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Building construction materials effect in tropical wet and cold climates: A case study of office buildings in Cameroon

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ABSTRACT

This paper presents the results of an experimental study that was conducted in 15 office buildings in the humid and cold tropics during the working hours of the dry and rainy seasons in Cameroon. This was with the aim to study the effects that local and imported materials had on indoor air quality. To achieve this objective, the adaptive model approach has been selected. In accordance with the conditions of this model, all workers were kept in natural ventilation and, in accordance with the general procedure, a questionnaire was distributed to them, while variables, like air temperature, wind speed, and relative humidity were sampled. The results showed a clear agreement between expected behaviour, in accordance with the characteristics of building construction, and its real indoor ambience once they were statistically analysed. On the other hand, old buildings showed a higher percentage of relative humidity and a lower degree of indoor air temperature. Despite this, local thermal comfort indices and questionnaires showed adequate indoor ambience in each group of buildings, except when marble was used for external tiling. The effect of marble as an external coating helps to improve indoor ambience during the dry season. This is due to more indoor air and relative humidity being accumulated. At the same time, these ambiences are degraded when relative humidity is higher. Finally, these results should be taken cognisance of by architects and building designers in order to improve indoor environment, and overcome thermal discomfort in the Saharan area.

1. Introduction

In the past few years, various research works have shown that people spend about 90% of their time in an indoor environment. In view of this, the major concern of building designers is to ensure that buildings are built so as to provide comfortable and healthy conditions for its occupants. Nowadays in new cities, lifestyle has changed dramatically, especially in sub-Saharan Africa. In these regions, very few designers take into account the climate of the surroundings and the variety of building construction methodologies usually employed in Europe and America, which are becoming increasingly more prevalent in Africa. As a result, thermal discomfort dominates these types of buildings, and necessitates the occupants using artificial heating, ventilation and airconditioning systems (HVAC). Owing to the high outdoor relative humidity in this region, some indoor ambience problems have been identified in the past few years. In particular, in newly renovated buildings located in central and eastern Cameroon, the high indoor moisture-laden relative humidity is a persistent

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problem. Consequently, the indoor air almost always contains a higher percentage of water vapour than the outdoor air which can cling to the walls with the risk of condensation and wall damage [1–5]. Furthermore, another side effect of this higher level of relative humidity is poor indoor air quality and its related effects over the occupants [2,6–10]. The key to controlling this drawback is related with building construction materials. Hameury's studies [3] have shown how a structure made of solid wood can control changes in humidity even if the ventilation rate is relatively high. Despite this, from these same studies, it can be concluded that it is difficult to precisely quantify the phenomenon and the effect in terms of comfort for people and their health. Only in a few studies, like those of Gaur and Bansal [11] and Simonson *et al.* [12], have they tried to quantify this effect. They have concluded that indoor temperature is affected by moisture, and that the increase in relative humidity depends on the rate of air exchanges, outside air and moisture transfer between structures and indoor air. Virtanen et al. [13] showed that hygroscopic structures can exert a significant influence over indoor air relative humidity, and this can improve comfort and appreciation of indoor air quality. This is one possible solution to solving the problems in Cameroon indoor environments mentioned above. In sub-Saharan Africa, specifically in Cameroon, very few studies have been conducted to analyse the influence that buildings have on indoor air quality. The main objective of this work is to study the thermal effects of local material used in old buildings. Also, the effect that imported material used in new buildings have over indoor air quality and, in particular, during the early working hours, as this is directly related with energy consumption. To achieve these objectives, 15 office buildings located in the capital city of Cameroon were studied during two seasons, in accordance with the procedure developed by Toftum et al. [14].

2. Materials

In this study different indoor air variables were sampled. Between others, variables like indoor air speed, indoor relative humidity, CO_2 concentration, and indoor air temperature were measured using a thermo-anemometer (model C.A1226) and a CO_2 Monitor (model CO200).

On the other hand, outdoor weather variables were sampled to consider the effect of weather and indoor conditions. In this sense, data relating to outdoor temperature, wind speed and relative humidity were collected from the national weather stations. It must be explained that all these equipments were calibrated before use, to ensure reliability and accuracy during the sampling processes. Furthermore, the sampling accuracy of each device is shown in Table 1.

3. Methods

As mentioned earlier, this study was conducted in new and old office buildings located in Cameroon. It must be clarified here, that old buildings were considered as those that were more than 25 years old. In particular, these old buildings are named B2, B6, B9, B11, B12, and B14 in the tables and figures, since they were built with earthen bricks.

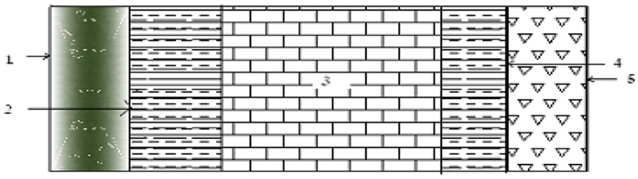
On the other hand, the new buildings are named B1, B3, B4, B5, B7, B8, B10, B13 and B15, since they used parpen bricks, as we can see in Table 1. Finally, for favourable comparison, all buildings present the same wall structures and orientation. They have an internal coating that mostly consists of marble, which is often dressed in fabric wool. The outer layer of the wall is made of mud bricks and plaster in old buildings. In new buildings, bricks of parpen, plaster and paint are employed. An example of a wall segment is given in Fig. 1, and the structure and characteristics of the buildings studied are reported in Table 2.

In all these buildings, large windows occupy more than half the wall areas, and are covered by curtains, thus preventing light rays from entering indoors and doors are mostly made of wood. In accordance with previous research works, selected offices were naturally ventilated, and the cooling and heating systems were interrupted during the experimental studies.

Also, in these buildings, more than 8 employees were estimated having a sedentary occupation, which corresponds with a metabolic rate of 1 met in accordance with thermal comfort standards.

Table 1
Characteristics of the measurement systems.

Device	Function	Range	Resolution	Accuracy
CO_2 monitor (model CO200)	CO_2	0–9999 ppm	1 ppm	±(5% rdg+50 ppm)
	Temperature	−10 °C to 60 °C	0.1 °C	±0.6 °C
		14–140 °F	0.1 °C	±0.9 °F
	Humidity	0.1–99.9%	0.1%	±3% (10–90%)
Digital thermometer	Temperature	−20 °C to 0 °C	1 °C	±7 5.0% of rdg+ 4 digit
		0–400 °C	1 °C	±1.0% of rdg+3 digits
		400–1000 °C	1 °C	±2.0% of rdg
C.A 1226 thermo-anemometer	Air velocity	0.15–3 m/s	0.01 m/s	±3% R+0.1 m/s
		3.1–30 m/s	0.1 m/s	±1% R+0.2 m/s
	Temperature	−20 °C to +80 °C	0.1 °C	±0.3% R+0.25 °C
	Air flow	0–99,999 m3/h	1 m3/h	±3% R+ 0.03* surf.



1. External coating (plaster, 0.6 cm); 2. Concrete (1.1 cm); 3. Brick (10 cm); 4. Concrete (0.5 cm); 5. Internal coating (marble, 1 cm)

Fig. 1. Layers of a standard wall.

Table 2
Some characteristic of offices studied in the buildings.

Buildings	Altitude (m)	Floor area (m^2)	Volume (m^3)	Height (m)	External coating	Type of brick	Type of building
B_7	782 ± 2	71.5	299.1	4.2	Plaster	Parpen	New building
B_{15}	730 ± 7	47.5	137.7	2.9	Marble	Parpen	New building
B_{10}	731 ± 7	36.0	126.0	3.5	Plaster	Parpen	New building
B_{13}	763 ± 2	55.2	209.8	3.8	Paint	Parpen	New building
B_3	784 ± 5	59.5	220.1	3.7	Plaster	Parpen	New building
B_4	763 ± 4	96.0	288.0	3.0	Plaster	Parpen	New building
B_5	762 ± 8	49.0	186.2	3.8	Plaster	Parpen	New building
B_8	748 ± 7	32.0	121.6	3.8	Paint	Parpen	New building
B_1	750 ± 8	80.0	280.0	3.5	Plaster	arpen	New building
B_9	696 ± 5	66.0	270.6	4.1	Paint	Earth	Old building
B_{11}	734 ± 5	45.0	180.0	4.0	Marble	Earth	Old building
B_{12}	717 ± 3	76.5	306.0	4.0	Paint	Earth	Old building
B_2	762 ± 3	84.0	336.0	4.0	Plaster	Earth	Old building
B_{14}	747 ± 4	35.7	149.9	4.2	Plaster	Earth	Old building
B_6	761 ± 3	54.0	210.6	3.9	Paint	Earth	Old building

3.1. Analysed cities

As it is well known, Cameroon is divided into three climatic zones: the Sudanese, the sudano-Sahelian, and the equatorial regions. Cameroon is characterised by an equatorial climate that has two main seasons of equal amplitudes. In particular, present research work was conducted in the equatorial city of Yaounde.

Yaounde is the political capital of Cameroon, and is located approximately 300 km from the Atlantic coast. Yaounde enjoys a sub-equatorial climate with four seasons: a long dry season from mid-November to late March; a short rainy season from April till mid-June; a short dry season from mid-June till mid-August; and a long rainy season from mid-August till mid-November. Its altitude is between 600 m and 800 m.

Yaounde City was built on several hills and enjoys a picturesque setting and a relatively fresh climate in the coastal regions. As a consequence of this climate the maximum temperature ranges between 30 °C and 35 °C, and the minimum is in the region of 15 °C.

It stretches geographically between 3 °52′N latitude and 11 °32′E longitude. Its population was appraised at about 2.5 million inhabitants in 2011. During the early 1990s, the rural exodus to the city gave rise to super populations with a growth rate estimated at 7% per year. Consequently, this large exodus resulted in several suburbs being created at the western and northern regions of Yaounde City.

3.2. Indoor air

It can be observed that in Yaounde, indoor climate is conducive to study and work. In particular, during the rainy season, the internal temperature often drops to 15 °C, and it rarely reaches 31 °C in the dry season. The average relative humidity varies around 65% ± 10%, while the wind speed rarely reaches 0.47 m/s. These different characteristics can be explained by the fact that Yaounde City is built on seven hills.

3.3. Statistical study

Several researchers have demonstrated the influence that the wall or the building structure has on the heat and moisture transfer from the outside to the interior. For example, Toftum et al. [14–16] and Simonson et al. [17] showed that passive transfer of moisture between the indoor air and hygroscopic structures moderates and enhances indoor thermal comfort and perception of indoor air quality (PAQ). More recently, Orosa and Baalina [5] have shown that hygroscopic structures have the potential to improve local thermal comfort and PAQ, particularly in the early working hours, and that the influence of relative humidity is more readily accepted than the thermal effect.

In our research work, in accordance with these previous research works, to analyse the effect of different building constructive materials over indoor ambiences, a sampling process with frequencies of 10–20 min was carried out during the working hours from 08:00 to 17:00, and during the unoccupied period from 17:30 to 22:00, in each season. There were also certain devices for sampling the indoor conditions from 07:00, to be adapted to the indoor environment conditions at 08:00.

These sampling devices were placed at a height of 1.1 m in accordance with the ASHRAE Standard 55 [15] and ISO 7730 [16] requirements. These devices were placed far away from any heat source, and as close as possible to the employees so as to obtain more realistic indices.

The temperature and relative humidity conditions in each of the new and old buildings were thus obtained. The comparison of averages has been carried out by means of the analysis of the variance of a factor (one-way ANOVA) using the statistical software SPSS for a level of significance of 0.05, and a Tukey post-hoc to define the homogeneity of groups [18]. This analysis has been made initially with the values of the first working hours to define groups of buildings with similar indoor air behaviour.

3.4. Thermal comfort and perception of indoor air quality models

Different local thermal comfort indices were employed in this research work. For example, the percentage of dissatisfaction from warm respiratory thermal comfort(PD_{WRC}) [19–21] expresses the degree of discomfort caused by human respiratory tract evaporation, convection, and insufficient cooling of mucous membranes. This index was selected to assess the impact of temperature and humidity on the perception of inhaled air based on 14 combinations of air temperature and relative humidity. This model has a temperature validity range between 20 °C and 29 °C, and steam partial pressure of 1000–3000 Pa [5]. The obtained expression was a function of the air temperature (t_a) and the partial vapour pressure (Pa), as is shown by Eq. (1).

$$PD_{WRC} = \frac{100}{1 + \exp[-3.58 + 0.18\cdot(30 - t_a) + 0.14\cdot(42.5 - 0.01Pa)]} \tag{1}$$

The other selected warm respiratory comfort index employed in this work was the acceptability

ACC_{WRC} This index was obtained by linear regression of moist air temperature and partial vapour pressure, as we can see in Eq. (2).

$$Acc_{WRC} = -1.06 + 0.046\cdot(30 - t_a) + 0.038\cdot(42.5 - 0.01Pa) \tag{2}$$

Laboratory experiences of Fanger [19–21] have established Eq. (3) to measure the effect of temperature and humidity on the perception of indoor air quality (PAQ). Eq. (4) shows the acceptability of clean and polluted air based on the moist air enthalpy Eq. (3):

$$PD_{IAQ} = \frac{\exp(-0.18 - 5.28\cdot Acc}{1 + \exp(-0.18 - 5.28\cdot Acc)}\cdot 100 \tag{3}$$

$$Acc_{IAQ} = -0.033\cdot h + 1.662 \tag{4}$$

Where Acc_{IAQ} is the moist air acceptability, and h is the enthalpy.

The ACC_{IAQ} values go from -1 to $+1$, with $+1$ being clearly acceptable, 0 just acceptable, and -1 clearly unacceptable. Once all these indices were defined, the warm respiratory comfort Acc_{WRC}, and the perception of indoor air quality PD_{IAQ} , were evaluated at a specific time in all these buildings to define the real thermal comfort conditions that we can find in that indoor ambiences.

3.5. Subjective measurements

The questionnaires used in this work were distributed between 09:00 and 11:00. Altogether, 218 questionnaires were collected during the study of the 15 office buildings. These questionnaires were compiled in accordance with ISO 7730 [16] and ISO 10551 standards [20]. From these questionnaires, clothing and metabolic rate were assessed and, at the same time, it was also possible to know the sex, age, weight and size of each occupant. Finally, like in previous research works, thanks to the questionnaires, it was also possible to find out the thermal sensation, thermal preference and acceptance of the thermal environment in the occupied areas.

4. Results and discussions

Thus, when the statistical analysis of one-way ANOVA was done, it was found that only for a significance level of 0.1, the temperature group of old buildings (B2, B6, B9, B11, B12 and B14) can be clearly differentiated from the other buildings, as we can see in Table 3. This shows an average value of 25.3 °C with a standard deviation of 0.49. This value is clearly more

Table 3
Buildings with same temperature behaviour.

Building	Group of new buildings
B6	
B2	
B9	
B12	
B14	
B11	
B4	
B1	24.6526
B3	24.9895
B15	25.0211
B5	25.1053
B8	25.2421
B10	25.3632
B7	25.8842
B13	26.1632
Significance level	**0.100**

than an average indoor air temperature of 23.3 °C obtained for old buildings under a standard deviation of 0.44. Experiments with B4 show an indoor temperature during the morning that clearly differentiates it from the other new buildings. When indoor relative humidity was analysed, the group of new buildings under a significance value of 0.05 with an average value of 67% and a standard deviation of 1.67, was clearly defined.

At the same time, the old buildings showed an average relative humidity of 73% and a standard deviation of 0.69 for a significance level of 0.97. Only building B7 experienced an indoor relative humidity that clearly differentiated it from the other new buildings. From this statistical study, we can conclude that relative humidity is the more distinctive parameter to be employed in order to evaluate indoor ambience. Consequently, it can be concluded that relative humidity is the better parameter for recognising each different group of building and construction. Furthermore, as expected, this difference of 6% in relative humidity implies a different indoor thermal comfort condition under the same indoor average temperature. For instance, under 25.3 °C and relative humidity of 67% and 73%, indoor air acceptability of 45.3% and 52.0%, and corresponding perception of indoor air quality of −0.31 and −0.42 are obtained, respectively. Despite this, it must be realised that both indoor average states are within thermal comfort limits and health (Table 4).

Initially, once the constructive classification of buildings was statistically validated, the average indoor air temperature, relative humidity, and air velocity in new and old buildings during the dry and rainy seasons, are represented in Figs. 2, 3 and 4 during the early working hours of the day. Furthermore, this data was organised in indoor air relative humidity during the most humid period, the rainy season, due to it being the most extreme condition in which to understand the effect of construction materials. From Fig. 2, it can be concluded that old buildings showed a lower average temperature

Table 4
Buildings with same relative humidity behaviour.

Building	Group of new buildings	Group of old buildings
B7		
B10	64.8684	
B3	65.4737	
B5	66.5000	
B8	67.9474	
B1	68.3632	
B4	68.9421	
B13	68.9474	
B15		
B6		72.7053
B2		72.7368
B14		73.4421
B12		73.7368
B9		73.9263
B11		74.4947
Significance level	**0.050**	**0.975**

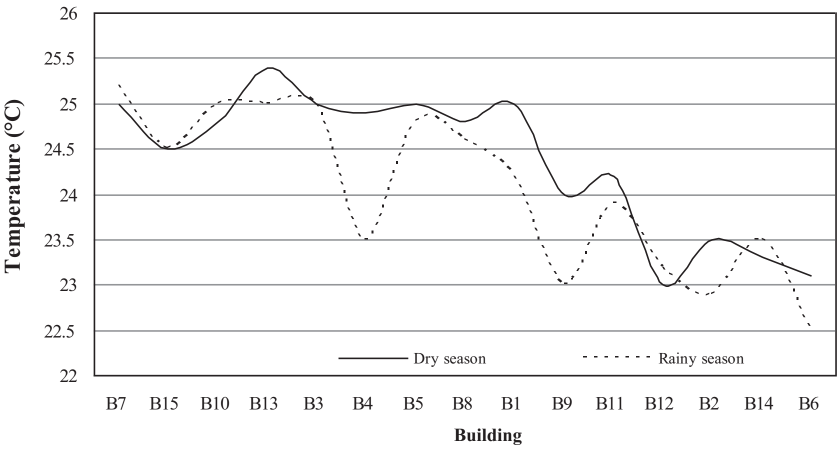


Fig. 2. Indoor average air temperature.

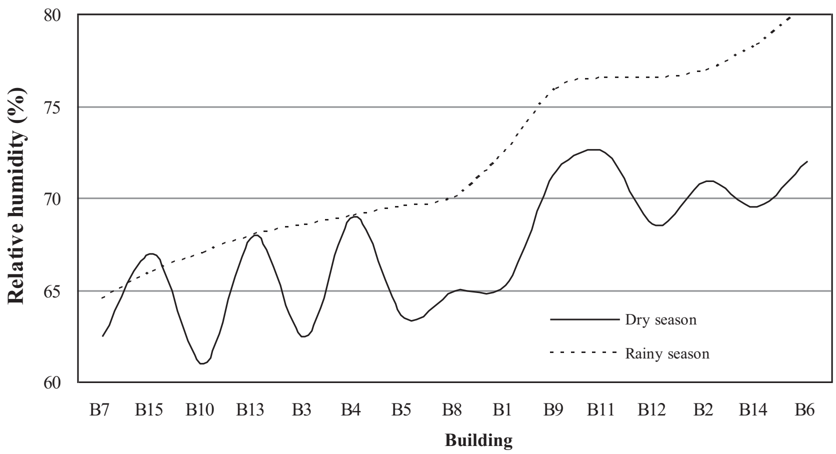


Fig. 3. Indoor average relative humidity.

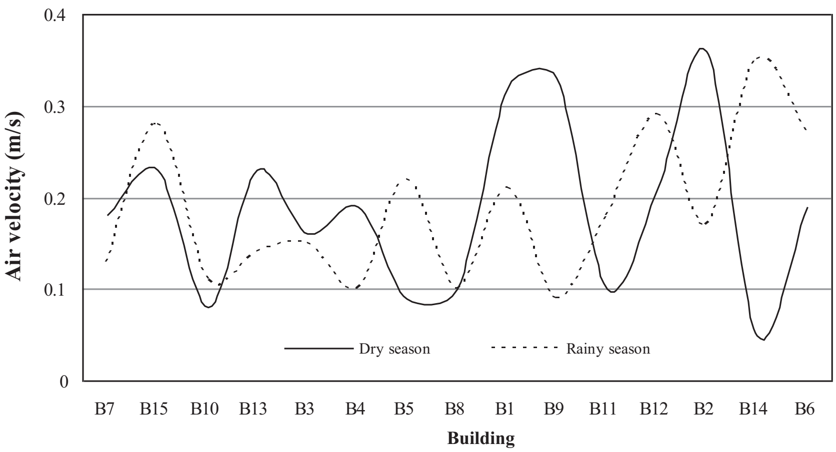


Fig. 4. Average air speed.

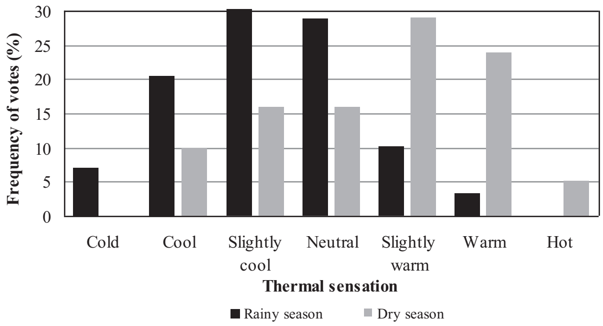


Fig. 5. Questionnaire results.

than the new ones. This lower average temperature differed by about 2 °C.

Indoor air relative humidity during the day's early working hours was higher in the old buildings than in the new ones, in clear accordance with the previous analysis, as we can see in Fig. 3.

Finally, in Fig. 4, it can be observed that, in new and old buildings, indoor air velocity is nearly constant and equal to 0.15 and 0.25 in both seasons, respectively. It is related with a higher number of air changes in the old buildings due to the effect of the windows and doors.

Once the main indoor air thermal parameters have been defined, it is time to analyse indoor thermal comfort conditions. Two kinds of approaches were employed: questionnaires and thermal comfort models. An initial analysis of questionnaires has shown that, in most of these offices, the staff were elderly people, ranging in age from 28 to 60 years, with a sedentary activity, and under a clothing insulation about 0.8–1.4 clo. Questionnaire results showed that in the early hours of work, the thermal sensation curve experiment gives a clear displacement towards cold environments, as we can see in Fig. 5. In the rainy season, 28.9% of employees felt neutral thermal comfort, while 16.0% felt neutral thermal comfort during the dry season. At the same time, in the dry season, there is a 5.0% and a 0.0% of occupants with a hot and cold sensation, respectively, and the inverse effects are observed in the rainy season.

Two different indices of thermal comfort were obtained for this same working period; ACC_{WRC} and **Erreur! Source du renvoi introuvable.** PD_{IAQ} which are represented in Figs. 6 and 7. From Fig. 6, we can conclude that occupants of new buildings experience an almost neutral thermal comfort sensation in both seasons. The old ones showed a clear increment in the indoor air acceptability as a consequence of a lower indoor air temperature.

As a consequence of this effect, Fig. 7 showed a rather high percentage of dissatisfied persons, about 50% in new buildings, as against 40% in old buildings during the dry season. This effect is experienced as a certain reduction in the rainy season as a consequence of an excessive indoor air relative humidity level in the old buildings. These average effects during the early working hours of the day are related with the effectiveness of a building's coating over indoor air relative humidity. Thus, we can see that the more impermeable external coating implies a higher indoor air relative humidity during the dry season and, consequently, a better indoor air perception. This is the case with the old buildings using marble for external coating (B11). During the rainy season, this same building experiences a higher relative humidity, and reaches the worst indoor air acceptability of all the buildings (–0.2). At the same time, in new buildings (B15), this kind of external coating

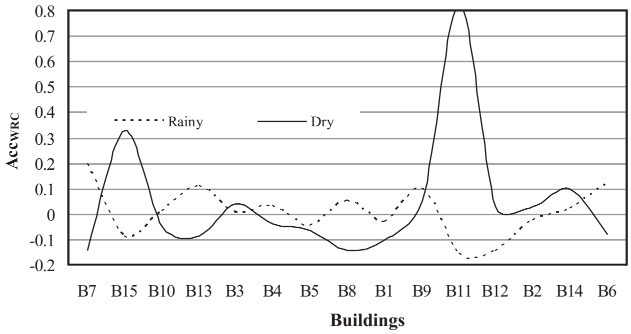


Fig. 6. Indoor air acceptability.

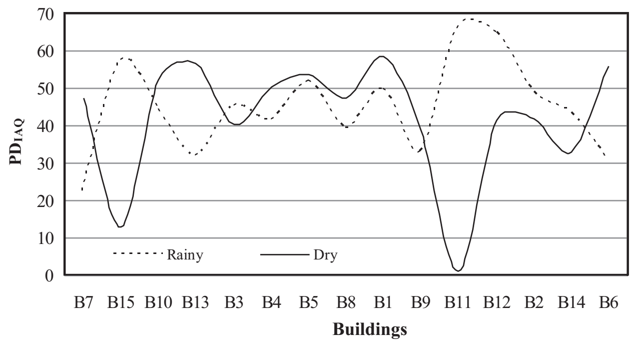


Fig. 7. Indoor air percentage of dissatisfaction due to indoor air quality.

implies, during the dry season, an increment of indoor air relative humidity and indoor air acceptability when they are compared with other external coatings like paint and, in particular, with plaster (B7 and B10). Consequently, the worst percentage of dissatisfied persons is during the rainy season (70%), in a similar way as happens with the building B11 (60%) under these same conditions, as a clear example of benefits of marble used as external coating in this climatic region.

Finally, there does not seem to be too much of a difference in indoor ambience behaviour between plaster and paint coatings.

5. Conclusions

In this work, an experimental study was conducted with the aim to finding out the influence of earthen brick buildings adapted to the local climate, and blocks on indoor air quality during the first hours of work in 15 office buildings. A total of 218 questionnaires were collected and analysed.

Results showed a clear agreement between expected behaviour, in accordance with the construction characteristics, and the real indoor ambiences. For example, when indoor relative humidity was analysed, it was clearly defined as the group of new buildings under a significance value of 0.05 with an average value of 67%, and a standard deviation of 1.67. At the same time, the old buildings showed an average relative humidity of 73%, and a standard deviation of 0.69 for a significance level of 0.97. Indoor air temperature was higher in the new buildings than in the old, with a mean difference of 2 °C during the two seasons of the same year.

Consequently, these indoor ambience indices and questionnaires, showed that thermal comfort was adequate in each group of buildings, except when marble is employed as external coating. The effect of marble as external coating improves indoor ambiences during the dry season, due to its ability to accumulate more indoor air relative humidity, but undergoes a degeneration of these ambiences when relative humidity is higher.

Finally, these results should be given cognisance by architects and building designers in order to improve indoor environment against thermal discomfort in the Saharan area.

However, extensive studies about this effect over longer periods of time, once thermal and hygroscopic materials reach stationary behaviour must be conducted in the next few years to clarify the real effect of passive methods over thermal comfort and energy consumption in this region.

Acknowledgements

Authors are grateful to the various authorities of the city who gave us access to information about their locality. They also thank the head of the national weather station and all those, near and far, who participated in this research during the field study.

Appendix. : Synthesis of the questionnaire

Note: This questionnaire is anonymous; the results of the statistical evaluation, the analysis and conclusions will be published. Please carefully read each question before answering and don't discuss with your friend who also filled this questionnaire.

*** Thanks you for your co-operation and the time you will have to devote to this questionnaire ***

PART 1: PERSONAL DATA
(Please tick off the appropriate box,)

Age…………. Sex : M ☐ **F** ☐ height…………., weight…………
What is the type of house you live in? : Modern☐ Traditional☐

Is it with: mud ☐ wood☐ stone☐ glass ☐

Is it plastered ☐ Paint☐

How long did you live in the town?..
How long you live in your present house?..
How old is your house?..
What is the color of your house? ……………………………………………………………
How many rooms does it have?..

PART 2: THERMAL QUESTIONNAIRES (please tick off the appropriate box)

1) **How do you feel about the temperature in this moment?**
Cold ☐ , cool ☐ , Slightly cool ☐ , Neutral☐ , Slightly warm ☐ , warm☐ , Hot ☐

2) **How do you find it?**
Acceptable☐ Slightly acceptable☐ Not acceptable☐ Slightly not acceptable☐

3) **What is your thermal sensation?**
Comfort ☐ Light annoyance ☐ Annoyance ☐ Heavy annoyance☐

4) **How would you like to feel?**
Much too cool ☐ Too cool ☐ A little bit cool ☐ No change ☐ A little bit warm☐ Too warm ☐ Much too warm☐

5) **On the basis of your personal preferences, how would you consider the room temperature?**
Acceptable ☐ Not acceptable ☐

6) **How do you consider this room?**
Perfectly tolerable ☐ Slightly hard to tolerate☐ Hard to tolerate☐ Veryhardto tolerate ☐ intolerable☐

7) How do you feel about the air flow in this moment?

Completely not acceptable☐ Not acceptable ☐ Slightly not acceptable ☐

Slightly acceptable ☐ Acceptable☐ Perfectly acceptable☐

8) Would you like to have an air mouvement

Smaller than now☐ Exactly how it's now☐ Greater than now☐

9) **You find this Environment** ?

Very Comfortable☐ Comfortable ☐ Slightly Comfortable☐ Slightly Uncomfortable ☐ Uncomfortable☐ Very Uncomfortable

10) **How would you describe indoor humidity in your Building?**

Very dry ☐ Moderately dry ☐ Slightly dry ☐ Neutral☐
Slightly humid ☐ Moderately humid ☐ Very humid ☐

11) Would you like to have an air humidity

Smaller than now☐ Exactly how it's now☐ Greater than now☐

Provide us indication regarding your clothing (e.g. Underwear, woman clothes, trousers, accessories, shirt, pullover etc.)

12) What was your occupation during last hour?

Occupation	**Last 10 minutes**	**minutes ago**	**minutes ago**	**minutes ago**
Doing Office job	☐	☐	☐	☐
Walking in slope	☐	☐	☐	☐
Walking in flat land	☐	☐	☐	☐
Walking in ascent	☐	☐	☐	☐
resting	☐	☐	☐	☐
running	☐	☐	☐	☐
seating	☐	☐	☐	☐
taking a bath	☐	☐	☐	☐
driving	☐	☐	☐	☐
reading	☐	☐	☐	☐
Doing something else	☐	☐	☐	☐
eating	☐	☐	☐	☐
washing dishes	☐	☐	☐	☐
cooking	☐	☐	☐	☐

PART 3: PERSONAL MICROCLIMATIC CONTROL (please tick off the appropriate box)

1) **How can you define the level of control of microclimatic conditions?**

No control☐ Light control☐ Medium control☐ High control☐ Total control☐

2) **How do you feel about the possibility of controlling thermal comfort?**

Satisfied☐ Not satisfied☐

3) **Can you open/close the windows?**

No ☐ Yes ☐

4) **Can you open/close the external doors?**

No☐ Yes ☐ there is no door☐

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