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Air quality measurements in commercial kitchens

Prepared by
Advantica Technologies Limited
for the Health and Safety Executive

CONTRACT RESEARCH REPORT
449/2002

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Air quality measurements in commercial kitchens

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The main objective of this work was to carry out air quality surveys in nine commercial kitchens and provide continuous monitoring of pollutants such as carbon monoxide and nitrogen dioxide as well as other relevant environmental parameters such as relative humidity and temperature levels attained for a period of at least 24 hours.

The commercial kitchens surveyed varied in their characteristics such as:

- size of the kitchen;
- type of fuel;
- type of ventilation- natural or extractor system; and
- the level of appliance usage.

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the author alone and do not necessarily reflect HSE policy.

HSE BOOKS

First published 2002

ISBN 0 7176 2524 9

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SUMMARY

At a recent Health & Safety in Hospitality Liaison committee meeting, a paper on the use of carbon monoxide alarms was considered and a number of potential issues were highlighted.

There are very limited data available regarding the operation of carbon monoxide alarms under extreme environmental conditions and whether domestic carbon monoxide alarms are capable of withstanding the extreme environmental conditions likely to be expected in commercial kitchens.

The main objective of this work was to carry out air quality surveys in nine commercial kitchens and provide continuous monitoring of pollutants such as carbon monoxide and nitrogen dioxide as well as other relevant environmental parameters such as relative humidity and temperature levels attained. The continuous monitoring of the pollutants not only provided an assessment of any peak levels but also an indication of personal exposure to low level background pollutant levels which have also been proven to have adverse health effects.

The commercial kitchens surveyed varied in their characteristics such as

- Size of the kitchen
- Type of fuel
- Type of ventilation- natural or extractor system
- The level of appliance usage

Overall, the levels of the contaminants generated in the nine commercial kitchens did not exceed the occupational guideline limits.

- The standalone silent monitor employed for this survey was effective in being a suitable tool for obtaining reliable air quality measurements while normal kitchen activities took place. This was especially important in the case of commercial kitchens where the levels of activity and the usage of space are significant parameters affecting the feasibility of integrating a monitor into the kitchen.

- The nine commercial kitchens surveyed varied in their characteristics such as the volume of the kitchen, extractor system employed, level of catering requirement and the type of fuel used, each being an important influence on the levels containments generated.

- In all except one kitchen, appliances were positioned in the middle of the kitchen with a canopy extractor hood system over them.

- The highest one minute concentration recording for carbon monoxide was 67.5 ppm and for nitrogen dioxide was 0.66 ppm.

- The level of occupancy varied depending on the catering requirement, i.e. the number of people the kitchen cooked for (which in turn meant that number of people that were employed in the kitchen).

- The levels of recorded relative humidity and temperature varied considerably between kitchens, the lowest temperature being that recorded between midnight and the early hours of the morning when the kitchen was not in use, which in turn depended on the heat retention of the building during that period. Where the monitor was subjected to dry heat e.g. heat rising from a hot plate the lowest humidity was recorded, 10%. Where steaming for

long periods was carried out the humidity levels reached 89%. Both of these extreme levels were reached for kitchen 9 where the monitor was placed on a small shelf overlooking hobs, fryers and a hotplate. The temperature followed a similar trend, lowest recorded during each survey period was 9.8°C and the highest was 48°C.

The findings of this work show that the environmental conditions within a commercial kitchen (compared to a domestic kitchen) can vary considerably. However, whilst the sample size of nine is thought to be too small to be a representative sample population of such premises, the findings may be used as an indication of the extreme environmental conditions that carbon monoxide alarms could be subjected to. A larger sample population would provide a more accurate assessment of the contaminant levels and environmental conditions.

1 INTRODUCTION

At a recent Health & Safety in Hospitality Liaison committee meeting, a paper on the use of carbon monoxide alarms was considered and a number of potential issues were highlighted.

There are very limited data available regarding the operation of carbon monoxide alarms under extreme environmental conditions and whether domestic carbon monoxide alarms are capable of withstanding the extreme environmental conditions likely to be expected in commercial kitchens.

The main objective of this work was to carry out air quality surveys in nine commercial kitchens and provide continuous monitoring of pollutants such as carbon monoxide and nitrogen dioxide as well as other relevant environmental parameters such as relative humidity and temperature levels attained. The continuous monitoring of the pollutants not only provided an assessment of any peak levels but also an indication of personal exposure to low level background pollutant levels which have also been proven to have adverse health effects.

2 EXPERIMENTAL DETAILS

2.1 SURVEY PROCEDURE

For the survey of the commercial kitchens, a simple questionnaire was designed detailing the personnel involved on the premises, type of appliances, ventilation, size of room and a sketch showing where the monitor was placed. A copy of the questionnaire is included in Figure 1.

Initially contact was made with personnel from Derbyshire and Leicestershire Councils and other contacts, to discuss the availability of suitable sites for the survey from their available database. Various lists were then collated. Contacts were then made with the majority of the potential establishments and nine suitable premises were selected and confirmed to take part in the air quality survey. The selected premises varied in type; staff canteens, hotels and conference centres located in different counties within the Midlands region.

The survey date was firstly agreed with the relevant personnel at each site, the survey period was 24 hours or more depending on the availability of the site, agreement of the personnel and feasibility with regard to the start and completion time of the survey.

On arrival at each site the questionnaire was completed with the personnel in charge, logging details in the questionnaire as well as determining the level of usage of the kitchen and the number of people it normally catered for. The plan of the kitchen was then studied and a suitable position for the monitor identified in each case. The position of the monitor was chosen to be as close as possible to the gas appliances available in the kitchen whilst still providing data representative of personal exposure. Most surfaces in the kitchen were used for the majority of the time and the selected location for placing the monitor had to be agreed with the personnel in order to ensure the safety of the monitor and avoid causing any complications to the normal working routine of the kitchen.

For the majority of the sites, the appliances were placed in the middle of the kitchen with a large umbrella extractor canopy extending over the whole area. The extractor system was turned on first thing on arrival and switched off when the establishment was closed.

2.2 INSTRUMENT USED

In this study, an air quality monitor was used to monitor parameters such carbon monoxide, oxygen concentration, humidity and temperature within the test kitchen. The air quality monitor (IAQ) has been designed in-house at Advantica and has been used successfully in carrying out indoor air quality measurements in a pilot survey in Loughborough[1] and two major surveys, in the Solihull[2] and Bristol[3] areas. The monitor is silent, battery powered, small and capable of measuring nitrogen dioxide (NO_2), carbon monoxide (CO) and oxygen as well as humidity/temperature on a continuous basis.

The monitor dimensions are 23 cm in length, 26 cm in width and 15 cm in height and the unit is powered by a 12 V battery pack within the monitor casing. A key switches on the monitor, turns

[1] Marks ST, 'A survey of air quality in kitchen using gas appliances'. GRTC R 1822, May 1997.

[2] Marks ST, Pool G, Dutton J. 'A survey on the exposure to air pollution in the home-indoor air quality in Solihull, West Midlands. GRTC R 2846, April 1999.

[3] Marks ST, Pool G. 'Indoor air quality survey in the Avon area and a comparison with a previous survey carried out in Solihull'. R 4192, December 2000

on the logger and opens up all logging channels simultaneously. All channels are averaged and logged every minute.

The monitor was calibrated and all cells checked before each survey was conducted, and then recalibrated and checked afterwards to account for any drift in the calibration and abnormality in the operation of the monitor. The monitor was then recharged, recalibrated and set up for the next survey.

2.3 SITES SELECTED

The sites were chosen from a list of commercial premises provided by the two local councils as well as other contacts. The sites chosen represented a different range of kitchen facilities commercially available. The sites varied in their location from between 20 miles radius to a 170 mile radius of the Advantica site.

The details of the sites visited are shown in table 1. A short description of each site is as follows:

2.4 SITE DETAILS

The sites surveyed are described in more detail in table 1.

- Site 1 - A large conference establishment serving breakfast, lunch and evening meal
- Site 2 - A hotel in a quiet area. The cooking area was somewhat closed off into a small space
- Site 3 - A busy takeaway restaurant in the middle of a town centre
- Site 4 - A staff canteen serving breakfast, lunch and evening meal
- Site 5 - A staff canteen operating 24 hours
- Site 6 - A staff canteen serving breakfast, lunch and evening meal
- Site 7 - A large bakery positioned on the outskirts of Derby.
- Site 8 - A staff canteen serving breakfast, lunch and evening meal
- Site 9 - A large conference establishment serving breakfast, lunch and evening meal

Table 1 Site Details

Site No.	*Fuel Type*	*Location*	*Near Busy Road Yes/No*	*Volume of Room m^3*	*Air Condi-tioning Yes/No*	*Mechanical Extractor system over appliances Yes/No*	*Comments*
1	Gas/ Elec.	Oxfordshire	No	137.5	No	Yes	Very packed & busy kitchen
2	Gas	Oxfordshire	No	27.3	No	Yes	Small area with appliances sectioned off from a walkway corridor. Complained about temp. rise discomfort.
3	Elec./ Gas	Derbyshire	No	215.6	Yes	Yes	Packed & very busy restaurant
4	Gas	Derbyshire	No	377.9	No	Yes	Very open area – kitchen opening up to the servicing area. All gas – positioned in middle of kitchen with large canopy type hood operating over all appliances. Had extra ventilation through meshed open windows.
5	Gas/ Elec.	Derbyshire	No	140.8	No	Yes	
6	Gas	Leicestershire	No	91.9	Yes	Yes	Kitchen opening up to servicing area
7	Gas/ Oil	Derbyshire	No	2331.2	No	Yes	Very big kitchen – 3 commercial ovens & areas for making bread dough & packing area.
8	Gas	Leicestershire	No	88.4	No	Yes	Packed Kitchen. All gas – positioned in middle of kitchen with large canopy type hood operating over all appliances.
9	Gas	Norththamp.	No	314.9	No	Yes	All gas – positioned in middle of kitchen with large canopy type hood operating over all appliances.

3 RESULTS

Each survey was carried out for duration of at least 24 hours. All channels were logged every minute and the raw data for carbon monoxide, nitrogen dioxide, relative humidity, temperature and occupancy recorded are shown in Figures A1 to A20. Any changes in the calibration were accounted for by incorporating the 'before and after' calibration data into the raw data.

Table 2 shows the peak maximum concentrations (1 minute data) for carbon monoxide and nitrogen dioxide together with the humidity and temperature measurements recorded for the duration of the survey period. The data quoted in the rest of the report refers to 1-minute average recordings.

Table 2 Air Quality Monitor Data

Site No.	*Max.CO (1 min data)*	*Max.NO_2 (1 min data)*	*Relative Humidity (%)*	*Temperature (°C)*
1	7	0.49	17 - 49	22.4– 35.7
2	67.5	0.24	22 - 39	20.5 – 30.8
3	2	0.08	26 - 42	14.4 – 21.8
4	2	0.08	27 - 46	18.0– 24.3
5	4	0.10	16 - 30	17.8 – 31.2
6	2	0.11	10 - 42	18.6 – 48.3
7	8.5	0.12	13 - 41	17.6 – 44.2
8	6.5	0.11	20 - 35	18.2 – 28.8
9	1.5	0.66	10 - 89	9.8 – 43.5

3.1 CARBON MONOXIDE

In all but one case (kitchen 2), carbon monoxide levels were below 10 ppm. In kitchen 2, a higher level of 67.5 ppm was recorded. For this kitchen, the extractor system was of a different arrangement to the rest of the kitchens surveyed. The cooking area was somewhat closed off in the corner of a much bigger room with the extractor system operated over each appliance and not via a large powerful canopy extractor positioned over all of the appliances as in the case of the other kitchens surveyed. The peak concentrations of 67.5 ppm lasted for a maximum of 1 minute and did not correspond to any drop in the oxygen levels.

The mean peak 1 minute values (excluding kitchen 2) for carbon monoxide were 4.9 ppm with a standard deviation of 2.8.

3.2 NITROGEN DIOXIDE

The lowest nitrogen dioxide concentration recorded was 0.08 ppm and the highest was 0.66 ppm. The highest level recorded was for kitchen 9, a busy, large conference establishment. For

this site, the monitor was placed in between the appliance on a shelf, under the extractor canopy. The monitor's position overlooked a large fryer gas hob and hot plate area and, once again, peak concentrations did not correspond to any drop in the oxygen levels.

The mean peak 1 minute values for nitrogen dioxide concentration were 0.24 ppm with a standard deviation of 0.2.

3.3 RELATIVE HUMIDITY AND TEMPERATURE

Table 2 shows the relative humidity and temperature range reached in each of the kitchens. As Figures A1 to A20 show, the rise in the emission levels was accompanied by an increase in the temperature and humidity measured, with maxima recorded at approximately the same time as the emission peaks.

The largest range of temperature and relative humidity was observed for sites 6, 7 and 9. For sites 6 and 9, the monitor position overlooked a hot plate/grill appliance. This resulted in an unusual dry heat with low humidity as shown as sharp peaks in Figure A12. For site 7, the commercial bakery, the only gas appliances were three large scale ovens (gas/oil fuelled). For reasons of practicality and lack of suitable space, the monitor was positioned overlooking the oven burner. This again resulted in a dry heat and low humidity environment, see Figure A14.

3.4 OCCUPANCY

The occupancy detector, fitted with a 180 degree lens vision recorded the presence of people during the survey period. An occupancy Figure of '50' indicated no occupancy and any levels above 50 indicated the presence of people. Depending on the operating routine of the kitchen i.e. the cooking times, the occupancy recordings varied between kitchens.

Site 5 registered a continuous occupancy recording above 50 due to the 24 hour operation routine of the kitchen. For the majority of other kitchens surveyed the occupancy decreased from about midnight (or sooner in some cases) until the morning breakfast preparation started. For site 7, where the monitor had to be placed near the burner (above the ground level) levels of occupancy were low.

3.5 COMPARISON OF SURVEY DATA WITH GUIDELINES

The Health and Safety Occupational Exposure limit EH40[4] for carbon monoxide is 30 ppm for 8 hours and 200 ppm for 15 minutes. For nitrogen dioxide, the limits are 3 ppm for 8 hour exposure and 5 ppm for 15 minutes exposure.

None of the kitchens surveyed exceeded the Occupational guideline limits for either carbon monoxide or nitrogen dioxide. Considering the one minute average concentrations the highest level recorded for carbon monoxide was 67.5 ppm and for nitrogen dioxide 0.66 ppm, averaged over 8 hours would still be below the guideline limits.

[4] Guidance note EH40 'Occupational Exposure Limits' ISBN 0 7176 20832, HSE Books, 2002

4 DISCUSSION

Many factors are thought to affect the emission levels that people are exposed to during cooking. They include:

- Size of the kitchen
- Type of ventilation- natural of extractor system
- Age and condition of the appliance
- The level of appliance usage

The nine commercial kitchens surveyed varied considerably in their characteristics so the opportunity to study these effectively was limited. The kitchens surveyed varied in their characteristics such as the volume of the kitchen, extractor system employed, level of catering requirement and the type of fuel used, each being an important affective parameter on the levels contaminants generated.

The design plan of all except one of the kitchens surveyed (kitchen 2) were similar in the way that the appliances were located in the middle of the kitchen with a canopy extractor hood system positioned over the whole area. For kitchen 2, each appliance had its own extractor system that was operated during the cooking period. The highest carbon monoxide level was recorded for kitchen 2.

The kitchens surveyed were mainly gas fuelled except for one the takeaway restaurant that was mostly electric (monitor was placed close to the only gas appliance present – a gas fryer) and the bakery that was gas/oil fuelled. The lowest nitrogen dioxide level was observed for the mostly electric powered restaurant (site 4 had similar maximum levels but higher background levels). This restaurant was one of the two sites surveyed that had an air-conditioning system operating as well as the extractor system.

The kitchen volume (not taking into account the volume of cupboards and appliances) varied considerably from 27 m^3 (kitchen 2) to 2331 m^3 (the commercial bakery).

The level of occupancy varied depending on the catering requirement, i.e. the number of people the kitchen catered for (which in turn meant that number of people that were employed in the kitchen) and the number of cooking periods. For example, two operated a 24 hour shift and two served breakfast and lunch whereas the rest of the kitchens surveyed cooked for breakfast, lunch and evening meal.

The levels of recorded relative humidity and temperature varied considerably between kitchens, the lowest temperature being that recorded between midnight and the early hours of the morning when the kitchen was not in use, which in turn depended on the heat retention of the building during that period. Where the monitor was subjected to dry, heat e.g. heat rising from a hot plate the lowest humidity was recorded, 10%. Where steaming for long periods was carried out, the humidity levels reached 89%. Both of these extreme levels were reached for kitchen 9 where the monitor was placed on a small shelf overlooking hobs, fryers and a hotplate. The temperature followed a similar trend, lowest recorded during each survey period was 9.8°C and the highest was 48°C.

The greatest one minute concentrations measured for carbon monoxide was 67.5 ppm and for nitrogen dioxide was 0.66 ppm. The levels of carbon monoxide and nitrogen dioxide did not exceed the occupational exposure limits of 30 ppm and 3 ppm respectively for 8 hour average in

any of the kitchens surveyed indicating the contaminant levels generated were under control at the time of the survey.

The British Standard specification for carbon monoxide detectors (for domestic use) states the operating temperature range to be within 17° to 23°C (± 2%) and for relative humidity to be within 40 to 60% (± 5%). The range of temperatures and relative humidity recorded for the surveyed kitchens varied considerably between kitchens. On the whole the range of temperature and relative humidity recorded were between 9.8° to 48.3°C and 10 to 89%, well outside the operating specifications for domestic carbon monoxide alarms.

It is important to note that the sample of commercial kitchens surveyed was small and should not be considered as a representative sample for all the commercial kitchen and hence the result should not be taken out of context. Although the concentrations of the contaminants were controlled effectively at the time of the survey, no indication was provided that this would be expected to be the case were the levels of control are less adequate.

5 CONCLUSIONS AND RECOMMENDATIONS

Overall, the levels of contaminants generated in the nine commercial kitchens did not exceed the occupational guideline limits for 8 hour average.

The standalone silent monitor employed for this survey was effective in being a suitable tool in obtaining reliable air quality measurements while normal kitchen activities took place. This was especially important in case of commercial kitchens where the levels of activity and the usage of space was an important parameter affecting the feasibility of integrating a monitor into the kitchen.

In terms of relating the exposure levels of kitchen staff during their work activity, the limited survey premises undertaken tended to indicate the presence of greater concentrations over only a very short period for CO, this was well below the 30 ppm for 8 hour guideline limit given in EH40[4] and even the 9 ppm for outdoor guidance (WHO).

It should also be emphasized that with the large variety of commercial establishments in existence and with the associated range of ventilation provision likely to prevail, that excessive personal exposure to airborne contaminants could be encountered within this industry.

The findings of this work show that the environmental conditions within a commercial kitchen (compared to a domestic kitchen) can vary considerably. However, whilst the sample size of nine is thought to be too small to be a representative sample population of such premises, the findings may be used as an indication of the extreme environmental conditions that carbon monoxide alarms could be subjected to. A larger sample population would provide a more accurate assessment of the contaminant levels and environmental conditions.

Questionnaire for Air Quality Survey in Commercial Kitchens

Date: **Monitor used:**

Site location:	
Type of premises:	
Contact person & telephone number:	
Survey date:	

Type of appliances:		
Ventilation:		
Size of room – in meters		
Width -	**Length -**	**Height -**

Sketch of the room:

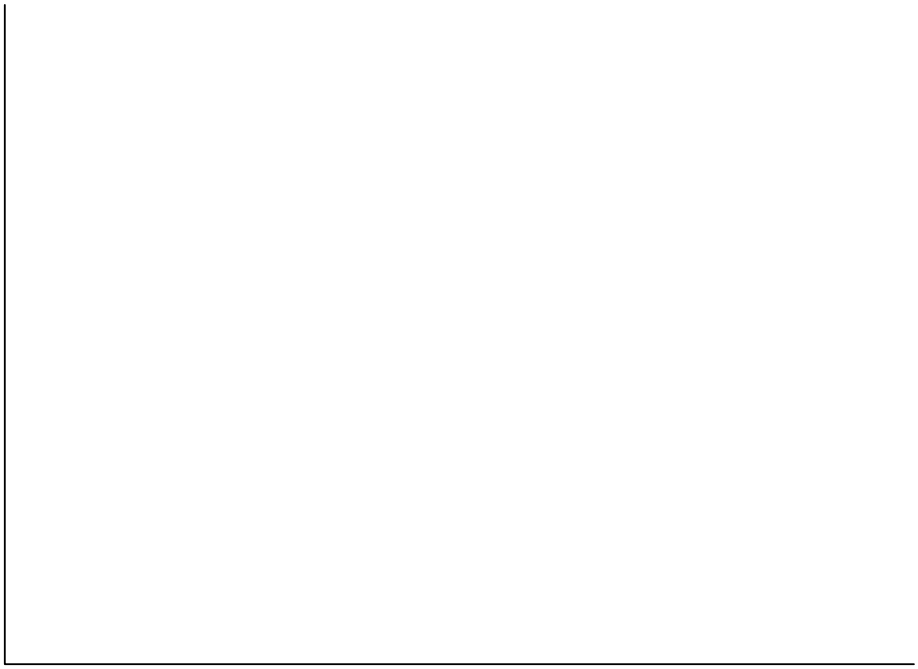

Figure 1 Questionnaire used for the survey

APPENDIX A GRAPHICAL PRESENTATION OF AIR QUALITY DATA

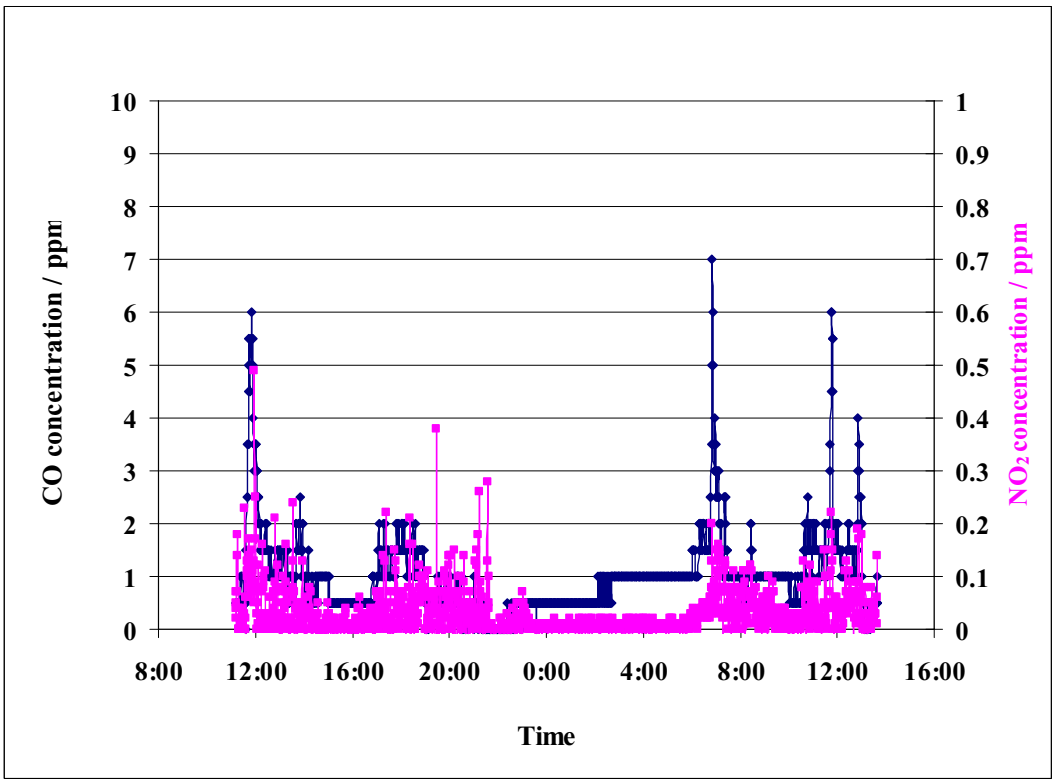

Figure A1 Site 1 - Carbon monoxide and nitrogen dioxide

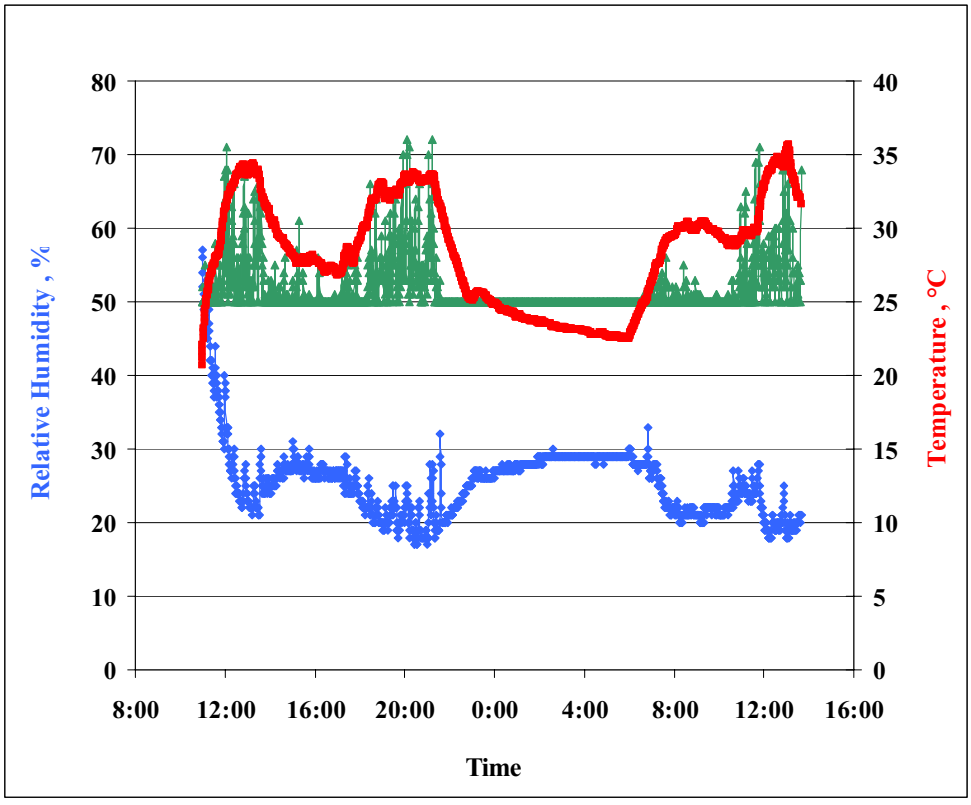

Figure A2 Site 1 - Relative humidity, temperature and occupancy (in green)

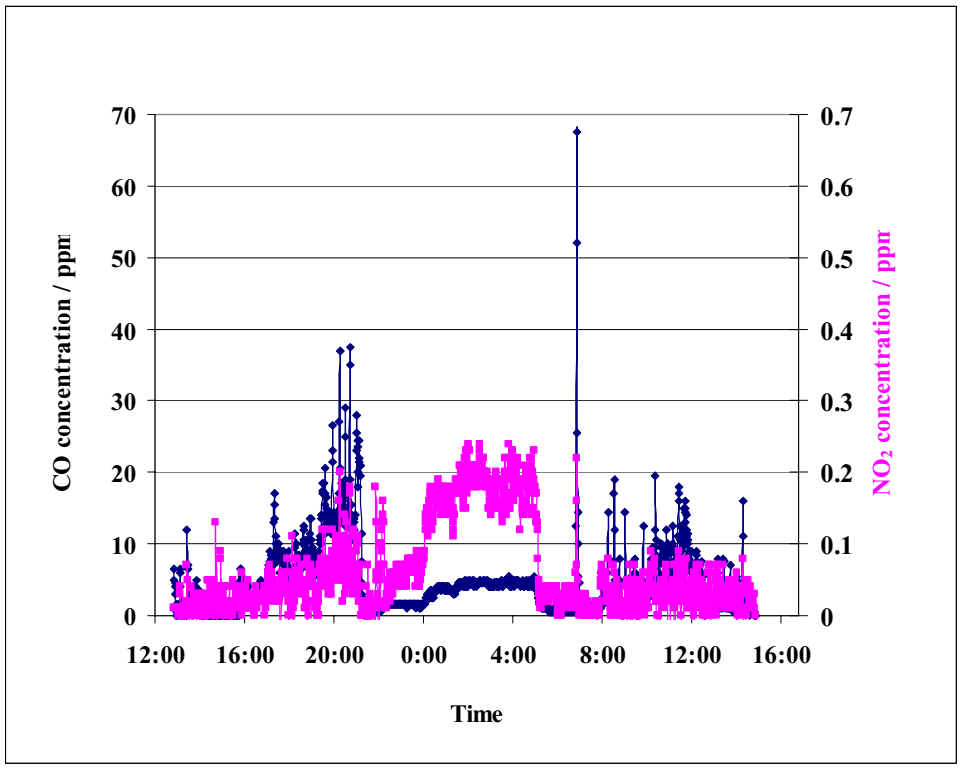

Figure A3 Site 2 - Carbon monoxide and nitrogen dioxide

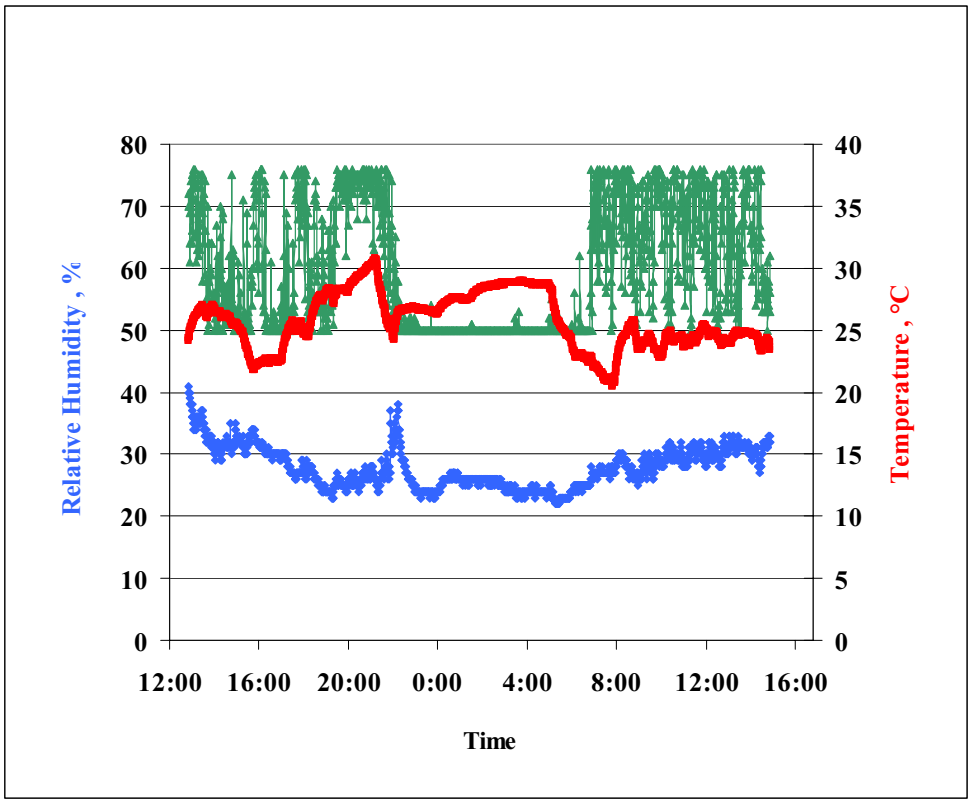

Figure A4 Site 2 - Relative humidity, temperature and occupancy (in green)

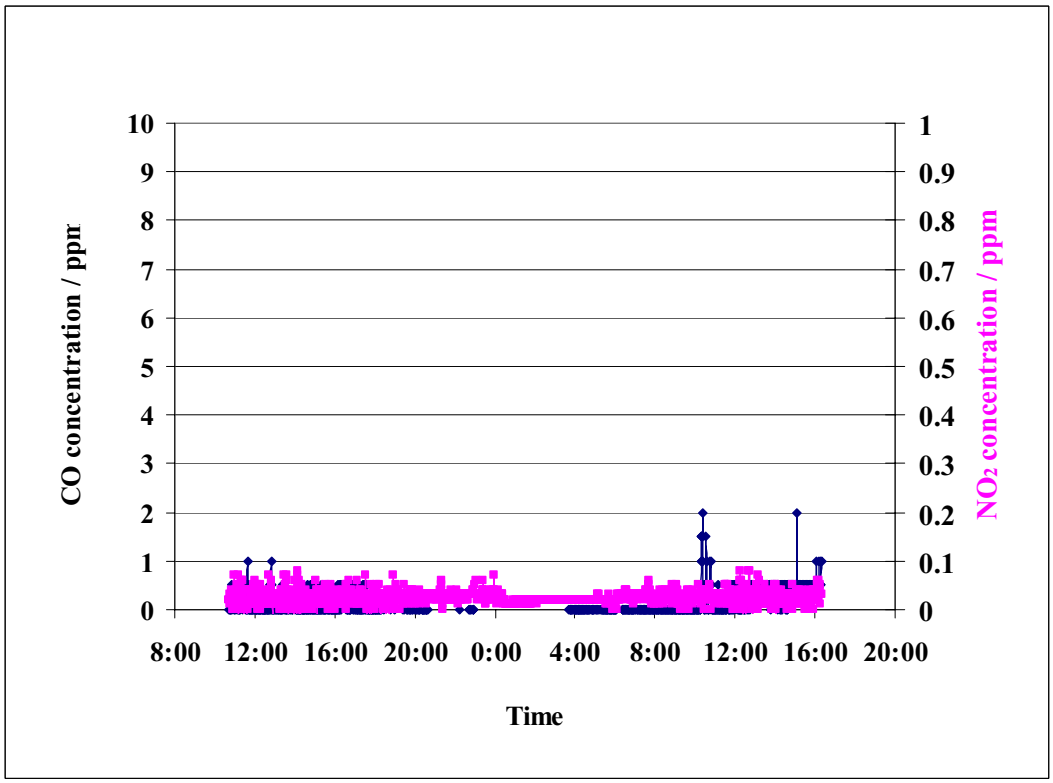

Figure A5 Site 3 - Carbon monoxide and nitrogen dioxide

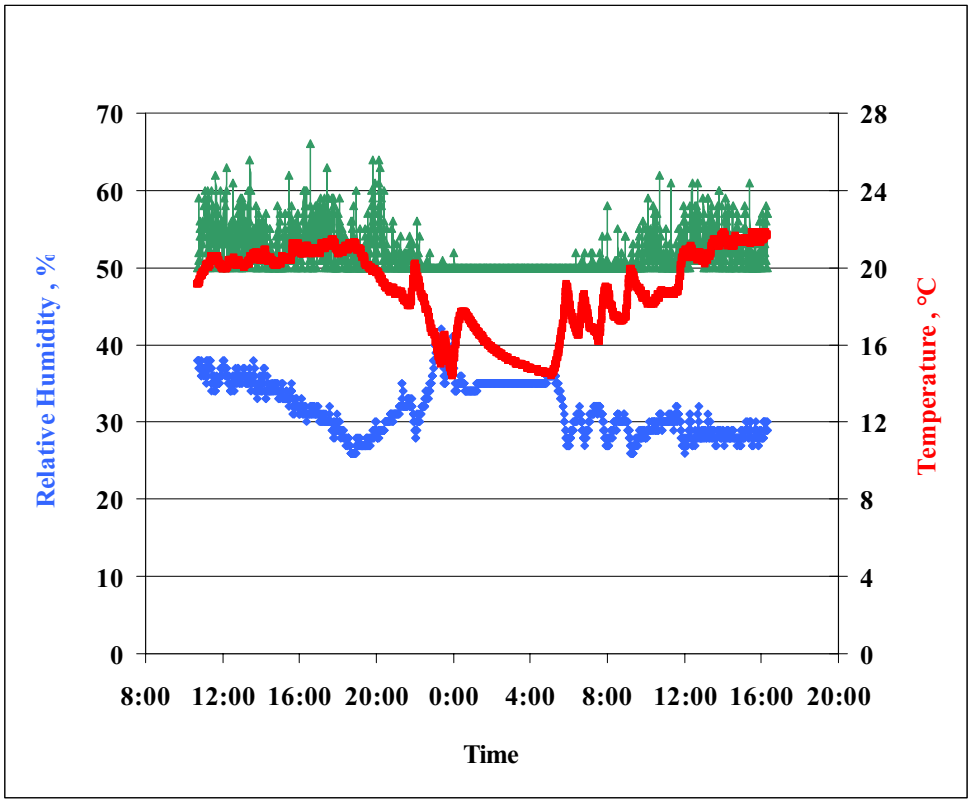

Figure A6 Site 3 - Relative humidity, temperature and occupancy (in green)

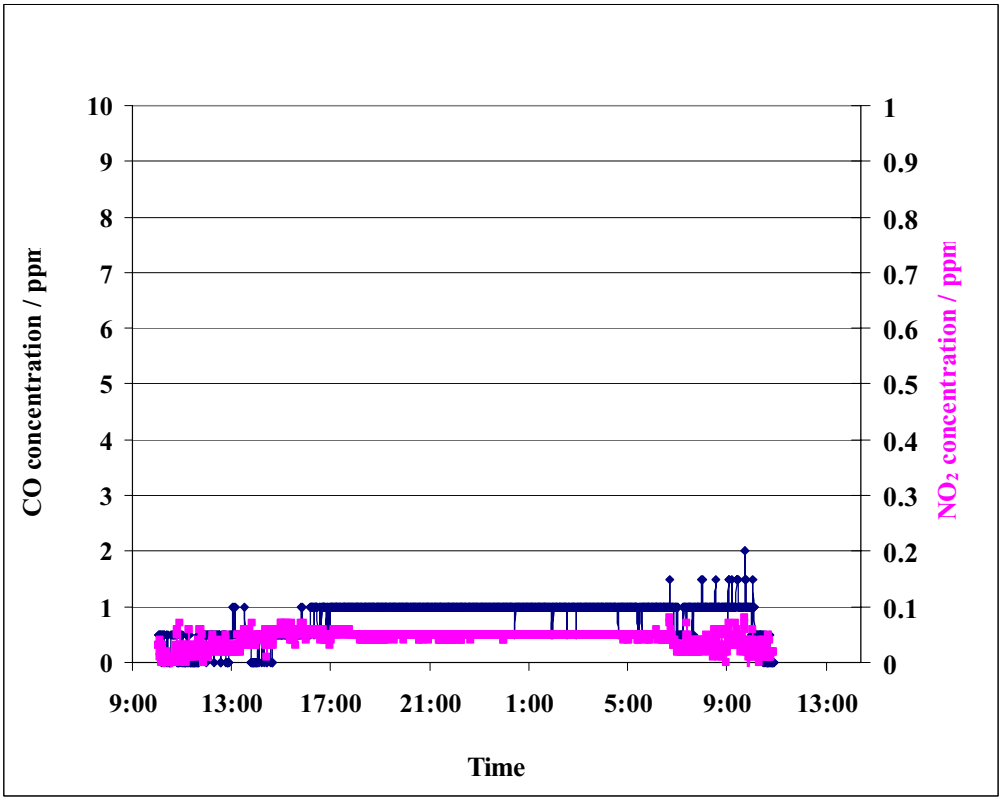

Figure A7 Site 4 - Carbon monoxide and nitrogen dioxide

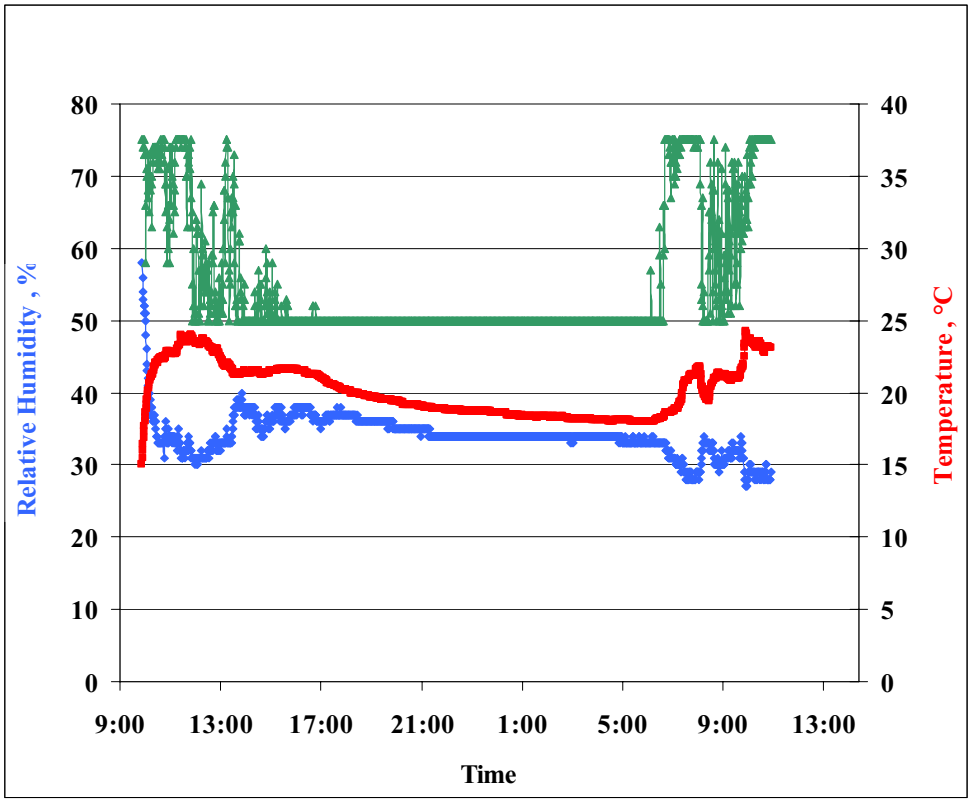

Figure A8 Site 4 - Relative humidity, temperature and occupancy (in green)

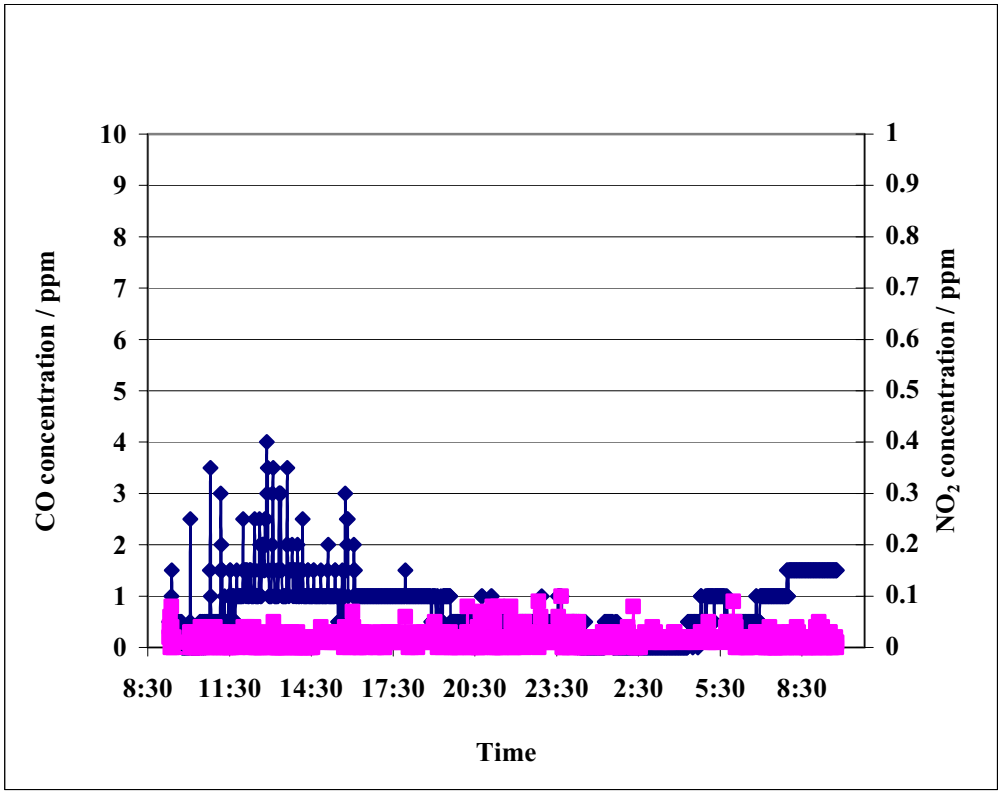

Figure A9 Site 5 - Carbon monoxide and nitrogen dioxide

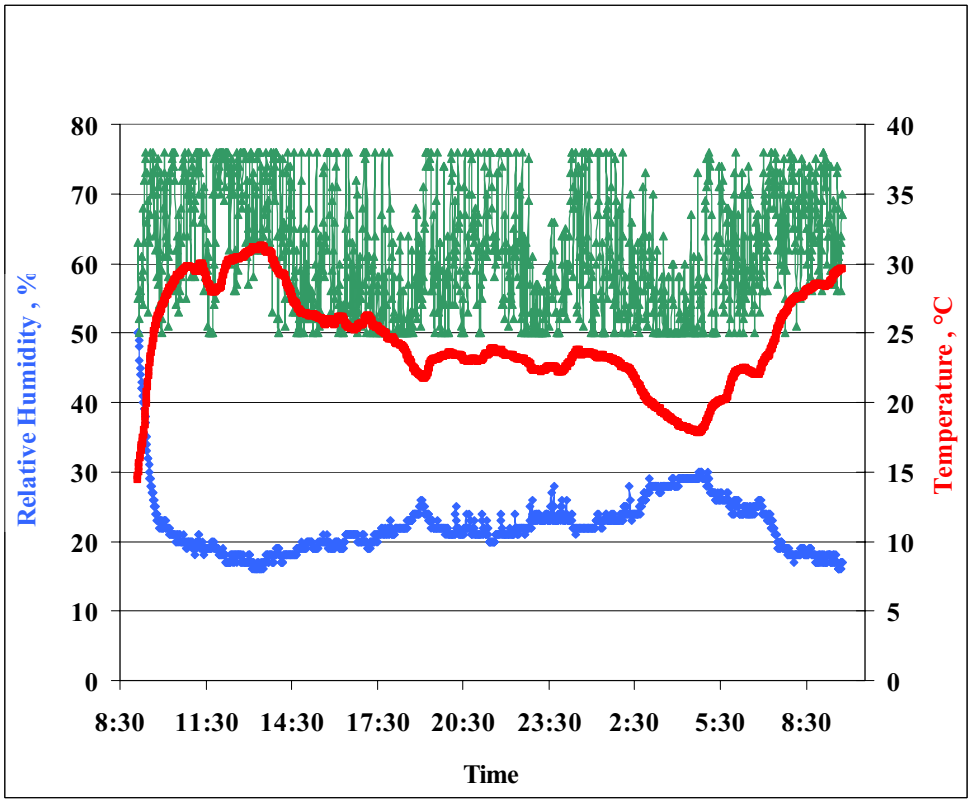

Figure A10 Site 5 - Relative humidity, temperature and occupancy (in green)

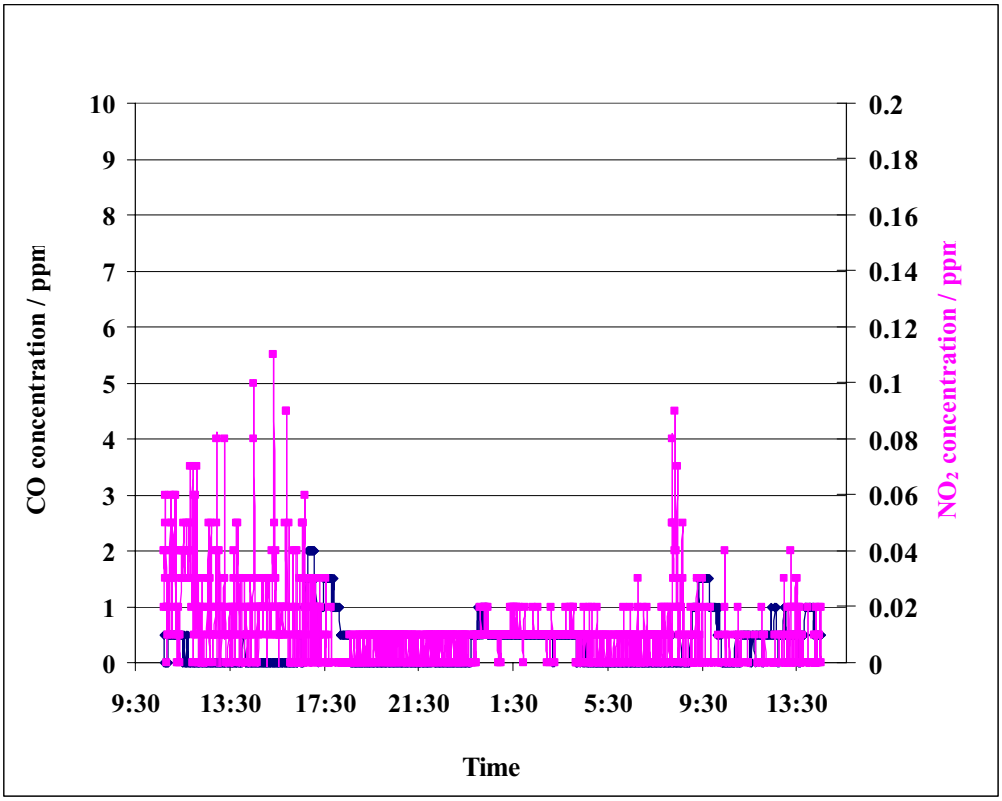

Figure A11 Site 6 - Carbon monoxide and nitrogen dioxide

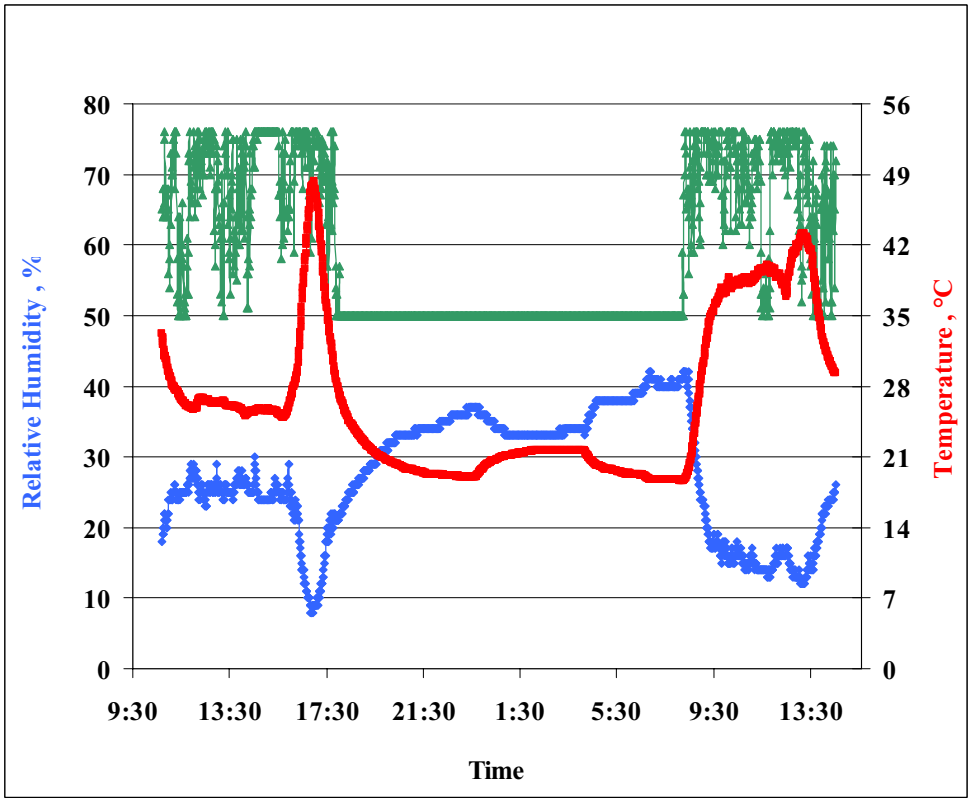

Figure A12 Site 6 - Relative humidity, temperature and occupancy (in green)

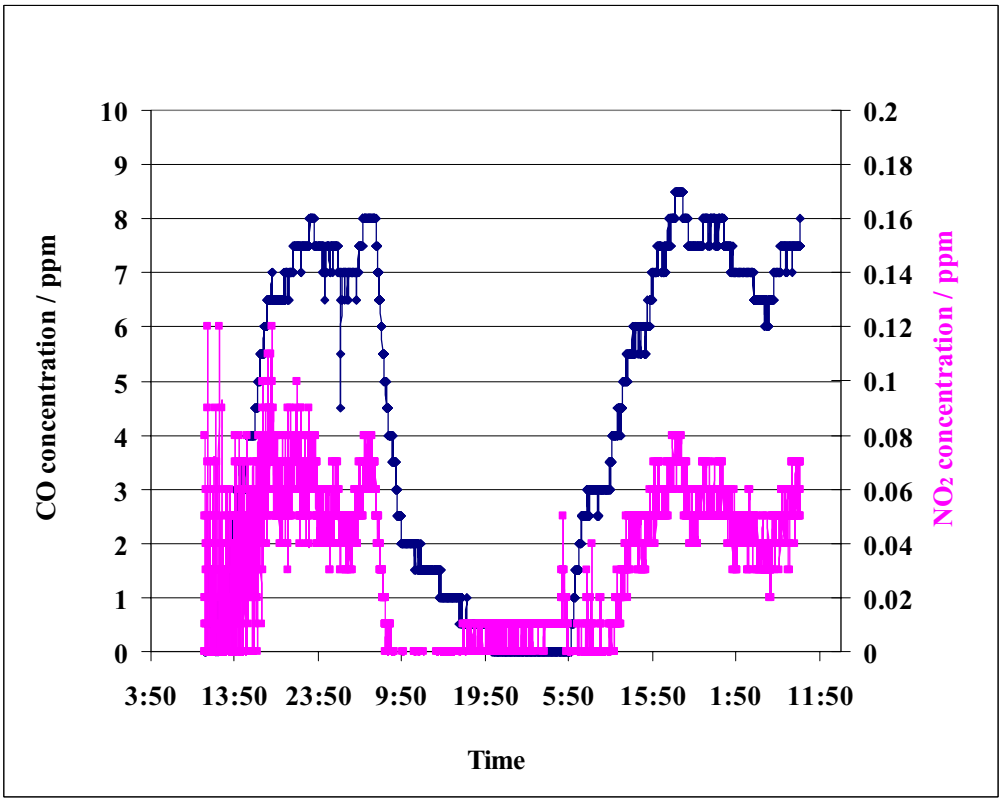

Figure A13 Site 7 - Carbon monoxide and nitrogen dioxide

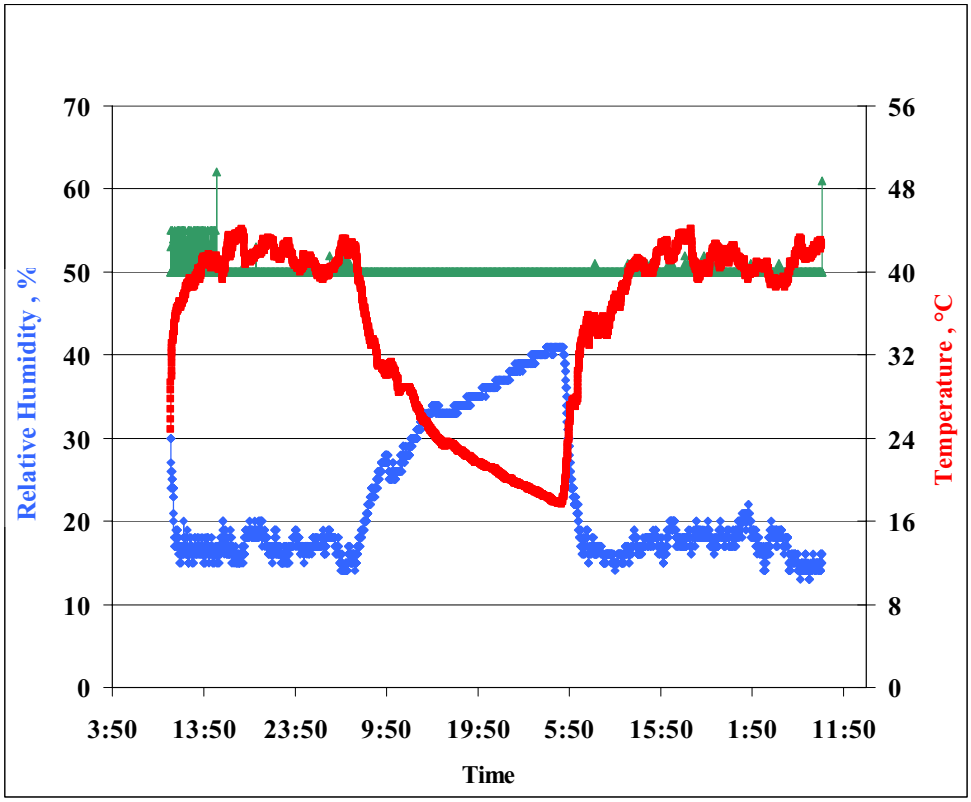

Figure A14 Site 7 - Relative humidity, temperature and occupancy (in green)

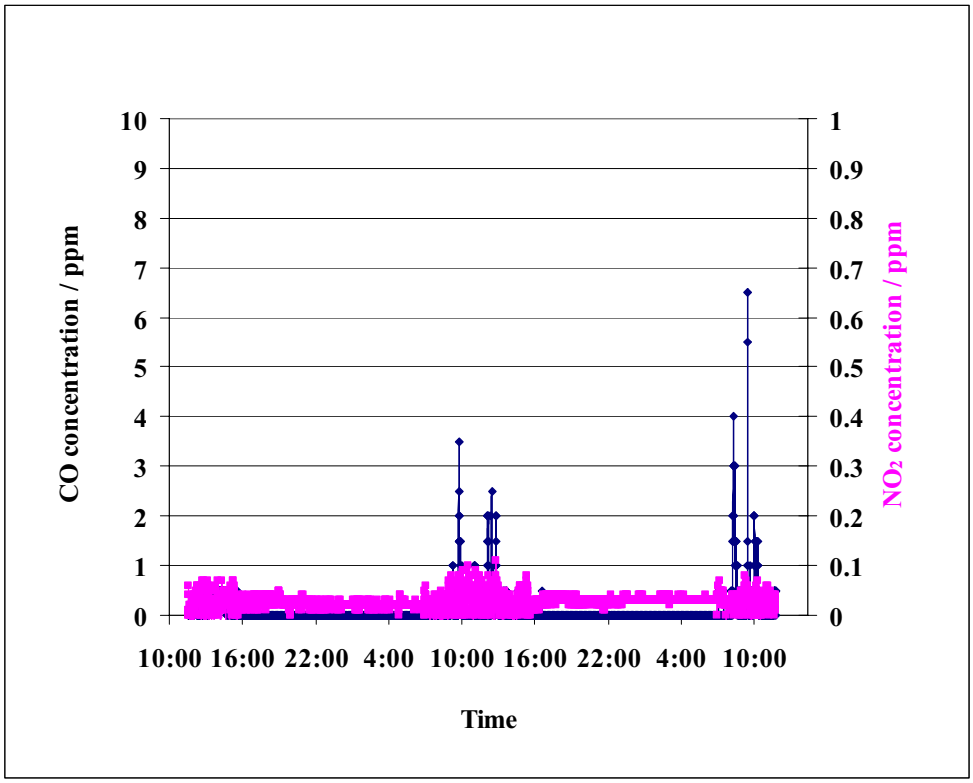

Figure A15 Site 8 - Carbon monoxide and nitrogen dioxide

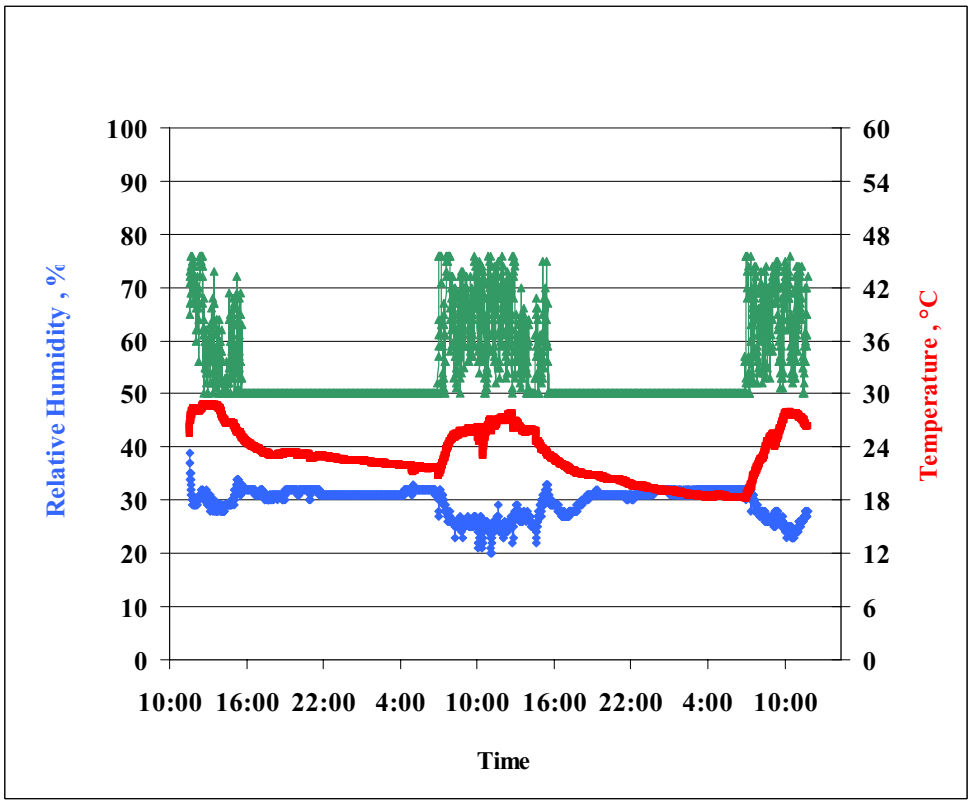

Figure A16 Site 8 - Relative humidity, temperature and occupancy (in green)

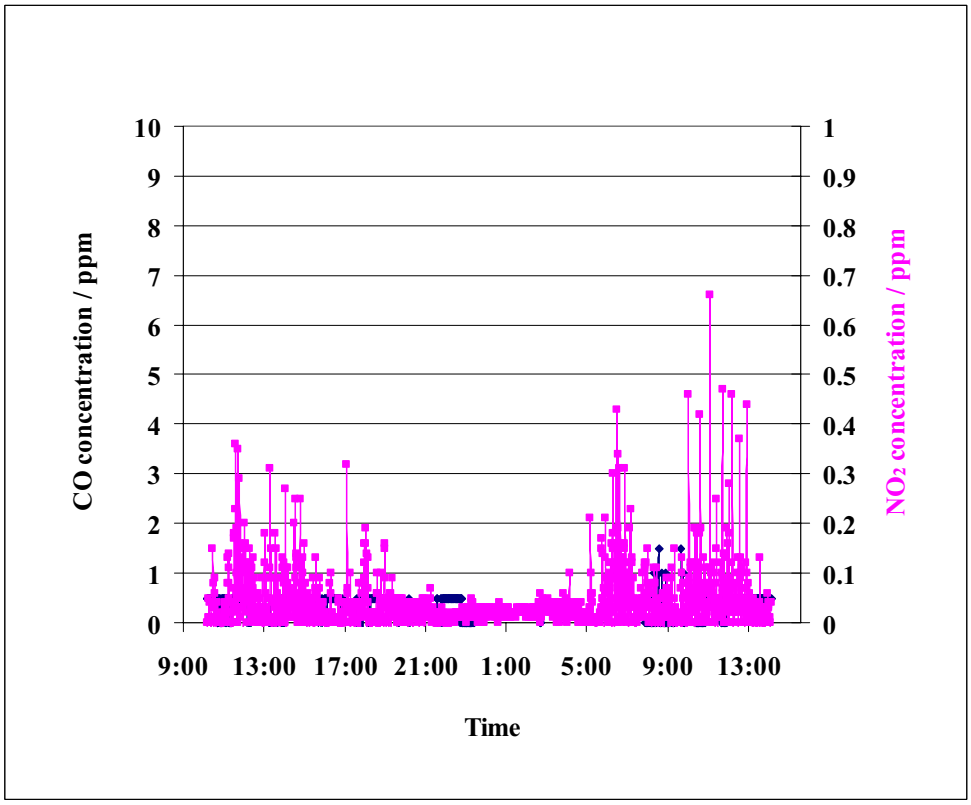

Figure A17 Site 9 - Carbon monoxide and nitrogen dioxide

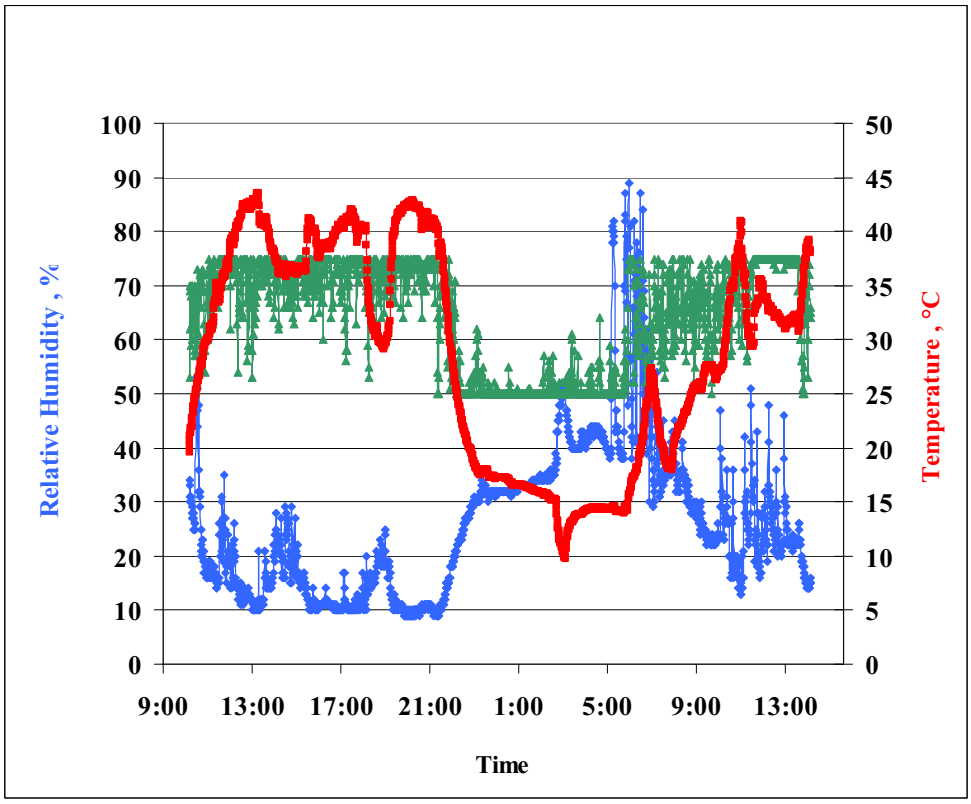

Figure A18 Site 9 - Relative humidity, temperature and occupancy (in green)

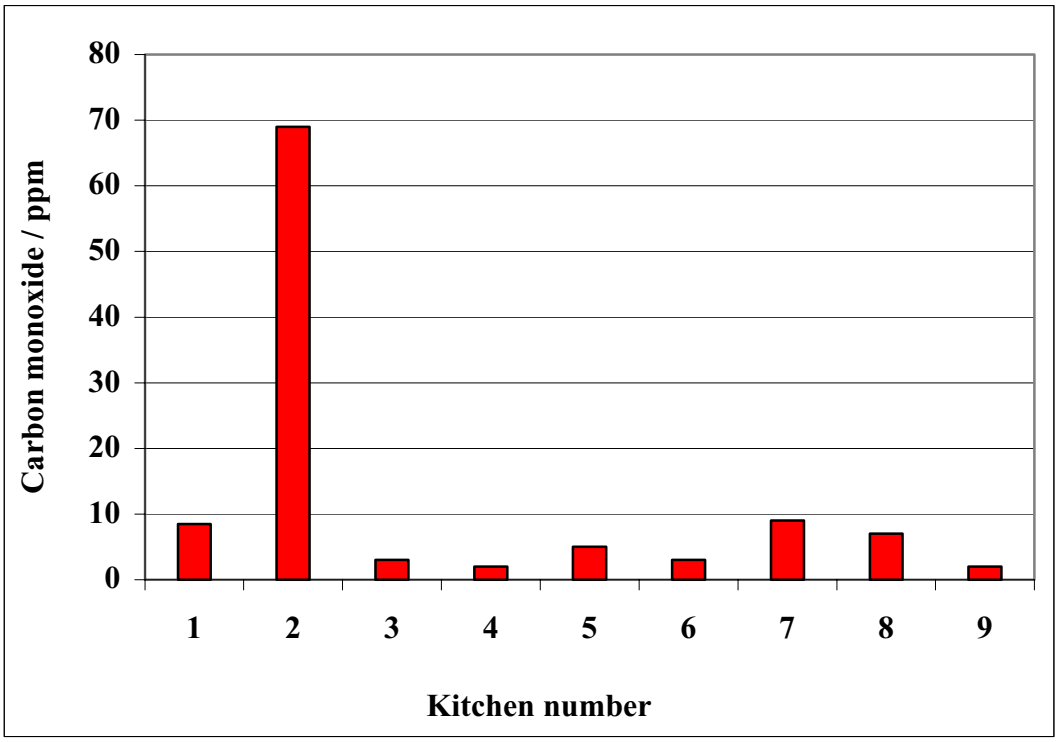

Figure A19 Carbon dioxide distribution for the surveyed kitchens

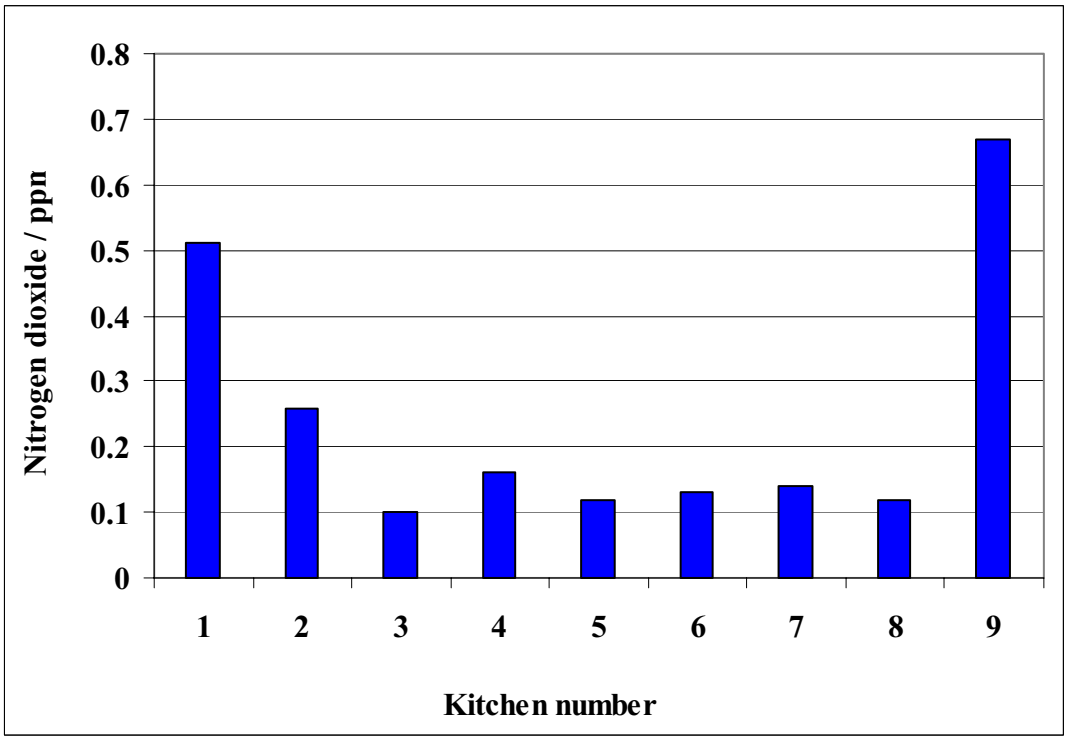

Figure A20 Nitrogen dioxide distribution for the surveyed kitchens

Position of the monitor in some of the surveyed kitchens

Position of the monitor in some of the surveyed kitchens

Position of the monitor in some of the surveyed kitchens

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