, and requiring substantial communication skills.

At the Indian side, the IITK has been able to further pursue the collaboration with the State Pollution Control Board and with the Central Pollution Control Board. These activities were very important to show the difference in monitoring, and to demonstrate the necessity to use reference methods to make sure that monitoring results are correct. The results will furthermore be pursued.

The relation between health and environmental quality, while known from literature, has not been demonstrated previously in Kanpur, one of the most polluted urban areas in India. The project has demonstrated that health benefits of reducing pollution can be substantial, at a time where the state authorities are implementing many measures for improvement. Thus the project lays a basis for documenting the benefits of such measures, using locally collected data instead of theoretical information from other places, which are not always directly applicable.

For IIT, as a teaching institution, the project has value in allowing a practical demonstration of the field skills, the importance of quality assurance and quality control, showing the basics of health impact assessment, and not least, providing the authorities with data on emissions, air quality and health effects that were not available before, and that should, by their nature, make a large impact.

8. Mutuality of benefits derived by individual institutions

The institutions participating in this project have each gained important experience. The Indian institutions obtained technical knowledge. All institutions generated new data that were not available before, and carried out environmental health impact assessment based on quality assured measurements, models and surveillance. Such data are not common in India, and contribute thus significantly to international knowledge basis. All institutions have also extended their contacts and improved their collaboration with State Pollution Control Board in Uttar Pradesh and Central Pollution Control Board.

9. Assessment of technology/knowledge transfer exchanged between institutions

There are four aspects of the technology and knowledge transfer: quality assurance and control, monitoring of particulate matter, emission inventories for criteria pollutants, and methods for air pollution/environmental health impact assessment.

Quality assurance and quality control methods and Standard Operating Procedures established at IIT laboratory, were demonstrated for the State Control Pollution Board sites in Kanpur, and were checked at the CPCB laboratory in Agra.

Monitoring of particulate matter done routinely in the monitoring network in India was compared to European standard method, and was found to provide significantly lower (20%) results than the European standard method. This has grave implications for the Indian monitoring network operation.

Emission inventories using a standardized reporting system were carried out using a combination of techniques. The emission inventories were done for the first time in Kanpur. IITK gained further insight into the methodologies used in Europe, and NILU gained access to a reference emission dataset that can further be used for air quality modelling and assessments.

Health data, collected using standardized and quality assured methods, are not very common, and are invariably very valuable both to the researchers, and to the authorities. They form a basis for being able to provide environmental health impact assessment. Such data set was collected by the GSVM medical college, and can be used for further investigations. First results showed that the dataset, when coupled with the environmental data generated in the project, demonstrates an association between deteriorated environmental quality and deteriorated respiratory health. Such results cannot be obtained without the other activities of the project, and is fairly unique and highly valued by the research teams.

10. Strategy for dissemination

Dissemination strategy was based on two workshops in India (Inception and Final), and on scientific publishing. For reasons connected to temporarily lower capacity of the participating institutions, the final workshop has yet to be performed, but it is quite essential to ensure transfer of the numerous results of the project to the national and state authorities. The study team wishes to find further possibility to convene this workshop at a later stage.

11. Assessment of any commercial spin-offs or prospects for commercial benefits as a off shoot of the project

This project does not have direct commercial spin-offs or prospects for commercial benefits. However, the project is commercially important for the manufacturer of the RDS sampler (an Indian company) that would have to bring their instrumentation in line with the standards used elsewhere. Further, the project has implications for the CPCB laboratory in Agra which has confirmed high quality of their operations.

12. Experience of the co-operating institutions regarding funding arrangements

The collaborating institutions value the flexibility of the funding arrangements, and have no comments to those.

Table 22 Audited statement of accounts for the approved grant

	Approved (latest provision)	Disbursement previous period	Funds received during the reporting period	Cumulative disbursement	Expenditure previous periods	Expenditure during the reporting period	Cumulative expenditure	Total budget	Total requirement
Task 1 Verification of measurement methods							782,749	678,240	
Personnel		208,614	0	208,614	385,438	100,074	485,512	345,840	275,760
Travel expenses		94,200	0	94,200	109,371	26,815	136,186	188,400	173,000
Other direct expenses		29,756	0	29,756	94,117	66,934	161,051	144,000	4,000
instrument rent					*12,690*	*30,456*	*43,146*	*50,000*	*0*
Other direct expenses					*81,427*	*36,478*	*117,905*	*94,000*	*4,000*
Task 2 Assessment of population burden of disease due to air pollution							359,719	438,200	
Personnel		39,640	0	39,640	112,838	214014	326,852	406,800	406,800
Travel expenses		31,400	0	31,400	23,843	0	23,843	31,400	31,400
Other direct expenses					9,024	0	9,024	0	0
Task 3 Dissemination and management					205,694		306,074	451,040	
Personnel		108,480	0	108,480	180,616	100,380	280,996	325,440	325,440
Travel expenses		35,000	0	35,000	23,927	0	23,927	125,600	125,600
Other direct expenses					1,151	0	1,151	0	0
Total	570,910	547,090	570,910	1,118,000	940,325	508,217	1,448,542	1,567,480	1,342,000

13. Conclusions

13.1 Comparison of monitoring equipment

The results show that the monitoring equipment for particulate matter, often used in the Indian monitoring network, provides 20% lower results than both high volume sampling equipment and the European reference method.

13.2 Emission inventories for criteria pollutants

Emission inventory for particulate matter, sulphur dioxide and nitrogen oxides were created for the area of the city of Kanpur, including point, area and line sources for the year 2006.

13.3 Association between the relative number of hospital visits and the extent of air pollution

There was a difference in the hospital visits between the areas with less pollution (cluster 1) and with more pollution (clusters 2, 3 and 4). For instance, comparing cluster 1 and 3, in the grids where the average pollution of SO_2 increased from 36.08 to 62.19, PM from 44.57 to 134.76 and NO_X from 39.00 to 194.15 kg per day, the relative risk of pulmonary problems of the inhabitants is higher by 3.33 (with 95% CI of (2.91, 3.81)), which is a very high increase. In other word, the morbidity with pulmonary disease is much greater in the higher polluted regions in Kanpur. This is consistent with the results from the study by Petroeschevsky et al. 2001, that the levels of air pollution make a significant contribution to the variation in daily hospital administration for asthma and respiratory disease in Brisbane, Australia.

There was no difference in the hospital visits between the areas of high pollution (cluster 3) and very high pollution (cluster 4). Apparently, both regions within clusters 3 and 4 are highly polluted. The relative morbidity with pulmonary disease in these two areas was higher than 0.003.

There was no any association between the time and the distribution of hospital visits in the areas with different levels of pollution. However, regardless of the variable level of pollution, a difference in the hospital visits between summer and winter months was present. In general, number of patients with pulmonary disease who came to the clinic was much higher during summer than the number during winter.

There was no difference in the occurrence of each pulmonary disease symptom (e.g. common cold, cough, fever and hemoptysis) between the areas of high pollution (cluster 3) and very high pollution (cluster 4). However, there was a difference in the occurrence of each pulmonary disease symptom between the areas of less pollution (cluster 1) and pollution (clusters 2, 3 and 4). This indicates that in more polluted areas, pulmonary disease patients show more serious symptoms.

13.4 Effect of the air pollution on the distribution of the symptoms among the patients of the clinic

Within the 12 pulmonary disease symptoms, only the symptoms 4 (common cold), 5 (cough), 6 (fever) and 7 (hemoptysis) were significantly influenced by the factor cluster. For the relatively more serious symptom, e.g. fever and hemoptysis, the relative risk increased in the highly polluted areas, e.g. in the highest polluted areas (cluster 4), the relative risk of having fever increased by approximately 25%. In the opposite, the less serious symptoms, e.g. common cold and cough were less frequent in the higher polluted areas.

14. References

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Appendix 1 Time plan and milestone list

Appendix 1.1 Revised time plan

		2006									2007											
	Month	***Apr***	***May***	***Jun***	***Jul***	***Aug***	***Sep***	***Oct***	***Nov***	***Dec***	***Jan***	***Feb***	***Mar***	***Apr***	***May***	***Jun***	***Jul***	***Aug***	***Sep***	***Oct***	***Nov***	***Dec***
Task 1	**Deployment of instrumentation**					x	x															
	Calibration procedures, reference samplers					x	x			x			x			x						
	Control of balance for filter weighing						x			x			x			x						
	Reference sampler assessment									x	x		x	x		x	x					
	Network samplers assessment									x	x		x	x		x	x					
	Technical visits of NILU personnel						x			x			x			x						
	Training in Norway														x							
	Reporting														x	x	x	x	x			
Task 2	**Health parameter selection and data extraction**						x	x	x	x	x	x	x									
	Emission inventory							x	x	x	x	x	x									
	Outdoor pollution assessment											x	x	x	x	x	x					
	Cooking habits: emissions and exposure patterns							x	x	x	x	x	x									
	Exposure assessment and statistical analysis														x	x	x	x	x	x	x	
	Visit to India																				x	
	Visit to Norway														x							
	Reporting																		x	x	x	x
Task 3	**Detailed project planning**	x	x	x	x	x	x															
	Inception workshop and first expert workshop							x														
	Final workshop																				x	
	Administration and reporting	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Appendix 1.2 Provisional milestone list

Date	Subtask No.	Action	Institution
October 15	**2.1**	Provide Urban Air reports to IITK. Provide a draft plan for sampling (in all, project budget is based on 180 filters for each location). Provide information on how to assess background particulate matter from satellite images (article).	NILU
October 15	**1.1**	Finish Standard Operating Procedures	CPCB/IITK
October 20	**2.2**	Finalization of at least two entry sheets for data entry from medical records	NILU/ GSVMMC
October 20	**2.3**	Procure meteorological mast and sensors. The equipment used in Agra is British Investigate MetOne.	IITK
October 20	**1.2**	Change instruments between sites in Kanpur	IITK
October 31	**1.3**	Send additional filters to India	NILU
November 10	**2.4**	Acquire sources for emission inventory. Compile short report on these sources, what data are available in them, and how these can be used in the emission inventory sheets (indicate what item will be relevant to what sheet, and if any re-calculation is necessary)	IITK
November 30	**2.5**	1. Make a short report on availability of census data and procedure for gridding. 2. Provide a map of Kanpur with an overview of wards, all available air quality and meteorology monitoring stations, main road network, and grid. Include all main point sources. 3. Provide a map of a larger area (ca 30 km around Kanpur) that would cover the whole area covered by the medical bus.	IITK
November 30	**2.6**	Send all electronically entered medical data to NILU (including the quality control/check files).	GSVMMC
November 30	**1.4**	Transfer sampling results to NILU	IITK, CPCB
December 31	**2.7**	Provide feedback on medical records	NILU
December 31	**1.5**	Technical visit. Transfer of reference sampler in Kanpur. Installation of back-up power supply. Installation of meteorological mast and equipment at one Kanpur site. Transfer of exposed filters from CPCB and IITK to NILU.	NILU IITK NILU/IITK NILU/IITK NILU
December	**1.6**	Transfer files with sampling results to NILU	

Date	Subtask No.	Action	Institution
31 December	**2.8**	Transfer the emission files completed to date	IITK
31 December	**2.9**	Transfer the gridded census data to NILU.	IITK
31 December	**2.10**	Transfer the completed electronic medical records to NILU.	GSVMMC
31 January 31	**1.7**	Change sampler between sites in Kanpur	IITK
January 31	**2.11**	Feedback on emissions, feedback on medical data coding	NILU
January 31	**2.12**	**Transfer all entered emission files to NILU**	IITK
January 31	**1.8**	NILU completes weighing of filters, draft results to the Indian partners.	NILU
January 31	**1.9**	Transfer of sampling results to NILU	IITK/GSVM
February 28	**1.10**	Change sampler between sites in Kanpur	IITK
February 28	**2.12**	Feedback on emissions, feedback on medical data coding	NILU
February 28	**2.13**	**Transfer all entered emission files to NILU**	IITK
February 28	**1.11**	NILU completes weighing of filters, draft results to the Indian partners.	NILU
February 28	**1.12**	Transfer of sampling results to NILU	IITK/GSVM
March 31	**1.13**	Change sampler between sites in Kanpur	IITK
March 31	**2.13**	Feedback on emissions, feedback on medical data coding	NILU
March 31	**2.14**	**Transfer all entered emission files to NILU**	IITK
March 31	**1.14**	NILU completes weighing of filters, draft results to the Indian partners.	NILU
March 31	**1.15**	Transfer of sampling results to NILU	IITK/GSVM

Appendix 2 Emission inventory

Appendix 2.1 Emission of SO_2 from various sources (kg/day)

Series No.	Grid Id	Landscape Pattern	Vehicles	Domestic	Garbage Burning	Restaurant & Halwai	DG Sets	Medical-waste Incinerator	Funeral Burning	Industries (area source, H<25 m)	Industries (Point source, H>25 m)
1	**K003**	**Institutional**	0.19	10.33	0.11	3.20	0.30				
2	**K004**	**Institutional**	0.16	10.34	0.11	3.20	0.32	0.24525			
3	**K016**	**Institutional**	0.66	12.12	0.14	3.20	0.82				
4	**K017**	**Institutional**	5.22	19.76	0.26	3.20	0.49				
5	**K018**	**Agricultural**	4.57	23.05	0.20						
6	**K029**	**Institutional**	0.15	13.50	0.18		0.57				
7	**K030**	**Institutional**	0.84	15.45	0.15		0.55				
8	**K031**	**Institutional**	6.90	18.06	0.17	3.20	0.55				
9	**K032**	**Institutional**	4.96	19.00	0.19	3.20	0.73				
10	**K033**	**Agricultural**	4.38	25.70	0.19						
11	**K034**	**Institutional**	1.42	24.47	0.26	3.20	0.80		0.17		
12	**K035**	**Residential**	2.65	48.42	0.59	4.92	0.34		0.2		
13	**K045**	**Agricultural**	6.65	33.45	0.29						
14	**K046**	**Residential**	1.05	55.10	0.65	4.92	0.30				
15	**K047**	**Agricultural**	5.26	41.35	0.31						
16	**K048**	**Residential**	9.68	56.30	0.70	4.92	0.28	0.33572		30.91126	8.512
17	**K049**	**Institutional**	7.72	51.96	0.51	3.20	0.80		0.29		
18	**K050**	**Residential**	5.76	62.50	0.65	4.92	0.31		0.26		
19	**K051**	**Residential**	2.66	59.92	0.65	4.92	0.29		0.53		
20	**K057**	**Agricultural**	3.90	39.05	0.30						
21	**K058**	**Agricultural**	17.52	37.14	0.28						
22	**K059**	**Residential**	12.24	46.73	0.53	4.92	0.33	0.51884		36.39439	26600
23	**K060**	**Residential**	8.42	53.96	0.60	4.92	0.35				
24	**K061**	**Residential**	8.76	57.68	0.83	4.92	0.28				
25	**K062**	**Residential**	14.38	64.26	0.94	4.92	0.28				
26	**K063**	**Residential**	25.00	89.00	0.97	4.92	0.28				
27	**K064**	**Residential**	18.15	120.80	1.33	6.57	3.89			0.3	
28	**K065**	**Commercial**	14.62	67.81	1.26	6.93	6.46		0.17	0.2	
29	**K066**	**Commercial**	0.25	67.93	1.15	6.93	6.47		0.51		
30	**K072**	**Agricultural**	2.30	38.68	0.30						
31	**K073**	**Agricultural**	7.71	40.11	0.33						
32	**K074**	**Residential**	7.86	56.92	0.73	4.92	0.30				
33	**K075**	**Industrial**	29.05	41.36	0.51	3.21	6.36			143.12965	58.359
34	**K076**	**Industrial**	8.11	35.34	0.58	3.21	5.18			99.71192	384.1089
35	**K077**	**Industrial**	10.83	29.50	0.48	3.21	6.99			20.16901	16.9272
36	**K078**	**Industrial**	13.33	29.27	0.47	3.21	6.39			51.58035	13.3357
37	**K079**	**Residential**	6.00	63.35	0.76	4.92	0.27				
38	**K080**	**Residential**	2.24	67.65	0.73	4.92	0.28				
39	**KS081**	**Residential**	2.69	66.44	0.75	4.92	0.29				
40	**K082**	**Residential**	0.78	36.64	0.34	4.92	0.30				
41	**K088**	**Industrial**	0.30	34.40	0.47	3.21	5.66				

Series No.	Grid Id	Landscape Pattern	Vehicles	Domestic	Garbage Burning	Restaurant & Halwai	DG Sets	Medical-waste Incinerator	Funeral Burning	Industries (area source, H<25 m)	Industries (Point source, H>25 m)
42	**K089**	**Residential**	6.56	45.26	0.59	4.92	0.24				
43	**K090**	**Residential**	9.78	65.24	0.84	4.92	0.24				
44	**K091**	**Residential**	10.77	38.97	0.89	3.89	0.18			0.914	
45	**K092**	**Residential**	2.28	47.53	0.74	4.92	0.18				
46	**K093**	**Residential**	8.06	53.37	0.71	4.92	0.14				
47	**K094**	**Agricultural**	4.11	38.72	0.36						
48	**K095**	**Residential**	8.25	48.28	0.60	4.92	0.15				
49	**K096**	**Industrial**	0.39	33.46	0.62	3.21	6.66			31.30892	102.1615
50	**K104**	**Agricultural**	5.19	32.55	0.31	0.00					
51	**K105**	**Residential**	6.94	45.61	0.60	4.92	0.19				
52	**K106**	**Residential**	6.15	35.75	0.52	4.92	0.21				
53	**K107**	**Protected**									
54	**K108**	**Residential**	11.14	44.91	0.54	5.71	7.27			14.77585	21.6125
55	**K109**	**Residential**	1.04	49.13	0.55	4.92	0.21				
56	**K110**	**Residential**	1.63	48.53	0.56	4.92	0.16				
57	**K111**	**Protected**									
58	**K118**	**Residential**	4.26	38.18	0.46	4.92	0.18				
59	**K119**	**Residential**	0.92	50.18	0.59	4.92	0.19				
60	**K120**	**Residential**	0.97	48.25	0.57	4.92	0.13				
61	**K121**	**Agricultural**	0.78	34.54	0.26						
62	**K122**	**Agricultural**	0.92	35.42	0.27						
63	**K123**	**Agricultural**	7.40	36.06	0.28						
64	**K124**	**Protected**									
65	**K125**	**Agricultural**	2.80	38.90	0.29						
66	**K126**	**Agricultural**	0.20	37.59	0.28						
67	**K132**	**Agricultural**	5.25	41.01	0.31						
68	**K133**	**Agricultural**	0.28	36.47	0.28						
69	**K135**	**Agricultural**	0.51	38.79	0.30						
70	**K136**	**Agricultural**	2.53	41.27	0.31						
71	**K137**	**Agricultural**	2.57	39.59	0.28						
72	**K138**	**Agricultural**	5.94	39.55	0.31						
73	**K139**	**Agricultural**	0.16	38.19	0.29						
74	**K146**	**Agricultural**	0.90	34.90	0.28						
75	**K150**	**Agricultural**	0.23	33.29	0.26						
76	**K151**	**Agricultural**	0.84	33.81	0.24						
77	**K152**	**Agricultural**	0.67	31.21	0.23						
78	**K153**	**Agricultural**	0.03	30.51	0.24						
	Total		**405.77**	**3169.83**	**35.72**	**207.57**	**74.17**	**1.10**	**2.13**	**429.40**	**27205.02**

Appendix 2.2 Emission of PM from various sources (kg/day)

Series No.	Grid Id	Landscape Pattern	Vehicles	Soil-Road Dust	Domestic	Garbage Burning	Restaurant & Halwai	DG Sets	Medical-waste Incinerator	Funeral Burning	Construction & Demolition
1	**K003**	**Institutional**	0.62	1.51	10.33	1.82	5.73	0.33			0.0235
2	**K004**	**Institutional**	0.60	0.73	10.34	1.84	5.73	0.34	0.52425		0.0135
3	**K016**	**Institutional**	2.47	2.65	12.12	2.23	5.73	0.88			0.0135
4	**K017**	**Institutional**	16.97	25.99	19.76	4.21	5.73	0.53			0.0235
5	**K018**	**Agricultural**	14.92	24.98	23.05	3.17					0.0235
6	**K029**	**Institutional**	0.58	0.63	13.50	2.82		0.61			0.0235
7	**K030**	**Institutional**	3.16	3.60	15.45	2.39		0.59			0.0235
8	**K031**	**Institutional**	26.45	40.48	18.06	2.65	5.73	0.59			0.0235
9	**K032**	**Institutional**	15.81	23.42	19.00	3.09	5.73	0.78			0.0235
10	**K033**	**Agricultural**	15.02	21.55	25.70	3.02					0.0235
11	**K034**	**Institutional**	5.35	5.20	24.47	4.12	5.73	0.86		13.04	0.0235
12	**K035**	**Residential**	10.05	9.26	48.42	9.40	9.25	0.37		15.61	0.0235
13	**K045**	**Agricultural**	21.39	20.04	33.45	4.58					0.0235
14	**K046**	**Residential**	3.96	3.76	55.10	10.40	9.25	0.33			0.0235
15	**K047**	**Agricultural**	17.72	15.88	41.35	5.00					0.0235
16	**K048**	**Residential**	37.60	36.00	56.30	11.12	9.25	0.30	0.71764		0.007
17	**K049**	**Institutional**	28.93	25.57	51.96	8.11	5.73	0.86		22.28	0.007
18	**K050**	**Residential**	21.22	21.61	62.50	10.45	9.25	0.33		20.01	0.007
19	**K051**	**Residential**	8.84	7.70	59.92	10.42	9.25	0.32		40.45	0.007
20	**K057**	**Agricultural**	12.54	8.80	39.05	4.84					0.007
21	**K058**	**Agricultural**	55.07	45.30	37.14	4.40					0.007
22	**K059**	**Residential**	40.35	37.13	46.73	8.51	9.25	0.35	1.10908		0.007
23	**K060**	**Residential**	27.69	23.34	53.96	9.55	9.25	0.38			0.007
24	**K061**	**Residential**	28.20	22.13	57.68	13.35	9.25	0.30			0.007
25	**K062**	**Residential**	47.44	37.26	64.26	14.98	9.25	0.30			0.007
26	**K063**	**Residential**	81.87	63.34	89.00	15.58	9.25	0.30			0.007
27	**K064**	**Residential**	68.20	8.49	120.80	21.35	12.01	4.17			0.003
28	**K065**	**Commercial**	58.60	6.16	67.81	20.21	12.62	6.92		13.34	0.0035
29	**K066**	**Commercial**	0.92	0.36	67.93	18.40	12.62	6.94		39.29	0.0035
30	**K072**	**Agricultural**	7.04	2.48	38.68	4.81					0.0035
31	**K073**	**Agricultural**	24.35	11.83	40.11	5.20					0.0035
32	**K074**	**Residential**	25.54	15.97	56.92	11.66	9.25	0.32			0.0035
33	**K075**	**Industrial**	91.29	72.83	41.36	8.16	5.86	6.82			0.0035
34	**K076**	**Industrial**	34.60	16.05	35.34	9.23	5.86	5.56			0.082
35	**K077**	**Industrial**	36.03	32.85	29.50	7.69	5.86	7.49			0.082
36	**K078**	**Industrial**	44.69	45.00	29.27	7.52	5.86	6.86			0.082
37	**K079**	**Residential**	22.45	19.38	63.35	12.09	9.25	0.29			0.082
38	**K080**	**Residential**	8.43	3.80	67.65	11.70	9.25	0.30			0.082
39	**K081**	**Residential**	8.62	4.89	66.44	12.08	9.25	0.31			0.082
40	**K082**	**Residential**	2.51	1.38	36.64	5.42	9.25	0.32			0.082
41	**K088**	**Industrial**	0.99	0.62	34.40	7.55	5.86	6.08			0.082

Series No.	Grid Id	Landscape Pattern	Vehicles	Soil-Road Dust	Domestic	Garbage Burning	Restaurant & Halwai	DG Sets	Medical-waste Incinerator	Funeral Burning	Construction & Demolition
42	**K089**	**Residential**	21.07	11.44	45.26	9.43	9.25	0.26			0.082
43	**K090**	**Residential**	33.84	30.59	65.24	13.36	9.25	0.26			0.082
44	**K091**	**Residential**	42.17	32.43	38.97	14.25	7.05	0.19			0.057
45	**K092**	**Residential**	8.83	5.80	47.53	11.78	9.25	0.20			0.057
46	**K093**	**Residential**	27.16	40.02	53.37	11.41	9.25	0.15			0.057
47	**K094**	**Agricultural**	14.90	19.76	38.72	5.70					0.057
48	**K095**	**Residential**	28.77	38.70	48.28	9.53	9.25	0.16			0.057
49	**K096**	**Industrial**	1.56	2.13	33.46	9.99	5.86	7.14			0.057
50	**K104**	**Agricultural**	17.15	19.58	32.55	4.98	0.00				0.057
51	**K105**	**Residential**	24.72	36.34	45.61	9.65	9.25	0.20			0.057
52	**K106**	**Residential**	20.93	28.73	35.75	8.25	9.25	0.22			0.057
53	**K107**	**Protected**									
54	**K108**	**Residential**	42.62	62.16	44.91	8.62	10.36	7.80			0.076
55	**K109**	**Residential**	3.49	5.34	49.13	8.81	9.25	0.22			0.076
56	**K110**	**Residential**	6.20	6.55	48.53	8.95	9.25	0.17			0.076
57	**K111**	**Protected**									
58	**K118**	**Residential**	13.91	17.56	38.18	7.40	9.25	0.20			0.076
59	**K119**	**Residential**	3.52	3.83	50.18	9.36	9.25	0.20			0.076
60	**K120**	**Residential**	3.73	3.61	48.25	9.15	9.25	0.14			0.076
61	**K121**	**Agricultural**	3.00	3.13	34.54	4.22					
62	**K122**	**Agricultural**	3.55	3.82	35.42	4.36					
63	**K123**	**Agricultural**	24.00	28.50	36.06	4.54					
64	**K124**	**Protected**									
65	**K125**	**Agricultural**	10.54	7.55	38.90	4.69					
66	**K126**	**Agricultural**	0.77	0.57	37.59	4.45					
67	**K132**	**Agricultural**	16.92	12.85	41.01	4.94					
68	**K133**	**Agricultural**	1.12	0.90	36.47	4.50					
69	**K135**	**Agricultural**	2.00	1.48	38.79	4.84					
70	**K136**	**Agricultural**	8.92	6.11	41.27	5.02					
71	**K137**	**Agricultural**	9.65	6.42	39.59	4.55					
72	**K138**	**Agricultural**	19.84	18.45	39.55	4.93					
73	**K139**	**Agricultural**	0.64	0.55	38.19	4.58					
74	**K146**	**Agricultural**	2.87	2.26	34.90	4.55					
75	**K150**	**Agricultural**	0.88	0.72	33.29	4.22					
76	**K151**	**Agricultural**	3.40	3.49	33.81	3.88					
77	**K152**	**Agricultural**	2.25	2.52	31.21	3.68					
78	**K153**	**Agricultural**	0.08	0.08	30.51	3.78					
	Total		1404.01	1233.91	3169.83	571.48	385.51	79.55	2.35	164.02	2.22

Appendix 2.3 Emission of CO from various sources (kg/day)

Series No.	Grid Id	Landscape Pattern	Vehicles	Domestic	Garbage Burning	Restaurant & Halwai	DG Sets	Medical-waste Incinerator	Funeral Burning	Industries (area source, H<25 m)	Industries (Point source, H>25 m)
1	**K003**	**Institutional**	6.53	89.31	9.54	9.19	0.99				
2	**K004**	**Institutional**	10.34	89.92	9.64	9.19	1.04	0.66375			
3	**K016**	**Institutional**	41.44	106.41	11.70	9.19	2.67				
4	**K017**	**Institutional**	193.47	175.81	22.09	9.19	1.62				
5	**K018**	**Agricultural**	170.89	198.66	16.65						
6	**K029**	**Institutional**	9.62	121.11	14.83		1.86				
7	**K030**	**Institutional**	51.78	134.31	12.53		1.80				
8	**K031**	**Institutional**	392.88	162.31	13.89	9.19	1.81				
9	**K032**	**Institutional**	166.54	163.98	16.21	9.19	2.39				
10	**K033**	**Agricultural**	196.32	217.35	15.86						
11	**K034**	**Institutional**	89.09	211.88	21.61	9.19	2.62		98.32		
12	**K035**	**Residential**	177.26	421.76	49.36	16.10	1.13		117.71		
13	**K045**	**Agricultural**	245.14	288.28	24.05						
14	**K046**	**Residential**	67.08	474.80	54.61	16.10	0.99				
15	**K047**	**Agricultural**	237.16	350.20	26.24						
16	**K048**	**Residential**	606.66	456.81	58.39	16.10	0.91	0.9086		45.6002	15.9488
17	**K049**	**Institutional**	500.85	420.96	42.58	9.19	2.63		168.02		
18	**K050**	**Residential**	347.33	508.99	54.88	16.10	1.01		150.94		
19	**K051**	**Residential**	113.15	491.03	54.69	16.10	0.96		305.11		
20	**K057**	**Agricultural**	149.60	315.35	25.42						
21	**K058**	**Agricultural**	598.27	299.84	23.12						
22	**K059**	**Residential**	507.67	382.56	44.70	16.10	1.07	1.4042		105.2113	49840
23	**K060**	**Residential**	356.08	446.86	50.13	16.10	1.16				
24	**K061**	**Residential**	340.93	488.64	70.08	16.10	0.93				
25	**K062**	**Residential**	624.92	533.68	78.64	16.10	0.92				
26	**K063**	**Residential**	1053.04	719.60	81.77	16.10	0.91			4.65	
27	**K064**	**Residential**	1196.72	712.88	112.08	19.74	12.74			3.1	
28	**K065**	**Commercial**	1259.40	583.17	106.11	19.92	21.14		100.63		
29	**K066**	**Commercial**	17.64	549.00	96.63	19.92	21.19		296.35		
30	**K072**	**Agricultural**	78.25	306.96	25.26						
31	**K073**	**Agricultural**	295.24	320.08	27.32						
32	**K074**	**Residential**	325.66	466.06	61.21	16.10	0.99				
33	**K075**	**Industrial**	998.93	326.91	42.83	9.51	20.81			287.5273	113.274
34	**K076**	**Industrial**	665.60	329.95	48.44	9.51	16.96			1050.525184	719.811
35	**K077**	**Industrial**	466.59	277.42	40.36	9.51	22.87			51.7263	39.828
36	**K078**	**Industrial**	580.82	273.96	39.48	9.51	20.93			174.0605	25.043
37	**K079**	**Residential**	394.88	527.08	63.45	16.10	0.89				
38	**K080**	**Residential**	160.27	555.78	61.42	16.10	0.92				
39	**K081**	**Residential**	102.70	551.17	63.40	16.10	0.95				
40	**K082**	**Residential**	28.94	292.86	28.47	16.10	0.97				
41	**K088**	**Industrial**	11.46	277.05	39.66	9.51	18.55				

Series No.	Grid Id	Landscape Pattern	Vehicles	Domestic	Garbage Burning	Restaurant & Halwai	DG Sets	Medical-waste Incinerator	Funeral Burning	Industries (area source, H<25 m)	Industries (Point source, H>25 m)
42	**K089**	**Residential**	261.33	377.11	49.51	16.10	0.80				
43	**K090**	**Residential**	484.14	536.92	70.15	16.10	0.79				
44	**K091**	**Residential**	696.33	379.25	74.83	11.69	0.59			5.56	
45	**K092**	**Residential**	172.35	458.27	61.85	16.10	0.60				
46	**K093**	**Residential**	324.57	501.75	59.89	16.10	0.47				
47	**K094**	**Agricultural**	221.56	356.17	29.90						
48	**K095**	**Residential**	390.33	445.25	50.06	16.10	0.48				
49	**K096**	**Industrial**	27.82	320.21	52.47	9.51	21.79			63.22024	195.6266
50	**K104**	**Agricultural**	203.64	304.28	26.13	0.00					
51	**K105**	**Residential**	344.20	427.62	50.65	16.10	0.62				
52	**K106**	**Residential**	260.07	342.13	43.31	16.10	0.68				
53	**K107**	**Protected**									
54	**K108**	**Residential**	617.36	371.27	45.27	16.83	23.81			23.3135	40.495
55	**K109**	**Residential**	41.57	401.59	46.23	16.10	0.68				
56	**K110**	**Residential**	102.11	402.68	47.00	16.10	0.51				
57	**K111**	**Protected**									
58	**K118**	**Residential**	155.37	416.21	38.84	16.10	0.60				
59	**K119**	**Residential**	59.97	528.53	49.16	16.10	0.63				
60	**K120**	**Residential**	65.90	515.58	48.06	16.10	0.44				
61	**K121**	**Agricultural**	52.17	344.47	22.17						
62	**K122**	**Agricultural**	61.87	354.91	22.87						
63	**K123**	**Agricultural**	278.04	364.17	23.85						
64	**K124**	**Protected**									
65	**K125**	**Agricultural**	198.53	394.64	24.64						
66	**K126**	**Agricultural**	15.68	384.99	23.38						
67	**K132**	**Agricultural**	205.38	419.40	25.93						
68	**K133**	**Agricultural**	23.23	374.60	23.63						
69	**K135**	**Agricultural**	42.48	401.26	25.39						
70	**K136**	**Agricultural**	147.75	423.91	26.38						
71	**K137**	**Agricultural**	190.23	393.04	23.89						
72	**K138**	**Agricultural**	254.28	406.89	25.89						
73	**K139**	**Agricultural**	12.99	380.88	24.06						
74	**K146**	**Agricultural**	32.85	361.00	23.89						
75	**K150**	**Agricultural**	16.71	341.89	22.16						
76	**K151**	**Agricultural**	68.81	342.99	20.37						
77	**K152**	**Agricultural**	25.97	319.68	19.32						
78	**K153**	**Agricultural**	1.01	311.95	19.83						
	Total		**19893.77**	**28026.21**	**3000.27**	**653.41**	**242.83**	**2.98**	**1237.08**	**1814.49**	**50990.03**

Appendix 2.4 Emission of NO_X from various sources (kg/day)

Series No.	Grid Id	Landscape Pattern	Vehicles	Domestic	Garbage Burning	Restaurant & Halwai	DG Sets	Medical-waste Incinerator	Funeral Burning	Industries (area source, H<25 m)	Industries (Point source, H>25 m)
1	**K003**	**Institutional**	3.03	7.03	0.68	1.45	4.61				
2	**K004**	**Institutional**	3.79	6.88	0.69	1.45	4.81	0.4005			
3	**K016**	**Institutional**	14.91	8.26	0.84	1.45	12.37				
4	**K017**	**Institutional**	79.96	13.95	1.58	1.45	7.48				
5	**K018**	**Agricultural**	72.00	15.16	1.19						
6	**K029**	**Institutional**	3.48	9.58	1.06		8.61				
7	**K030**	**Institutional**	19.04	10.24	0.90		8.33				
8	**K031**	**Institutional**	118.34	13.35	0.99	1.45	8.38				
9	**K032**	**Institutional**	67.93	12.67	1.16	1.45	11.07				
10	**K033**	**Agricultural**	78.75	16.41	1.13						
11	**K034**	**Institutional**	31.09	16.39	1.54	1.45	12.13		1.19		
12	**K035**	**Residential**	60.21	32.39	3.53	2.39	5.23		1.43		
13	**K045**	**Agricultural**	90.48	22.00	1.72						
14	**K046**	**Residential**	23.16	36.24	3.90	2.39	4.61				
15	**K047**	**Agricultural**	84.45	26.27	1.87						
16	**K048**	**Residential**	166.46	35.66	4.17	2.39	4.21	0.54824		15.3746	2.5536
17	**K049**	**Institutional**	169.56	32.98	3.04	1.45	12.18		2.04		
18	**K050**	**Residential**	123.05	39.20	3.92	2.39	4.68		1.83		
19	**K051**	**Residential**	40.34	37.94	3.91	2.39	4.46		3.7		
20	**K057**	**Agricultural**	51.51	24.53	1.82						
21	**K058**	**Agricultural**	217.22	23.10	1.65						
22	**K059**	**Residential**	184.12	29.77	3.19	2.39	4.96	0.84728		40.1889	7980
23	**K060**	**Residential**	126.83	34.29	3.58	2.39	5.36				
24	**K061**	**Residential**	120.09	38.18	5.01	2.39	4.31				
25	**K062**	**Residential**	217.63	41.84	5.62	2.39	4.25				
26	**K063**	**Residential**	366.92	55.61	5.84	2.39	4.21				
27	**K064**	**Residential**	212.40	62.94	8.01	3.10	59.01			0.1875	
28	**K065**	**Commercial**	124.79	46.30	7.58	3.35	97.88		1.22	0.125	
29	**K066**	**Commercial**	4.84	44.13	6.90	3.35	98.10		3.59		
30	**K072**	**Agricultural**	24.11	23.66	1.80						
31	**K073**	**Agricultural**	94.53	24.76	1.95						
32	**K074**	**Residential**	108.38	36.63	4.37	2.39	4.57				
33	**K075**	**Industrial**	361.65	25.70	3.06	1.52	96.35			232.81515	56.658
34	**K076**	**Industrial**	191.40	24.71	3.46	1.52	78.55			227.74135	116.35125
35	**K077**	**Industrial**	168.19	20.57	2.88	1.52	105.92			106.4098	58.835
36	**K078**	**Industrial**	213.83	20.23	2.82	1.52	96.93			393.2005	4.56
37	**K079**	**Residential**	132.35	40.92	4.53	2.39	4.10				
38	**K080**	**Residential**	44.83	43.01	4.39	2.39	4.27				
39	**K081**	**Residential**	34.11	42.94	4.53	2.39	4.42				
40	**K082**	**Residential**	9.74	22.47	2.03	2.39	4.47				
41	**K088**	**Industrial**	3.95	21.58	2.83	1.52	85.88				

Series No.	Grid Id	Landscape Pattern	Vehicles	Domestic	Garbage Burning	Restaurant & Halwai	DG Sets	Medical-waste Incinerator	Funeral Burning	Industries (area source, H<25 m)	Industries (Point source, H>25 m)
42	K089	Residential	85.14	30.07	3.54	2.39	3.68				
43	K090	Residential	170.63	43.14	5.01	2.39	3.65				
44	K091	Residential	181.65	29.93	5.34	1.76	2.74			11.525	
45	K092	Residential	52.15	35.07	4.42	2.39	2.78				
46	K093	Residential	134.57	37.45	4.28	2.39	2.18				
47	K094	Agricultural	84.67	26.42	2.14						
48	K095	Residential	153.04	32.91	3.58	2.39	2.24				
49	K096	Industrial	10.34	23.89	3.75	1.52	100.92			105.70943	72.5952
50	K104	Agricultural	78.90	22.40	1.87	0.00					
51	K105	Residential	136.96	32.04	3.62	2.39	2.88				
52	K106	Residential	104.12	25.53	3.09	2.39	3.16				
53	K107	Protected									
54	K108	Residential	182.87	29.24	3.23	2.65	110.27			80.836	6.48375
55	K109	Residential	17.03	31.45	3.30	2.39	3.16				
56	K110	Residential	36.41	31.38	3.36	2.39	2.37				
57	K111	Protected									
58	K118	Residential	61.56	28.86	2.77	2.39	2.80				
59	K119	Residential	21.40	37.04	3.51	2.39	2.90				
60	K120	Residential	22.64	35.91	3.43	2.39	2.03				
61	K121	Agricultural	18.37	24.26	1.58						
62	K122	Agricultural	21.89	24.90	1.63						
63	K123	Agricultural	108.06	25.50	1.70						
64	K124	Protected									
65	K125	Agricultural	62.54	27.47	1.76						
66	K126	Agricultural	4.87	26.81	1.67						
67	K132	Agricultural	73.00	29.38	1.85						
68	K133	Agricultural	7.33	26.14	1.69						
69	K135	Agricultural	13.12	27.97	1.81						
70	K136	Agricultural	47.63	29.59	1.88						
71	K137	Agricultural	58.53	27.62	1.71						
72	K138	Agricultural	93.29	28.47	1.85						
73	K139	Agricultural	4.21	26.88	1.72						
74	K146	Agricultural	12.13	25.16	1.71						
75	K150	Agricultural	5.42	23.86	1.58						
76	K151	Agricultural	23.22	23.87	1.45						
77	K152	Agricultural	10.36	22.26	1.38						
78	K153	Agricultural	0.39	21.85	1.42						
	Total		**6361.85**	**2115.17**	**214.30**	**99.35**	**1124.44**	**1.80**	**15.00**	**1214.11**	**8298.04**

Appendix 3 Health data-total number of patient

Grid no.	Total number of patient			
	Outdoor patient	ICU patient	Lungs patients	Indoor patient
K017	76	1	6	9
K018	0	0	0	1
K031	21	0	0	6
K032	222	2	12	49
K033	11	0	0	6
K034	28	0	0	4
K035	96	0	6	29
K044	1	0	0	0
K045	1	0	0	0
K046	0	0	0	1
K047	55	0	2	7
K048	114	0	11	18
K049	66	0	3	10
K050	159	4	8	45
K051	17	0	0	1
K058	193	0	16	18
K059		0	0	2
K060	4	0	0	2
K061	380	5	26	4
K062	110	2	6	4
K063	163	2	13	4
K064	174	1	15	76
K065	76	1	9	21
K066	4	0	0	2
K073	0	0	0	0
K074	25	25	1	3
K075	7	7	0	6
K076	197	1	22	24
K077	16	1	0	11
K078	206	2	4	71
K079	61	2	4	49
K080	0		0	0
K081	96	3	11	31
K088	62	0	2	29
K089	2	0	0	0
K090	99	2	14	10
K091	118	2	11	29
K092	98	1	5	44
K093	76	0	8	37
K094	30	0	3	2
K095	1	0	0	2
K096	1	0	0	1
K104	0	0	2	3
K105	0	1	5	14
K106	276	8	15	43
K107	0	0	0	0
K108	0	0	0	8
K109	0	0	7	19
K110	0	0	0	0
K111	20	0	0	18
K118	0	0	0	0
K119	49	2	7	35
K120	69	1	10	13
K121	247	5	26	36
K122	34	1	5	1
K123	0	0	0	0
K124	0	0	0	0
K125	0	0	0	0
K126	0	0	0	0
K134	2	0	0	0
K135	29	0	7	1
K136	14	0	2	5
K137	25	0	2	7
K138	0	0	0	0
K152	0	0	0	0
K153	0	0	0	7

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ABSTRACT
The aim of this report is to summarize all activities of the whole period for the India-Norwegian cooperation project: Environmental Health Assessment: Respiratory Disease in relation to Air Pollution in Kanpur, Uttar Pradesh. It includes: (1) verification of measurement methods in relationship to the European CEN/EN12341 standard on PM10 monitoring in Kanpur and Agra; (2) health effect assessment attributable to air pollution in the city of Kanpur; and (3) dissemination (workshops) and administration.

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