

INDOOR AIR QUALITY IN LIBRARIES IN THE UNIVERSITY OF LA CORUÑA

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ABSTRACT

The CO₂, H₂O and CO content of the indoor and outdoor air in the four libraries of the University of La Coruña (Spain) was monitored for 48 hours. For this a multipoint monitoring system was used, based on the infra-red photo-acoustic spectroscopy technique. This allowed us to identify the conditions of air renovation of indoor air with natural ventilation. Although good outdoors air quality was observed, the indoor air quality, on the other hand, was seem to deteriorate considerable during the periods of occupation. This would seem to indicate the need to improve the air renovation systems relative to the number of persons present.

INTRODUCTION

The indoor air quality in the four libraries in the University of La Coruña was monitored. These libraries, with their study areas, are open to students and teachers from 09:00 a.m. to 09:00 p.m. The procedure for renewing air by natural ventilation through manually-operated windows. In university environments the indoor air quality has a noticeable effect on the welfare, intellectual efficiency and the health of the users (1).

There are studies in several countries of the relationship between ventilation and indoor air quality (2), but no original data exist on similar situations in this part of the country.

The city of La Coruña lies on the north-west coast of Spain. It has a mild climate, a population of about 280000 and a moderate level of industrial activity. At the beginning of this study we arrived at the conclusion that the greatest indoor pollution factor was the human one. For this reason the components we identified as most influential on determining indoor air quality were carbon dioxide, water content and carbon monoxide. To this end we carried out a simultaneous study of these components in both indoor and outdoor air. The results of these studies are shown in the graphs.

METHODS

We chose four main libraries of different ages and design. The Marina Civil library is 25 years old and has an area of 220 m². The Arquitectura is 20 years old and has an area of 240 m². The Ciencias library was opened 12 years ago and has an area of 380 m², while the Economicas library is only 5 years old and covers an area of 240 m². During the months of May and June 1996, when this study was carried out, there was a normal level of activity in the libraries. In all four cases the number of occupants varied at any given moment between 20 and 50 people.

A multipoint sampler was used to take samples from both indoors and outdoors. The samples were transmitted to a monitoring system based on the infra-red photo-acoustic spectroscopy technique,

the results being recorded continually at 10 minute intervals over a 48-hour period.

RESULTS

Fig. 1 represents the variations of CO₂ in the Marina Civil library, where monitoring began at 17:12 hours on the 7th, with a value of 2200 mg/m³. Then it descended during the night to 700 mg/m³ at 07:30 hours on the 8th. It then increased with occupation to 4130 mg/m³ at 13:00 hours. It decreased because of a fall in occupation to 1255 mg/m³ at 15:30 hours. With an increase in occupation it rose to 3500 mg/m³ at 19:00 hours and, finally, it dropped to the same values as the outdoor air. On the 9th, it rose with occupation to 3650 mg/m³ at 13:00 hours, after decreasing for the same reasons as on the previous day. Finally, it rose to 3800 mg/m³ when the test ended. The outdoor air varied between 700 and 800 mg/m³. The indoor temperature oscillated between 16 and 21 °C.

Fig. 2 corresponds to the variations of CO₂ in the Ciencias library, where the measurements began at 18:13 hours on the 22nd, with a value of 3200 mg/m³. After closing at 21:00 hours, there were 2000 mg/m³. During the night fell to 950 mg/m³ at 07:30 hours. At 08:00 hours on the 23th, it began to rise to 3950 mg/m³ at 14:00 hours. After there was a decrease to 2100 mg/m³ at 21:00 hours, when occupation ended. During the night, it descended to 1100 mg/m³ at 08:00 hours on the 24th. Then, it rose with occupation to 3700 mg/m³ at 14:30 hours. Then it fell to 2000 mg/m³ at 18:00 hours and the test ended. Outdoors the CO₂ varied between 750 mg/m³ and 800 mg/m³. The indoor temperature oscillated between 17 °C and 21 °C.

Fig. 3 corresponds to the variations of CO₂ in the Arquitectura library, where the measurements began at 15:00 hours on the 28th, with a value of 1800 mg/m³. It decreased to 800 mg/m³ at 21:30 hours. During the night it fell slightly to a level of 750 mg/m³ at 08:30 hours on the 29th. Then it began to rise due to human occupation to 1350 mg/m³ at 12:15 hours. Then it fell to 1150 mg/m³ and at 15:00 hours there was a new rise to 1550 mg/m³ at 15:30 hours. It fell to 800 mg/m³ at 20:30 hours. During the night it descended to 760 mg/m³ at 08:30 on the 30th. After, it rose to a level of 1800 mg/m³ at 13:00 hours at which the test ended. Outdoor levels varied between 700 and 800 mg/m³. The indoor temperature oscillated between 17 °C and 22 °C.

Fig. 4 corresponds to the variations of CO₂ in the Economicas library, where monitoring began at 20:00 hours of the the 17th, with a value of 1350 mg/m³. Then it fell during the night to 825 mg/m³ at 08:00 hours on the 18th. It increased with occupation to 1850 mg/m³ at 13:00 hours. Then, it fell to 900 mg/m³ at 15:00 hours. It rose with occupation to 1350 mg/m³ at 21:00 hours. It fell during the night to 800 mg/m³ at 08:00 hours on the 19th. It increased with occupation to 2300 mg/m³ at 15:30 hours. It fell again to 1250 mg/m³ at 20:00 hours at which the test ended. Outdoor levels varied between 700 and 900 mg/m³.

Fig. 5 shows the variations of H₂O in the Marina Civil library, where the test began on the 7th at 17:10 hours, with a value of 11425 mg/m³. Later, during the night it fell to 9500 mg/m³ at 08:30 hours on the 8th. With occupation it rose to 11900 mg/m³ at 15:00 hours, falling to 10400 mg/m³ at 18:00 hours. It rose again with occupation to 11500 mg/m³ at 20:00 hours and fell during the night to 9500 mg/m³ at 07:30 hours on the 9th. It rose due to occupation to 10850 mg/m³ at 12:30 hour. After it fell due to a decrease in occupation and rose again to 11200 mg/m³ at 17:00 hours. Then there was a slight decrease to 10695 mg/m³ at 20:00 hours at which the test ended. Outdoor levels fell from 9625 to 9400 mg/m³.

Fig. 6 corresponds to the variations of H₂O in the Ciencias library, where the monitoring began at 18:25 hours on the 22nd, with a value of 12000 mg/m³. During the night it fell to 9800 mg/m³ at 08:30 hours of the 23rd. After it rose to 12350 mg/m³ at 11:30 hours. Then it fell to 11600 mg/m³ at 16:00 hours. Later it rose to 12755 mg/m³ at 17:30 hours. During the night, it fell to 9600 mg/m³ at 08:00 hours on the 24th. With occupation it rose to 12500 mg/m³ at 15:30 hours.

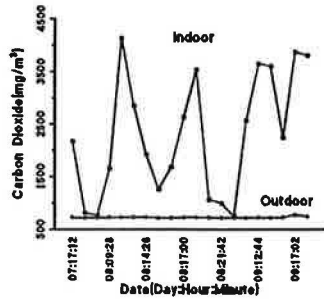


Figure 1. CO₂ concentration versus time in Marina Civil library.

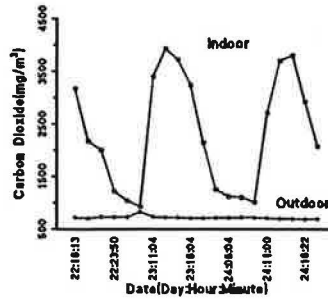


Figure 2. CO₂ concentration versus time in Ciencias library.

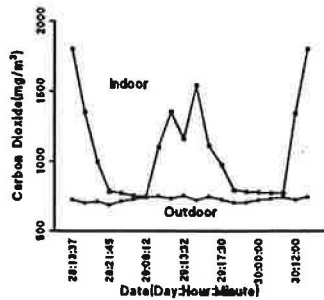


Figure 3. CO₂ concentration versus time in Arquitectura library

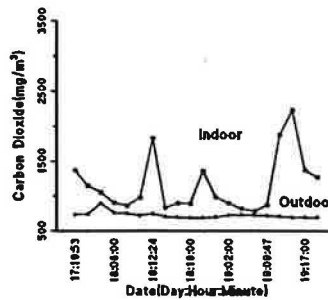


Figure 4. CO₂ concentration versus time in Economicas library

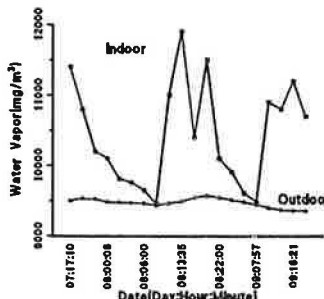


Figure 5. H₂O concentration versus time in Marina Civil library.

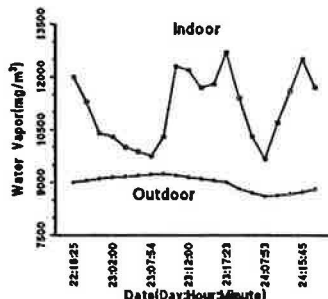


Figure 6. H₂O concentration versus time in Ciencias library

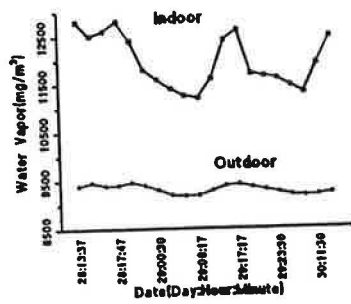


Figure 7. H₂O concentration versus time in Arquitectura library

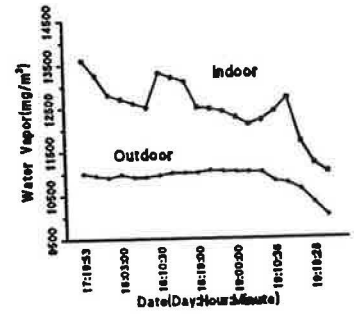


Figure 8. H₂O concentration versus time in Economias library

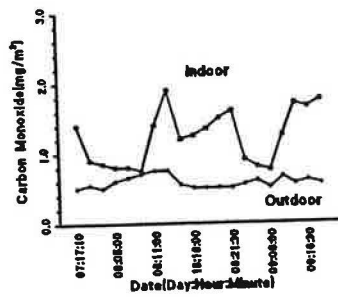


Figure 9. CO concentration versus time in Marina Civil library

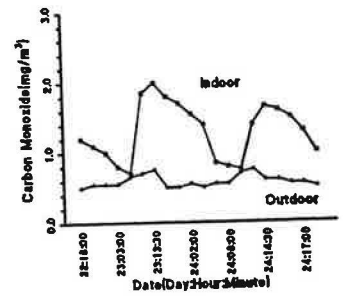


Figure 10. CO concentration versus time in Ciencias library

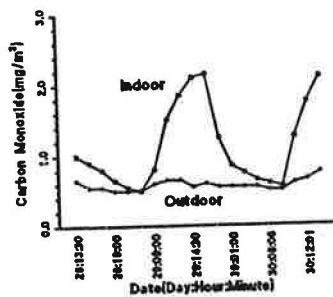


Figure 11. CO concentration versus time in Arquitectura library

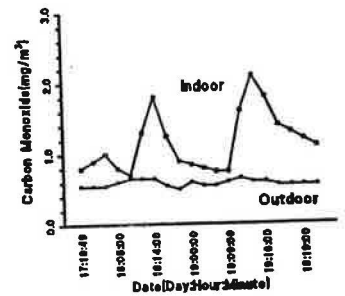


Figure 12. CO concentration versus time in Economias library

It fell to 11600 mg/m³ at 17:00 hours at which the test ended. Outdoor levels varied between 9300 and 8900 mg/m³.

Fig. 7 indicates the variations of H₂O in the Arquitectura library, where monitoring began at 13:37 hours on the 28th, with a value of 12800 mg/m³. Then there was a slight fall to 12500 mg/m³ at 15:30 hours. It rose to 12800 mg/m³ at 18:00 hours, falling to 11600 mg/m³ at 21:00 hours. It rose during the night to reach 11200 mg/m³ at 08:00 hours on the 29th. It rose to 12600 mg/m³ at 16:00 hours, falling to 11600 mg/m³ at 21:00 hours. At night it decreased to 11280 mg/m³ at 08:00 hours on the 30th. Then it rose to 12500 mg/m³ at 13:00 hours at which the test ended. Outdoor levels varied between 9200 and 9500 mg/m³.

Fig. 8 are shown the variations of the H₂O in the Economicas library, where monitoring began at 19:53 hours on the 17th, with a value of 13600 mg/m³. During the night it fell to 12500 mg/m³ at 08:00 hours on the 18th. It rose to 13300 mg/m³ at 13:00 hours, falling to 12250 mg/m³ at 21:00 hours. Then it continued to fall during the night to 12000 mg/m³ at 08:00 hours on the 19th. It then rose to 12700 mg/m³ at 12:00 hours. It fell to 11000 mg/m³ at 20:45 hours at which the test ended. In outdoor air it varied between 11000 and 10000 mg/m³.

Fig. 9 corresponds to the variations of CO in the Marina Civil library, in which monitoring began with 1.40 mg/m³ on the 7th at 17:10 hours. During the night it fell to 0.75 mg/m³ at 08:00 hours on the 8th. After it rose to 1.95 mg/m³ at 12:45 hours, falling to 1.20 mg/m³ at 15:30 hours. It ascended to 1.60 mg/m³ at 20:30 hours. There was a fall during the night to 0.75 mg/m³ at 08:00 hours on the 9th. It rose to 1.75 mg/m³ at 12:30 hours. Then it fell to 1.65 mg/m³ at 16:00 hours. It rose again to 1.8 mg/m³ at 19:00 hours at which the test ends. Outdoor measurement varied between 0.50 and 0.80 mg/m³.

Fig. 10 corresponds to the measurements of CO in the Ciencia library, which started with 1.20 mg/m³ on the 22nd at 18:00 hours. Then there was a night-time fall to 0.70 mg/m³ at 08:30 hours on the 23rd. After it rose to 2.05 mg/m³ at 13:30 hours. There was a gradual fall to 0.75 mg/m³ at 09:00 hours on the 24th. Then it rose from 1.75 mg/m³ at 15:00 hours. It then fell again to 1.00 mg/m³ at 20:30 hours at which the test ended. Outdoor levels varied between 0.50 to 0.80 mg/m³.

Fig. 11 shows the variations of CO in the Arquitectura library, which show an initial value of 1.00 mg/m³ at 13:30 hours on the 28th. After, during the night-time hours, it fell to the level of the outdoor air. Then at 08:00 hours on the 29th, it rose to a peak of 2.15 mg/m³ at 16:00 hours. After, it fell to 0.55 mg/m³ at 08:15 hours on the 30th. Then there was a rise to 2.10 mg/m³ at 13:30 hours at which the test ended. Outdoor levels varied between 0.50 and 0.80 mg/m³.

Fig. 12 represents the values of CO in the Economicas library, which were taken with an initial value of 0.80 mg/m³ at 19:49 hours on the 17th. Then it rose to 1.00 mg/m³ at 21:00 hours. Then, there was a night-time fall to 0.65 mg/m³ at 08:00 hours on the 18th. With occupation it rose to 1.80 mg/m³ at 15:00 hours. After it dropped to 0.80 mg/m³ at 17:00 hours. There was a night-time fall to 0.70 mg/m³ at 09:00 hours on the 19th. Then it rose to 2.15 mg/m³ at 14:30 hours. Finally it fell to 1.10 mg/m³ at 20:30 hours at which the test ended. Outdoor levels varied between 0.50 and 0.75 mg/m³.

DISCUSSION

It is recognised that CO₂ does not have direct harmful effects on health, but when there are concentrations higher than 1600 mg/m³ there exists clear evidence of a lack of ventilation (5). As can be observed in Figs. 1 to 4, the CO₂ content during the hours of occupation is higher than the recommended value. During the hours without occupation values tend to fall to those of outdoor air, which oscillated between 700 and 800 mg/m³. It would be better to use a system which adjusted the ventilation according to number of persons.

As can be seen in Figs. 5 to 8, the outdoor levels of H₂O (between 8000 and 11000 mg/m³), are

influenced by climatic conditions. That is to say, if the prevailing wind is from the North-West (the North- Atlantic) it has a high moisture content, whereas if it is from the North-East (the Continental land-mass of Europe) the water content is appreciably lower. The highest indoor value measured was 13600 mg/m³, while the minimum was equal to or a little higher than the outdoor level. Therefore, taking into account an indoor temperature during occupation of 20 °C, the recommended limit of relative humidity corresponds to a concentration of 10400 mg/m³. Thus some of the indoor moisture levels can be seen to be excessive. However, as can be seen in the last part of the graph in Fig. 8, when outdoor levels show a tendency to fall there is also a decrease in indoor levels.

The CO content shown in the graphs in Figs. 9 to 12, outdoor and indoor, is well within normal levels and does not go beyond recommended safety limits.

The overall conclusion to be drawn is that, given the levels of human occupation, air renewal procedures should be modified to avoid going above the recommended levels.

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