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SHORT COMMUNICATION

Analysis of indoor air quality in a store with additional gas heater

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ABSTRACT

The quality of the internal environment is an extremely important issue, because users of rooms spend a significant part of the day inside buildings. The quality of the environment is largely dependent on the quality of the indoor air. The parameters of the air we breathe affect our health and the comfort of use of the rooms. Poor indoor air quality can cause a decrease in human comfort and various illnesses and ailments. Therefore, care should be taken to ensure adequate ventilation in the rooms, especially those that have an additional source of pollutant emissions. The purpose of this work is to examine the effect of heating a commercial premises room with a gas heater on air quality. The following parameters were measured as part of the tests: carbon dioxide concentration, air temperature and relative air humidity. The most important parameter significantly affecting the deterioration of the quality of the interior microclimate is carbon dioxide, the level of which reached high values, well above the hygienic minimum (1000 ppm). In order to compare the values of the tested parameters, the measurements were carried out in two options - for a period of five days with the stove running and another two days without additional heating.

***Keywords*:** indoor air quality, thermal comfort, carbon dioxide, air pollution, ventilation, heating, gas heater

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1. INTRODUCTION

Indoor air quality is a very important issue because users of rooms spend most of their time inside buildings and are not aware of how much air quality affects health, well-being and the condition of the organism. The parameters of the air we breathe affect our health and the comfort of use of the rooms. Currently, when energy efficiency is a priority, an extremely difficult task is to maintain comfort and conditions appropriate for health in the rooms. Room users seeking to save as much as possible want to reduce their heating expenses. One way is to minimize heat loss, which is usually removed by the ventilation system together with the indoor air. By reducing the number of ventilation air changes, heat losses can be reduced, but this will adversely affect air quality. At the same time, with the decrease of air quality, the level of comfort of the person staying in the room will decrease. It can also cause many illnesses and ailments. To overcome the undesirable impact of poor air quality on human health, monitoring and testing the content of pollutants and other compounds that reduce air quality is crucial [1-3]. The concept of air quality is related to the interior microclimate. It can be defined as a group of physical and chemical parameters that are variable over time in the space of a given room. It is a kind of ecosystem that allows creating favourable conditions for users. Due to the fact that we spend the most time indoors, we should pay attention to the microclimate prevailing inside them, because it affects the efficiency of work and the general well-being of people [4,5]. The microclimate of the interior consists of thermal factors: air temperature, relative humidity, air velocity and non-thermal factors, which include air ionization, microflora and microfauna present in it and various types of pollutions (e.g. CO_2, CO, SO_2, NO_2, volatile organic compounds, dust). Thermal factors are responsible for feeling of thermal comfort, that is, the state of satisfaction with thermal conditions of the environment, the one in which thermal balance of the human body is maintained [6,7]. Non-thermal factors of the interior microclimate, which mainly include various types of pollution, e.g. gases produced as a result of combustion processes, volatile organic compounds, dust, fungi and molds, are main cause of discomfort and diseases of users of rooms. Air pollutions, which can be most often observed in rooms heated with gas heaters, as well as the effects of these pollutants on the human body are presented in the table below (Table 1) [2].

Table 1. Internal air pollution and their effects on human body [2]

Type of air pollution	Effects of impact on human
Carbon dioxide (CO_2)	fainting, headaches, faster breathing and difficulty in breathing
Carbon monoxide (CO)	highly toxic, concentrations of <400 ppm, headache, dizziness, vomiting and fainting
Nitrogen oxides (NO, NO_2)	adverse effect on the respiratory system, the cause of the body's hypoxia
Volatile organic compounds (VOC)	carcinogenic
Microorganisms	allergic reactions (asthma, runny nose, sneezing, skin rashes), carcinogenic

Heating devices whose operation is based on gas combustion may cause a deterioration of the air quality in the room, especially when they are used without a ventilation trunk. Heaters emit nitrogen dioxide (NO_2), carbon monoxide (CO), carbon dioxide (CO_2), which can exacerbate respiratory problems and cause other health problems for users [8-11].

2. MATERIALS AND METHODS

2. 1. Place of measurements

The purpose of measurements of the basic parameters of air quality was to investigate the effect of heating a commercial premises room with a gas heater on air quality. The place where the research was conducted was a store heated by a gas heater, located in Białystok, Swobodna Street 43. The building was put into use in 1994, while the store consistd of two rooms and a toilet, with a total area of 30 m^2. The building has windows with wooden woodwork and a gravity ventilation system. Use of the object consists in the sale of textiles, work clothes and health and safety articles.

2. 2. Methodology of measurements

In order to determine the quality of indoor air, an air test was carried out in store in Białystok, which was carried out using the Testo 435-4 multifunction measuring device and a compatible IAQ (Figure 1.).

The measurements were carried out with the Testo 435-4 meter with the following accuracy range: temperature (0-50 °C ± 0.3 °C), relative humidity (2-98% RH ± 2% RH), carbon dioxide concentration (0 -10,000 ppm ± 100 ppm). The Testo 435-4 measuring device enables the measurements of basic air parameters that make up its quality, namely room temperature, relative humidity, carbon dioxide level and barometric pressure value.

Figure 1. Testo 435-4 meter and IAQ probe for testing air quality

The air quality test was carried out on November 2, 2015 - November 8, 2015. The Testo 435-5 continuously records the measurement results. At that time in the store during its opening hours, i.e. between 8.00 AM and 4.00 PM, there were two employees and shoppers. In order to maintain a comfortable temperature in the store (at that time there were frosts) a gas stove was functioning inside as an additional source of heating (Figure 2).

In order to carry out the test, a measuring station was selected, which was located at a height of about 1.5 m, near the source of emission of pollutants and near the electrical socket, to ensure constant operation of the measuring device.

Figure 2. Gas heater Duraterm PG-02

3. RESULTS

The research on the basic parameters of air quality, i.e. the concentration of carbon dioxide, temperature and the level of relative humidity were carried out in a commercial premise - store with health and safety articles. Results of measurements from each day of the study were presented in 2-hour intervals, from 8.00 AM to 16.00 PM, therefore during the opening hours of the store.

The results are presented graphically (Figure 3-5).

First of the air quality parameters tested was the concentration of carbon dioxide, the results of the measurements are shown in the graph (Figure 3). At the opening of the store, at 8.00 AM the CO_2 content fluctuates around 350 ppm. At 10.00 AM and at 12.00 AM culminates the CO_2 content in air and it is on average 4300 ppm and 4100 ppm level. On some days, the values reach up to 5500 ppm. This is due to the high CO_2 emission from gas combustion in heater. In addition, the CO_2 level is higher as a result of the breathing processes of users staying in the store. It should be noted that level of carbon dioxide significantly exceeds the recommended minimum hygienic level, i.e. 1000 ppm.

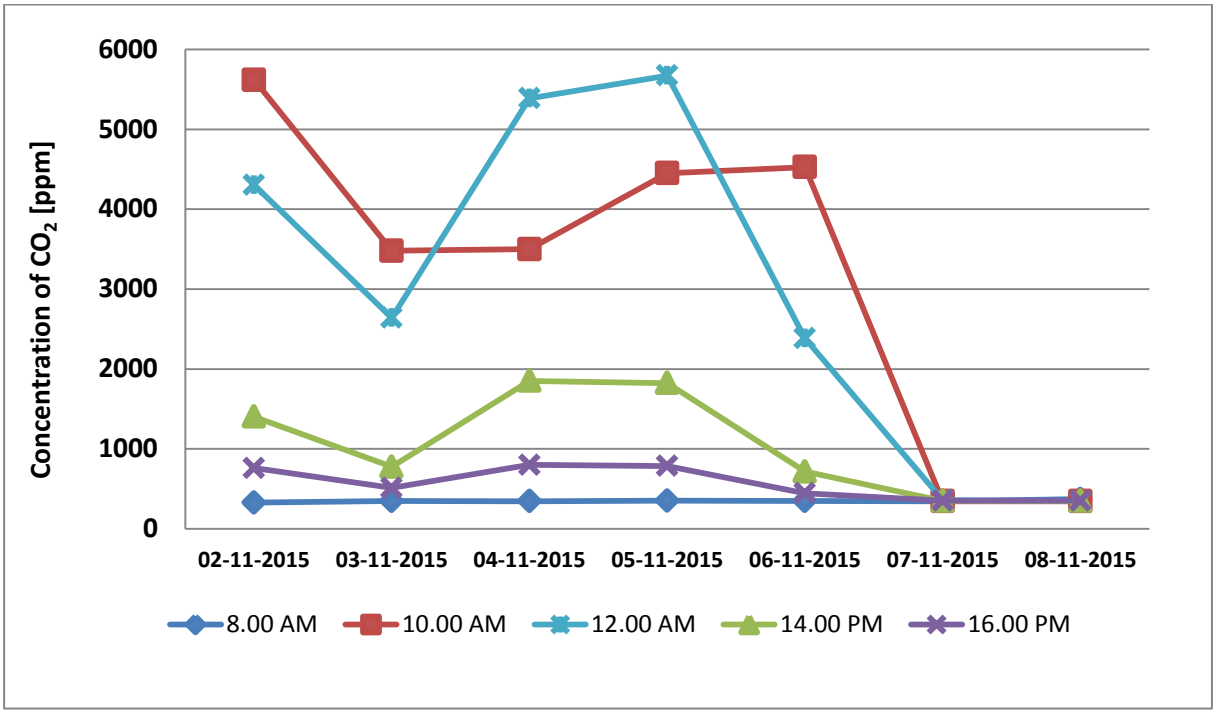

Figure 3. Concentration of carbon dioxide at selected hours (own study)

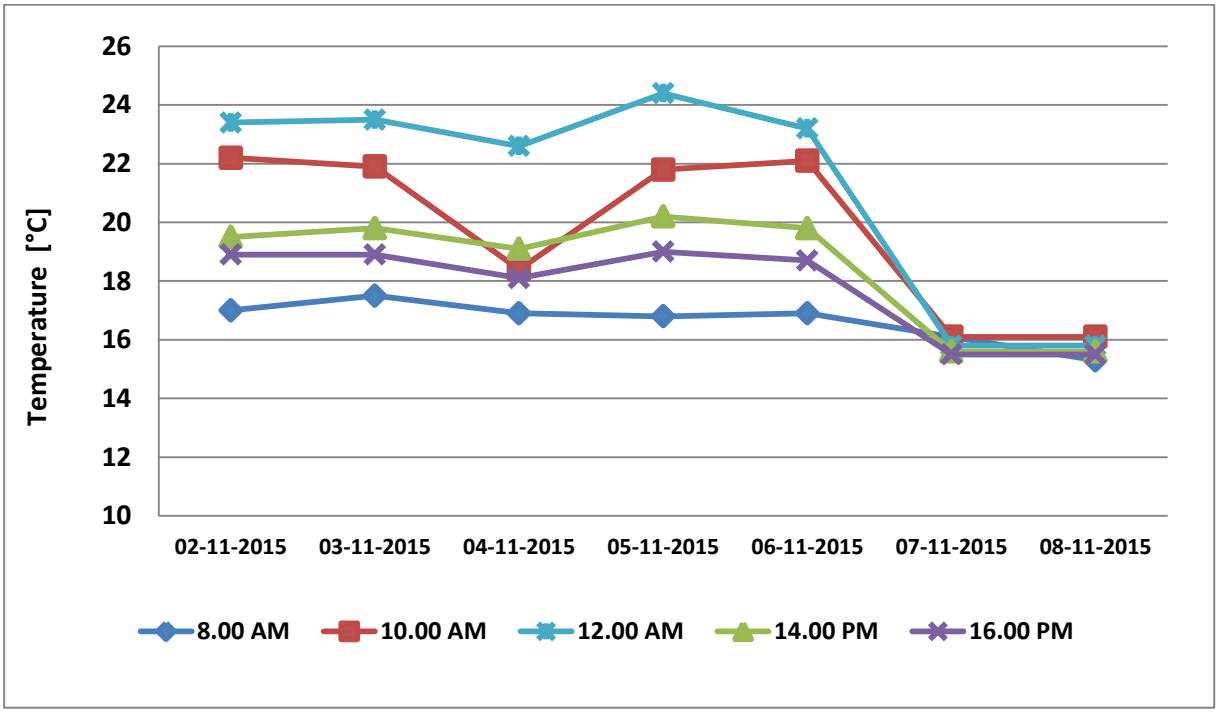

Figure 4. Temperature of air at selected hours (own study)

Excesses sometimes reach five times the standard level. Lower values of CO_2 concentration in store were recorded at 14.00 AM - on average 1300 ppm and at 16.00 AM - on average 650 ppm. This is associated with a small number of customers in the store and a reduction in gas burning in the stove as a result of heating the room during the day. However, on the 7th and 8th of November (Saturday and Sunday), the store was closed, the users did not use the room and the gas heater was turned off. Throughout this time, the CO_2 level fluctuated around 350 ppm, which is close to the CO_2 concentration in the ambient air.

Next parameter examined was air temperature (Figure 4). When the store opens at 8.00 AM temperature level fluctuates around value of 17 °C and is lowest during each test day. This is due to the cooling of the room during the night. Temperature level increases similarly to the CO_2 concentration - also between 10.00 AM and 12.00 PM the highest values were recorded, on average 21 °C and 23 °C. Reason may be a large number of customers in store and intensive work of the gas heater. Temperature level decreases after 14.00 PM until the store is closed. During the closing period, temperature stabilizes at a level below 16 °C.

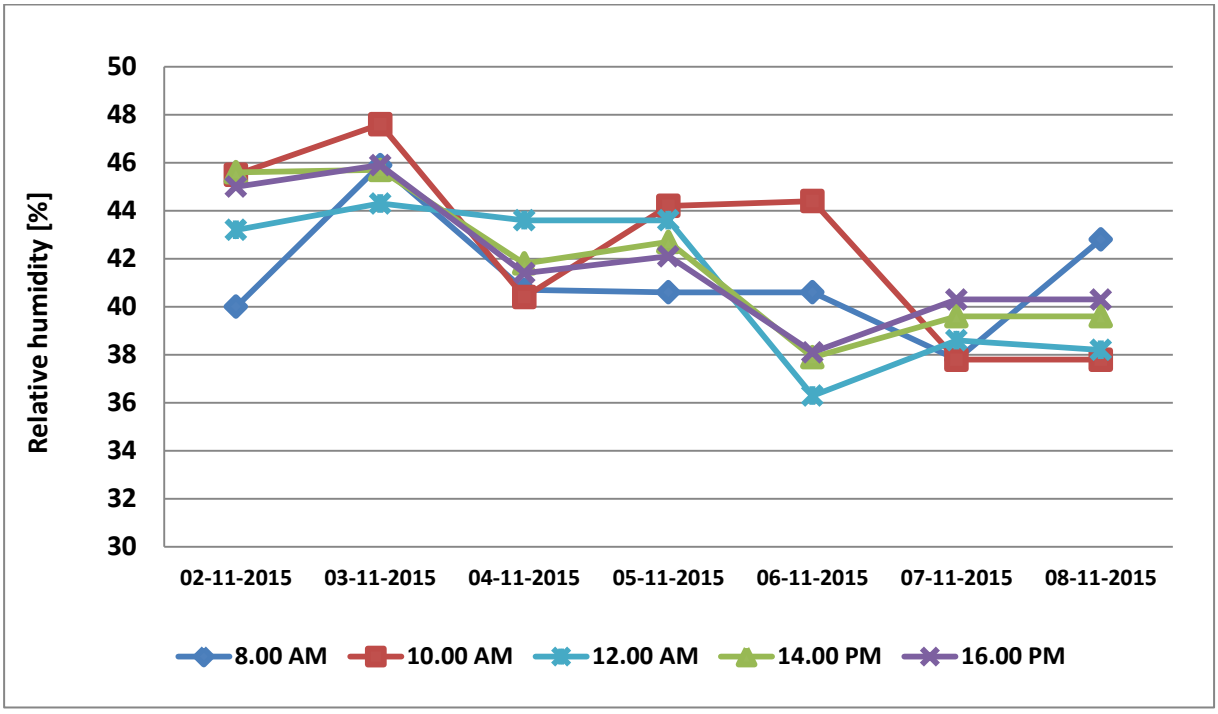

Figure 5. Relative humidity of air at selected hours (own study)

The last parameter tested was air relative humidity (Figure 5). Its values were usually the lowest at 8.00 AM (40-46%, average 42%), and the highest at 10.00 AM (40-48%, average 44%). The high moisture content in the indoor air at this time could have been caused by the large number of customers staying in the store. Also, there is a decrease in the relative humidity of the air in store over a week.

4. CONCLUSIONS

The following table (Table 2) presents results of measurements of basic air parameters: carbon dioxide concentration, air temperature values and relative humidity content in the air. They form overall air quality in the room. In the store with an additional source of heating, which was a gas stove, some parameters were exceeded. The most significant is the concentration of carbon dioxide, which should not exceed 1000 ppm in enclosed spaces. In the examined object, the CO_2 level was within the normal range only during the store opening and closing hours. Between 10.00 AM and 14.00 PM there were significant exceeding, sometimes five times of hygienic minimum. The average value of the carbon dioxide concentration during opening hours is 2142 ppm, which is more than twice as high as the hygiene standard. Such high values of CO_2 concentration were caused by the gas heater operation as an additional source of heating in the room.

Table 2. Results and comparison with recommendations

Parameter	Unit	Recommended value for commercial premises	Examined value	The average value examined (1 day/ 8.00-16.00)
Concentration of CO_2	ppm	max 1000	327 – 5673	2142
Temperature	°C	18 – 22	15,0 – 24,5	20
Relative humidity	%	30 – 65	36,0– 47,6	43

It can be concluded that examined internal air parameters - temperature and relative humidity - were usually maintained at an appropriate level. However, the level of carbon dioxide significantly exceeded the recommended hygienic minimum, sometimes as much as 5 times. It can be stated that the air quality and microclimate of interior of the store were at a low level, due to significant exceeding of CO_2 standards. High concentrations of carbon dioxide in the tested air occurred only when the gas heater was working. Exceeding the standards were long-lasting, so they could have caused undesirable health effects for working people as well as for customers of the store. In conclusion, poor air quality suggests using of another heating source, e.g. an electric heater.

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