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Study Of The Effects Of Occupant Exposure To Co2 On Health In Collective Housing In Guelma: A Comprehensive Evaluation

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Abstract

The rapid urbanization and increased prevalence of collective housing have raised concerns about indoor air quality and its impact on occupant health. Among the various indoor pollutants, carbon dioxide (CO2) has garnered significant attention due to its potential effects on human health. In this study, we conducted a comprehensive evaluation to investigate the effects of CO2 exposure on the health of occupants residing in collective housing in Guelma. The research involved measuring and monitoring CO2 levels in various living spaces within the housing units, while concurrently conducting health surveys and assessments among the residents. The main objectives were to assess the association between CO2 concentrations and potential health issues, including respiratory symptoms, headaches, fatigue, and overall well-being. The measurement survey was conducted inside five apartments in the Gahdour-Tahar neighborhood located in the city of Guelma (northeast Algeria). We measured the CO2 concentration during the year 2023 by using the instrument Air Quality test JD-3002 were carried out. Measurements were taken three times a day: 9 am, 1 pm, and 7 pm. The indoor pollution sources were also assessed through the analysis of domestic activities. Acute health symptoms were investigated using a subjective questionnaire.
Our findings revealed a concerning correlation between elevated CO2 concentrations and adverse health outcomes among the occupants. Higher CO2 levels were associated with increased reports of respiratory discomfort and a noticeable decline in overall health perception.

Keywords: *Collective Housing, C02 concentration, health, indoor air, occupant.*

1. Introduction

With the rapid expansion of urban centers and the increasing demand for collective housing, the issue of indoor air quality has become a matter of paramount concern (Batagoda, 2010). Indoor air quality directly influences the health and well-being of occupants, who spend a significant portion of their lives within these built environments. Among the numerous of indoor pollutants, carbon dioxide (CO2) has emerged as a critical focal point due to its potential effects on human health (Schriver, 2009; Khelil, 2019).

CO2 is a naturally occurring gas produced through respiration and the combustion of fossil fuels (Miszczuk, 2017). In indoor spaces, CO2 levels can rise significantly, primarily driven by human occupancy and limited ventilation. High levels of CO2 in indoor environments have been associated with various adverse health outcomes, including respiratory discomfort, headaches, fatigue, and reduced cognitive performance (Shriram, 2018; Thévenet, 2016). Therefore, understanding the impact of CO2 exposure on the health of occupants in collective housing is of paramount importance for creating healthy and sustainable living spaces (Ouled

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diaf, 2023). According to conducted research, children exposed to indoor CO2 concentrations exceeding 1000 ppm develop respiratory symptoms (Azuma, 2018). Lack of oxygen leads to accelerated breathing at 2.5% volume of CO2, while dizziness and restlessness occur at 8 to 10% volume of CO2. Fainting and convulsions are observed at 10 to 15% volume of CO2, paralysis and ruptured blood vessels at 15 to 20% volume of CO2, and fatality at over 20% volume of CO2 (Schriver, p.10). A study conducted at the University of the United Arab Emirates reported that high CO2 levels could cause headaches (Guo, 2023). Increased CO2 levels also negatively affect the physical reactions of occupants; when CO2 levels reach 2700 ppm, both heart rate and drowsiness are increased (Snow, 2019).

The city of Guelma, situated in northeastern Algeria, has witnessed substantial urbanization and a surge in collective housing developments. As more individuals and families opt for apartment living, the implications of indoor air quality on health cannot be ignored. However, despite the potential risks posed by elevated CO2 levels (Roulet, 2012; Ouled diaf, 2022), research investigating the specific effects of occupant exposure to CO2 on health within collective housing contexts in Guelma remains limited.

This study aims to bridge this gap in knowledge by conducting a comprehensive evaluation of the effects of CO2 exposure on the health of occupants residing in collective housing in Guelma city. Our research endeavors to shed light on the relationship between indoor CO2 concentrations and various health parameters, providing critical insights for policymakers, urban planners, and public health authorities.

The objectives of this study encompass several key aspects. Firstly, we seek to quantify and analyze CO2 levels in different living spaces within collective housing units to identify potential hotspots of CO2 accumulation. Secondly, we aim to explore the association between CO2 concentrations and occupant health, examining the prevalence of respiratory symptoms, headaches, fatigue, and overall well-being.

By comprehensively assessing the effects of CO2 exposure on occupant health, our findings will contribute valuable evidence to the ongoing discourse on indoor air quality and its impact on human well-being. Moreover, the results of this study will inform the development of evidence-based strategies for improving indoor air quality in collective housing settings, thereby promoting the health and comfort of the residents. In the following sections, we will outline the methodology employed for data collection and analysis, present the obtained results, and discuss the implications of our findings that could serve as a foundation for future research initiatives and guide policy recommendations aimed at fostering healthier and more sustainable living environments in collective housing in Guelma city and beyond.

2. Method and materials

2.1. Presentation of the case study

In this research, we have selected five F3-type apartments (A1, A2, A3, A4, and A5) located within the collective buildings of the Guehddour Tahar-Guelma housing complex (Algeria) (Figure1). The primary objective was to first measure the concentration of carbon dioxide as an indicator characterizing indoor air quality (IAQ) under specific conditions. Subsequently, we investigated the sources of this contaminant, and finally, we studied its impact on the health status of the occupants

Figure 1: Location of the analyzed buildings. (Source: Google-earth 2023)

2.2.Analysis of indoor pollution sources

When the building is well insulated and increasingly airtight, the air is not sufficiently renewed through unintentional natural ventilation. This results in higher levels of pollution indoors than outdoors, degrading the indoor air quality. Indoor pollutants can originate not only from the infiltration of outdoor air, which can be particularly polluted in certain places like heavily trafficked areas or in proximity to industrial or agricultural zones, but also from numerous internal sources mainly related to human activities.

The occupancy rate in a dwelling affects indoor air quality through metabolic or anthropic pollutants. Each individual can emit 10,000 bacteria per minute at rest and up to 50,000 during activity (Schriver, 2009). Their respiration adds carbon dioxide to the air: a resting person produces 20 liters of CO_2 per hour (Liébard, 2005). Domestic activities also contribute to air impurities. Cooking, cleaning tasks (dishwashing, bathing/showering, laundry, drying and ironing of clothes, floor cleaning), and home heating all produce water vapor and add carbon dioxide to the air.

In this regard, human activity within their living space is a factor that influences indoor pollution. Therefore, analyzing domestic activities in the studied homes is an important step in identifying the sources of indoor air impurities.

2.3.Measurement protocol

In order to assess and examine pollutants and indoor air quality (IAQ) within inhabited spaces, numerous studies have shown that measuring the concentration of carbon dioxide, CO_2, allows for the evaluation of indoor air confinement (Le Pennec, 2022; Schriver, 2009). As a result, this phase of the study is carried out using an experimental system that involves manual Indoor In-situ measurements of indoor air quality parameters, such as carbon dioxide (CO_2) concentration, using an instrument called the "Air Quality Tester JD-3002" (See Table 01).

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Table 01: Instrumentation and measured parameter.

Parameter	Instrument	Illustration
Dioxyde de carbone CO2	Air Quality tester JD-3002	

This In-situ measurement is based on direct and on-site readings of the results. Indoor CO2 concentrations were continuously measured in each apartment for one week. The measurements were carried out in various spaces of the studied accommodations (Kitchen, Stay, Room, and Bathroom) during three time periods on the same day: in the morning at 9 am, in the afternoon at 1 pm, and in the evening at 7 pm, during the period from March to June 2023. The measurements were taken at one-minute intervals. The measurements were monitored against the following conditions:

- Natural ventilation practices (opening and closing) of windows
- Domestic activities (cooking, cleaning, bathing, sleeping, etc.)
- Indoor environment (air conditioning, heating, fan)
- Occupancy rate in the dwelling.

The choice of the CO2 indicator is based on its health impact, simplicity, and measurement reliability. It is measured according to the standard for indoor air quality NBN EN 137-79 (see Table 02).

Table 02 : Indoor Air Quality Classification (Schriver, 2009)

Air quality	**CO2 levels above the outdoor level**	**Outdoor fresh air flow rate**
Excellent (IDA1)	≤400 ppm	≥ 54 m3/h.per
Average (IDA2)	400-600 ppm	36 à 54 m3/h.per
Acceptable (IDA3)	600-1 000 ppm	22 à 36 m3/h.per
Mediocre (IDA4)	≥ 1 000 ppm	≤22 m3/h.per

2.4.Subjective analysis

Qualitative information and simultaneous data on occupant activities, kitchen conditions, and outdoor conditions were gathered through surveys conducted with both the building and its occupants. The study of the effects of indoor air pollution on occupants' health is assessed using a questionnaire. An investigation was conducted during the measurement periods regarding the following symptoms: fatigue, headaches, drowsiness, eye irritation or dryness, throat irritation or dryness, and irritation or dryness of nasal mucous membranes. The residents' responses are organized into graduated voting scales to quantify the frequency and intensity of the answers (1-very strong, 2-strong, 3-moderate, 4-weak, and 5-very weak) (see table 3).

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Table 03: Conduct of the In-situ Survey.

	1	2	3	4	5
Fatigue					
Headaches					
Drowsiness					
Eye irritation or dryness					
Throat irritation or dryness					
Irritation or dryness of nasal mucous membranes					

3. Results and discussion

3.1. Sources of indoor pollutants

Based on residents' responses to the question (How much time do you typically spend inside your homes?), the residents of the studied neighborhood spend 60% to 80% of their time indoors. Therefore, they will be exposed to indoor air, which increases the need for healthy, fresh, and breathable indoor air. Figure 02 illustrates the various domestic activities carried out by the occupants during the day.

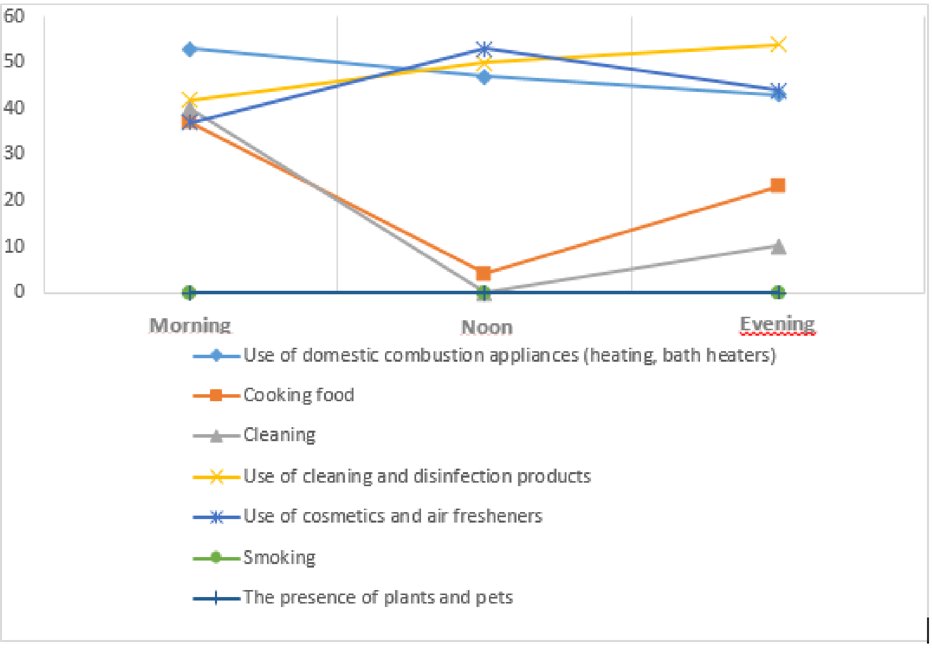

Figure 02: Daily Activities of the Residents.

Based on this figure, the majority of residents use carbon-based fuel appliances for certain domestic activities such as heating, hot water production, and cooking. These appliances can emit toxic carbon gases and pollutants if improperly used.

The cleaning activity (dishwashing, bathing/showering, laundry, drying, and ironing clothes, floor cleaning) is carried out in the morning and evening. It generates water vapor and introduces numerous harmful elements into the air. The use of cleaning and disinfection products, as well as cosmetics and air fresheners, occurs throughout the day. According to Schriver (2009), these products are sources that increase the particle content in the air by

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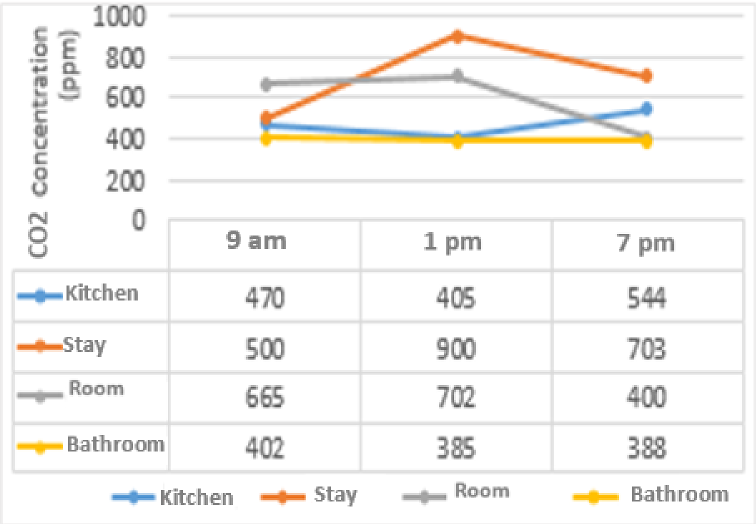
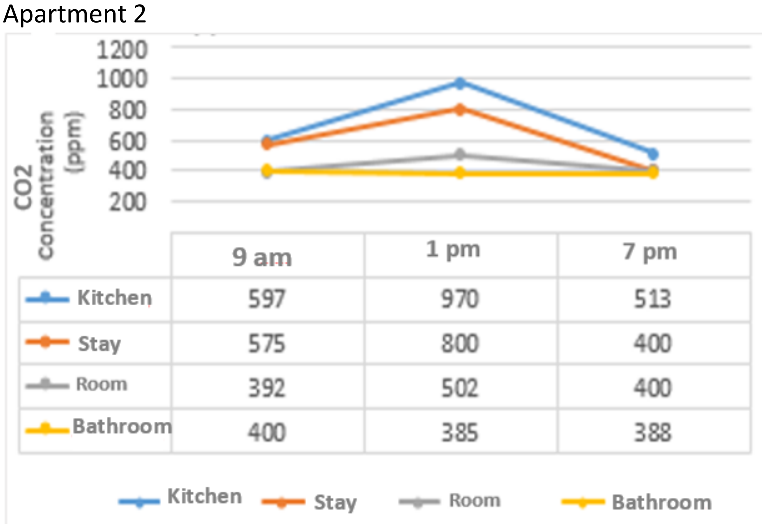
generating many pollutants. However, smoking, plants, and domestic animals are non-existent in the surveyed households.

3.2. Indoor In-situ measurements evaluation

The graphs in Table 04 below represent the variations in the concentration of CO_2 in the different spaces of the selected accommodations, namely the kitchen, stay, room, and bathroom.

Table 04: Results of CO_2 concentration measurements in the different spaces of the studied accommodations.

<table>
<tr><th>Graphs</th><th>Interpretation</th></tr>
<tr><td>Apartment 01

</td><td>– At 9 am, the CO2 levels belong to the IDA2 class (400-600 ppm), and the Indoor Air Quality (IAQ) is moderate (See Table 02).
– At 1 pm, the CO2 values have increased, especially in the bedroom and stay, reaching 702 and 900 ppm, respectively (IDA3 class).
– At 7 pm, the CO2 level remains acceptable in all spaces.</td></tr>
<tr><td>Apartment 2

</td><td>– At 9 am, the CO2 levels belong to the IDA2 class (400-600 ppm).
– At 1 pm, the CO2 values have increased, especially in the kitchen and stay, reaching 970 and 800 ppm, respectively (IDA3 class).
– At 7 pm, the CO2 level remains acceptable in all spaces.</td></tr>
<tr><td>Apartment 3</td><td>– At 9 am, the CO2 levels belong to the IDA2 class (400-600 ppm).
– At 1 pm, the CO2 value has increased, particularly in the</td></tr>
</table>

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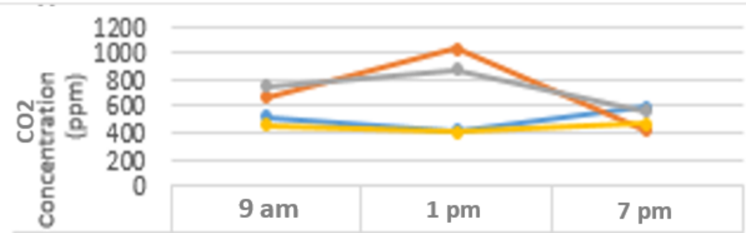


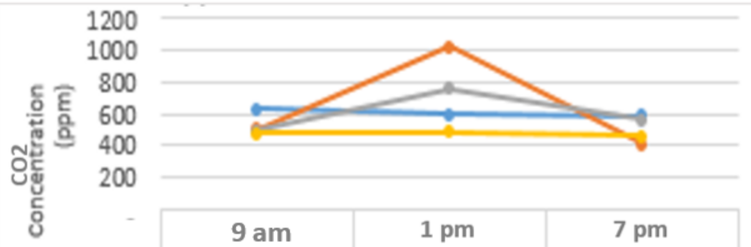
	9 am	1 pm	7 pm
Kitchen	520	415	590
Stay	667	1035	411
Room	748	877	565
Bathroom	460	408	462

Kitchen Stay Room Bathroom

stay, reaching 1035 ppm (IDA4 class), and at this moment, the indoor air quality becomes mediocre.

– At 7 pm, the CO2 level remains acceptable in all spaces.

Apartment 4



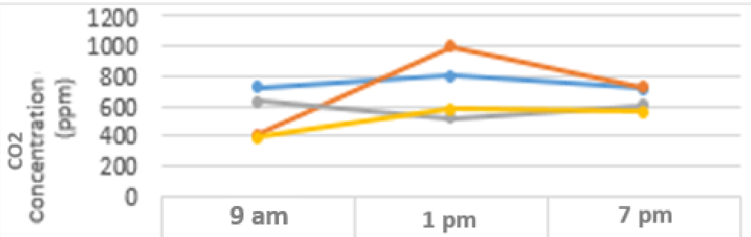
	9 am	1 pm	7 pm
Kitchen	630	600	590
Stay	503	1025	411
Room	495	760	565
Bathroom	480	485	462

Kitchen Stay Room Bathroom

– The same observation was made for this dwelling, with the CO2 concentration reaching its peak at 1 pm in the stay, measuring 1025 ppm.

– For the rest of the day, the CO2 levels fall within the range of (400-600 ppm), belonging to the IDA2 class (moderate air quality).

Apartment 5



	9 am	1 pm	7 pm
Kitchen	730	800	716
Stay	408	998	729
Room	636	520	609
Bathroom	397	585	562

Kitchen Stay Room Bathroom

– At 9 am, the CO2 concentration is higher in the kitchen, measuring 730 ppm.

– At noon, it increased in the stay to 998 ppm.

– In the evening, it proportionally decreased to 729 ppm in the stay, 717 ppm in the kitchen, 609 ppm in the room, and 562 ppm in the bathroom, respectively.

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From the graphs above, it is evident that the CO2 levels have exceeded the threshold value (1000 ppm) in apartments 3 and 4, reaching 1035 ppm and 1025 ppm, respectively. This occurred at 1 pm in the stay, where the occupancy rate was very high (6 people in apartment "3" and 5 people in apartment "4"), and all windows were closed.

Consequently, the high concentration of CO2 is attributed to the significant human occupancy. This is due, in addition to the mode of window opening and closing and the domestic activities analyzed earlier, to the metabolic process (respiration).

3.3. Health effects

Figure 03 illustrates the intensity of symptoms and illnesses that threaten the health of the residents in the study neighborhood, which have a significant relationship with the occupants' exposure to indoor air. Higher CO2 levels inside the studied dwellings have increased the intensity of health symptoms.

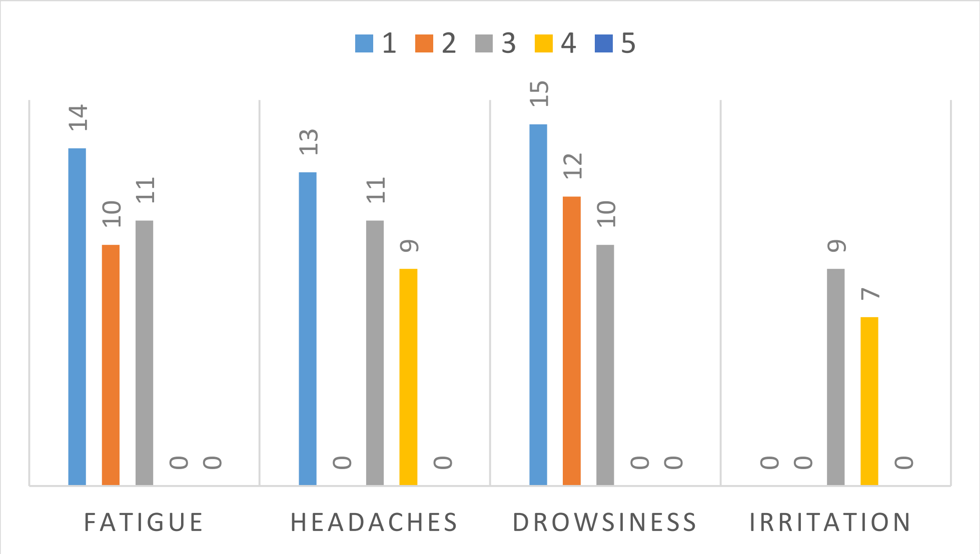

Figure 03 : The intensity of health symptoms

4. Conclusion

This empirical study evaluated the effects of occupants' exposure to carbon dioxide (CO2) in the collective housing of the Guehdour-Tahar Guelma city (Algeria) on their health. The results confirm the poor ventilation of the studied accommodations and demonstrate that occupants significantly influence the indoor air quality through their daily domestic activities and the use of natural ventilation (opening and closing windows). These factors constitute pollution sources that can compromise the health comfort within these dwellings.

Analyzing the results obtained from the measurement campaign, it is evident that higher CO2 levels considerably degrade the indoor air quality in these dwellings, significantly contributing to unacceptable comfort conditions. Thus, this measured parameter (CO2) appears to act as a risk factor for poor Indoor Air Quality (IAQ). Furthermore, this contaminant can lead to health problems among the occupants. Therefore, the occurrence of

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symptoms such as fatigue, headaches, and drowsiness among the residents of the studied dwellings is linked to their exposure to high CO2 concentrations.

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