The effect of CO_2 on the nocturnal restlessness of an Alzheimer patient

Bart Cremers

Zehnder Group Nederland
Lingenstraat 2
8028 PM Zwolle, The Netherlands
bart.cremers@zehndergroup.com

ABSTRACT

At typical indoor CO_2 levels there is no scientific evidence that CO_2 is harmful to comfort and health of healthy persons, though there is a potential for negative effects on some aspects of performance. Research also indicates that insufficient bedroom ventilation may negatively affect the quality of sleep.

This document reports practical observations of the effect of CO_2 on the nocturnal restlessness of an Alzheimer patient. During a month, the CO_2 values in the bedroom of the patient were recorded. Typical values of the CO_2 level in the bedroom are evaluated, and related to the occupancy of the bedroom and the position of an exterior window and an interior door to the hallway.

The nocturnal behavior of the Alzheimer patient was observed by the partner of the patient occasionally. The result of the study on this particular Alzheimer patient was that the nocturnal restlessness was absent when the bedroom CO_2 level did not exceed 750 – 800 ppm. Above this value, the restlessness emerged in symptoms like humming, teeth grinding, apnoea and sometimes leading to panic. Intervention of the partner by opening the window was followed by a gradual decrease in CO_2 and consequently a more restful sleep.

Although this study is the practical observation of one Alzheimer patient only, it shows that the effect of typical indoor CO_2 values may be larger for people suffering from Alzheimer's disease than for healthy persons. More research on a larger number of patients is being carried out at the moment.

KEYWORDS

Indoor air quality, sleep quality, Alzheimer, nocturnal restlessness

1 INTRODUCTION

The relation between the indoor air quality in buildings and the health of occupants gets more and more attention nowadays. However, it is difficult to point to health effects that have a direct relation to poor indoor air quality. In a risk assessment study Logue (2011) indicated that the risk of indoor air quality on shortened life expectancy is in between the risk of car accidents and the risk of heart diseases.

There may be a stronger relation between the indoor air quality in bedrooms and the sleep quality of inhabitants. Strøm-Tejsen et al. (2014) showed that a higher ventilation rate (open window) had a significant positive effect on sleep latency and the ability to fall asleep.

This research reports the measurement of bedroom CO_2 levels and nocturnal restless behavior of an Alzheimer patient as observed by the husband of the patient.

2 METHOD

A couple (husband and wife) is living in a naturally ventilated house. Fresh air is provided in a natural way via the envelope of the house, possibly increased by the opening of one or more windows.

Since 2007, the wife is suffering from Alzheimer's disease, with gradual increasing symptoms of dementia. During days, she occasionally suffers from restless behaviour, indicated by periodic introvert behaviour and humming sounds. During the nights, the restless behaviour occasionally shows, indicated by snoring, apnoea, restless sleep and panic when she wakes in the night.

During nights and in the afternoon, the wife, and sometimes the husband, take a sleep in the bedroom (fig. 1). The window in the bedroom is a top-hinged turnable window which is occasionally opened according to the wish of the husband. The interior door from the bedroom to the hallway may be opened or closed, as desired by the husband.

Figure 1: The bedroom with a view on the window.

An indicator for the indoor air quality in the bedroom is the CO_2 level, which has been recorded in a 15 minute interval with a CO_2 logger (Wöhler type CDL 210, see fig. 2a). This logger simultaneously records temperature and relative humidity as well. The logger was placed on a small table next to the bed on the side where the husband sleeps, as far as possible from the direct breathing area.

In order to avoid psychological influence by the indicated CO_2 level, it was proposed to cover the screen with tape, but this was refused by the husband so he could see whether an intervention like opening a window had an effect on the CO_2 level.

The nocturnal behaviour of the wife was described during the night and the day by the husband in a notebook. Incidents of restless behaviour were noted with the specific time. Also, changes in the window position and interior door position were noted. Lastly, the occupation of the bedroom was noted. For an example of one page of the notebook (excluding Dutch description of the behaviour), see figure 2b.

The indoor air quality and the observed behaviour was recorded during 5 weeks from the 5th of February 2014 until the 13th of March 2014.

a) b)

Figure 2 a: The CO_2 logger, b: example page of the notebook.

3 INFLUENCE OF WINDOW AND DOOR POSITION ON CO_2 LEVEL

In order to give an idea how the bedroom CO_2 level was dependent on occupation and on window/door position, the average CO_2 level was evaluated in categories. Figure 3 shows columns in the front row for an unoccupied bedroom, the middle row columns for one person and columns in the back row when two persons are in the bedroom. Furthermore, the horizontal axis shows the positions of window and interior door (closed or open).

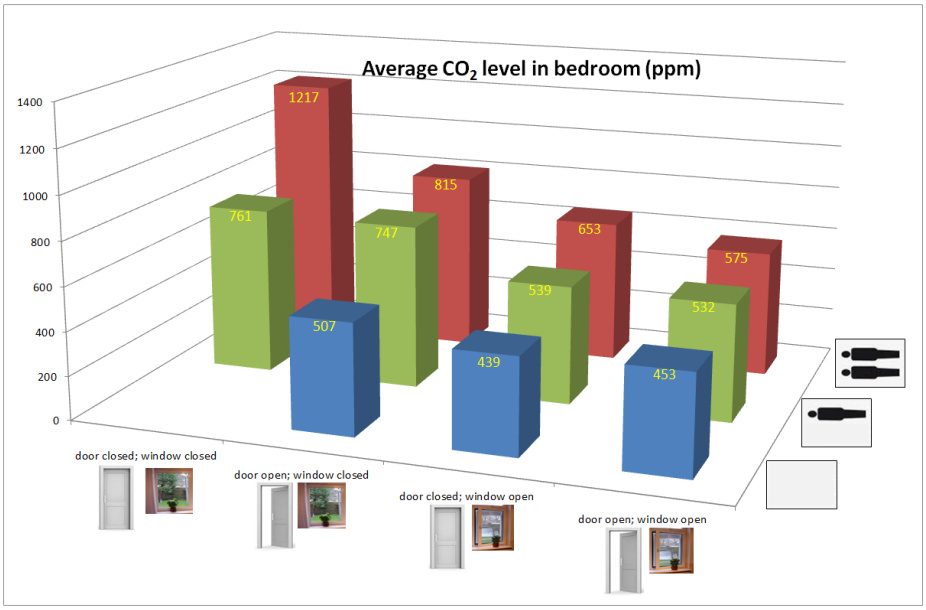

Figure 3: The effect of occupation, window and door position on the average CO_2 level in the bedroom. Left to right: door & window closed, door open & window closed, door closed & window open, door & window open.

As expected, the CO_2 level rises with the number of people in the room. The results also show that the largest reduction of CO_2 can be achieved by opening the window, and leaving the door open to the hallway also helps to reduce the CO_2 level. Obviously, opening the window increases mixing of indoor air with fresh outdoor air, while opening the door increases mixing with indoor air from the hallway. There is one exception to this last effect: when the bedroom is unoccupied, an open door to the hallway leads to a slightly higher CO_2 value, because CO_2 level from the hallway can be larger than CO_2 level from the bedroom.

The average values of CO_2 level in the bedroom are for a 5 week period, so they cannot be regarded as statistical. Moreover, the number of recordings for each situation are not comparable. There were a lot of recordings with window and door both open, while only a few short periods with window and door both closed. In spite of this, the effect of occupation and window and door position on the CO_2 level is logical and gives guidance to keep the indoor air quality to a certain level.

4 INFLUENCE OF CO_2 LEVEL ON RESTLESSNESS OF ALZHEIMER PATIENT

Figure 4 shows the first 5 days of the recording period, where the husband experimented a lot with opening and closing of windows and doors in the bedroom. The observed restless behavior of his wife as described in the notebook coincides with peaks in the bedroom CO_2 level. Whenever this behavior was apparent, the window and/or door was opened in order to lower the CO_2 level again. According to the observations, approximately 30 to 45 minutes after this intervention (also indicated in the graph), his wife was breathing and sleeping normally again.

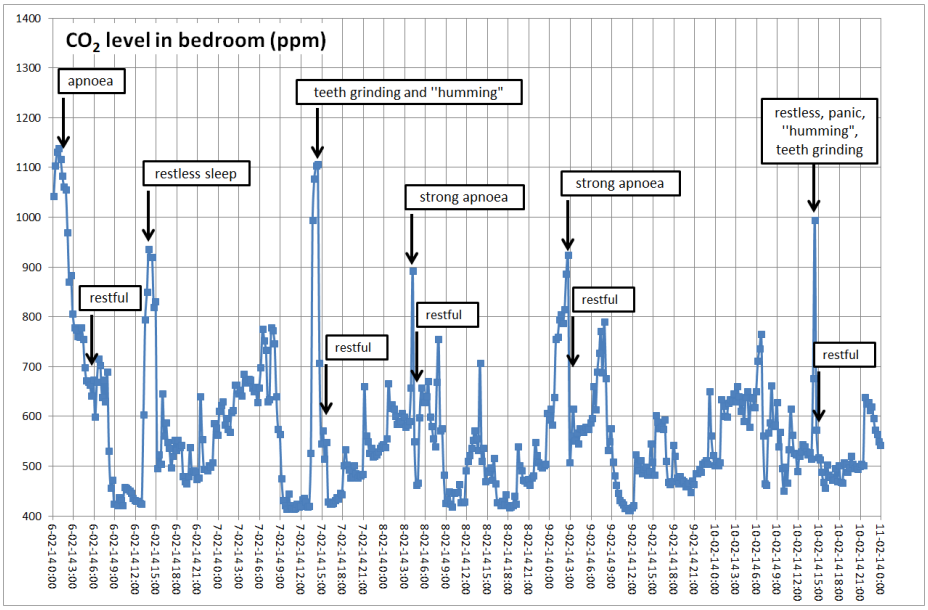

Figure 4: The bedroom CO_2 level and the observed behavior of the Alzheimer patient during a five day experimental period.

After a couple of nights of experimenting, the husband of the Alzheimer patient decided to keep an eye on the CO_2 level and intervene with window and door opening in a more anticipating way. Figure 5 shows that the restless behavior during sleeping has decreased in occurrences, except for some nights when CO_2 levels were quite high where window or door was left closed.

From the recorded period and the noted observations, the data seems to indicate that the restless sleep behaviour is not observed when CO_2 levels are kept below approximately 800 ppm.

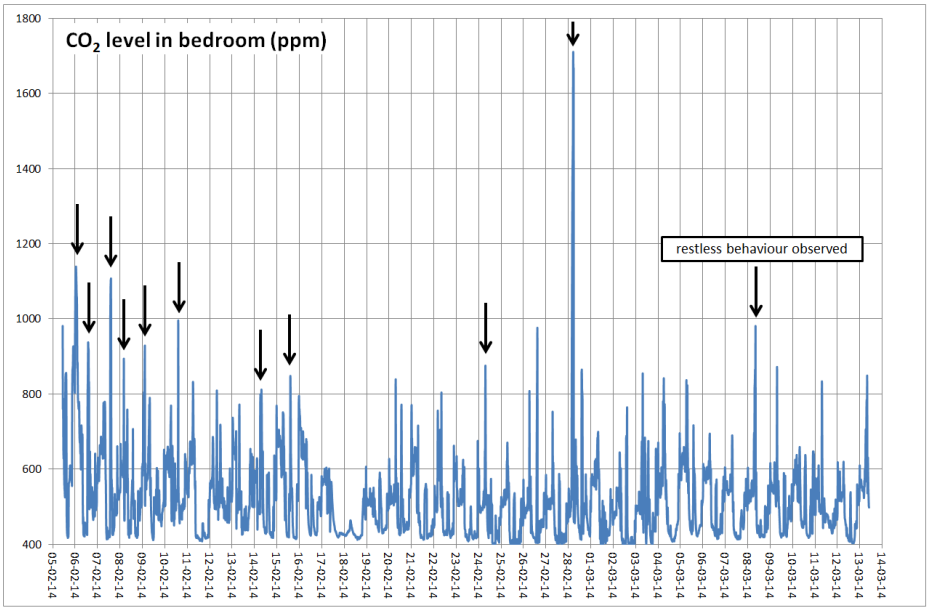

Figure 5: The CO_2 level and the occurrences of restless behavior (arrows) during the 5 week recording period.

5 DISCUSSION

The restlessness during the sleep of the Alzheimer patient in this research seems to be coincident with high levels of CO_2 in the bedroom. According to the observations of her husband during the recording period, but also afterwards, the restless behavior has not been observed anymore when the CO_2 levels are kept below 800 ppm. The temperature and relative humidity recordings were also available, but they had no clear deviating pattern coinciding with the restless behavior of the Alzheimer patient.

From the average CO_2 levels recorded in the bedroom, the advice is given to at least open the window of the bedroom in order to keep the CO_2 level below 800 ppm when the bedroom is occupied with one or two persons.

Following this strategy, the husband decided to place two CO_2 loggers permanently, one for the bedroom and one for the living room. Also daytime restless behavior seems to have been decreased since the time that living room CO_2 levels are kept below 800 ppm by opening windows and doors occasionally. Before this knowledge, it was concluded that the restless behavior during for instance birthday parties was originating from the larger number of people in the living room, bringing stress signals to the Alzheimer patient. But this research and the observations may indicate that the elevated CO_2 level itself is responsible for the restless behavior. Nowadays, people are welcome to the house again, without restless behavior, as long as open windows and door keep the CO_2 level low.

The recordings and observations in this research are for one patient only. But following this research, a couple of initiatives have been started to monitor the indoor air quality and the nocturnal restlessness of Alzheimer patients in care facilities. Only after this larger research these early observations can be substantially backed up by more scientific evidence.

The question arises whether the relation between CO_2 level and restless behavior can be broadened to a larger group like people suffering from dementia, or even healthy people. The author of this article postulates that healthy people have an adaptive response to higher CO_2 levels, meaning they can cope with elevated levels, both physically and mentally, without

suffering restless behavior. But people suffering from Alzheimer, or another form of dementia, may have lost this adaptive response to high CO_2 levels and can react physically more intense and already at relatively low CO_2 levels of about 800 ppm. Extensive observational and medical studies have to be carried out to prove if this is the case.

6 CONCLUSIONS

This research shows that the restless behavior of an Alzheimer patient coincides with peaks of the bedroom CO_2 level above 800 ppm. The observed restless sleeping behavior like snoring, teeth-grinding, apnoea and panic were not observed anymore when CO_2 levels are kept below 800 ppm. After a peak of CO_2 level and coincident restless behavior, a window was opened so that CO_2 level decreased and after 30 to 45 minutes the sleep of the Alzheimer patient was observed to be restful again.

Much more research should be carried out in the near future if the relation between CO_2 level and restlessness also exists for a larger group of Alzheimer patients, or wider for a group of people suffering from dementia or even for healthy people.

7 REFERENCES

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