International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459,ISO 9001:2008Certified Journal, Volume 4, Issue 2, February 2014)

Adaptive Study of Thermal Comfortin Equatorial Zone: Case of Some Buildings in Cameroon.

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***Abstract*--Thermal comfortis animportant parameterin buildings. It can significantly influence human healthas well as his productivity. Thispaperpresentsthe resultsof a field study conducted in the equatorial region of Cameroon. The adaptiveapproach coupled to the analytical approach was used toprovide aholistic viewof thermal comfortin buildings. A questionnaire, formulatedaccording tothe standards of ISO7730 andISO10551 was used. Various values of environmental parameters were taken at the same time the occupants were filling the questionnaires. Thestudy was conductedin 2011during four seasons(long dry season, small rainy season, short dry seasonandlong rainyseason), more precisely in Yaounde city. The average comfort temperature obtained was 25.0°C while the thermo neutral temperature was 23.7 °C in modern habitat against 23.3°C in traditional ones.The preferencetemperature variedaccording to season and type of residence. In general, 77.5 % of votersfound their habitatacceptable.**

***Keywords*-- thermal comfort,equatorial climate, seasons, habitat, adaptive approach.**

I. Introduction

The current standards ofthermal comfortare based onlaboratory studies conductedinrooms, ignoringthe complex interactionbetween the occupants andtheir environment that may affect their comfort. Sensations and thermal preferences are relative and vary from one individual to another.Thermal comfort can be defined as the set of multiple interactions between the occupant and the building. It can be described with many physiological, physical, quantitative or qualitative, parameters, more or less uncertain and vague. Thermal neutrality results from a thermal equilibrium achieved by few (or none) physiological responses [1]. However, many studies showed that thermal neutrality does not necessarily correspond to thermal comfort.

The study of thermal comfort in buildings is useful not only to define conditions for a comfortable area, but also to give the architectural recommendations and to propose the best suitable materials to each type of region [2]. Two main approaches were used to study thermal comfort in buildings. One considered as rational, based on the work of Fanger in a mechanically controlled area and the other considered adaptive which the research topic of many recent works. Several researchers confirmed the reliability of this approach. The parameters of thermal sensation were established based on several scales including one of the most important which is that of ASHRAE, whose index expressing the thermal neutrality is defined as zero. Many studies showed the importance of thermal comfort in classrooms, buildings, traditional and modern habitats such as those made by Djongyang and Tchinda [3] in northern Cameroon which gave many parameters related to comfort. A. Kemajou and L. Mba [4] devoted themselves to obtain the thermal comfort in homes in hot zone by a judicious use of building materials. Hugo S.L.C. Hens [5], found after study for PMV = 0, the PPD greater than 5%. Cinzia B. and R. Paola [6], later on, obtained a linear correlation betweenPredicted Mean Vote (PMV) and the difference between the Equivalent Uniform Temperature and the Comfort Uniform Temperature (Teu-Tu) and polynomial betweenPredicted Percentage of unsatisfied (PPD) versus of the absolute value with the same difference between temperatures PPD and (Teu-Tul). The work of De Dear and Brager [7] on the natural ventilation and the work of Nicol and Humphrey [8] on the index of thermal sensation have significantly contributed to initiation of the adaptive approach. The association of this approach to the so-called rational, allowed us to study the thermal comfort in its entirety. We also found works on thermal comfort in America, Asia literature and many other countries in Europe [9-16] but very few in Africa, particularly in equatorial regions.

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International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459,ISO 9001:2008Certified Journal, Volume 4, Issue 2, February 2014)

Many thermal insulation standards were established, completely ignoring that part of the globe. The purpose of this study which is the first of its kind in that locality is to study the thermal comfort during working hours in modern and traditional buildings in Cameroon (Yaounde) using the new adaptive approach associated little bit with the rational approach.

II. MATERIAL AND METHODS

2.1 Study area

The Yaounde city is builton several hills and enjoysa picturesque settinganda climate relatively"fresh". The maximum temperaturerange is between30°C and 35°C sometimes,and theminimum is15°C.Yaoundeis the capitalof the central region, the Cameroon political capital. This city is locatedapproximately at 300kmfromthe Atlantic coastand enjoys atemperatesub-equatorial climatewith four seasons including a large dry season(mid November tolate March), ashort rainy season(April-mid June), ashort dry season(mid June-midAugust) andalong rainy season(mid August-mid November). Its altitudeis between600-800m. Geographically, it is located between3°52' N latitude and 11°32'E longitude.It is built on 7 hills. Its populationwas about2.5 million inhabitants in 2011. Since the early90s, the population increased witha growth rateof7% per year. Figure 1 belowshowsthelocationof the city ofYaoundein Sub-Saharan Africa.

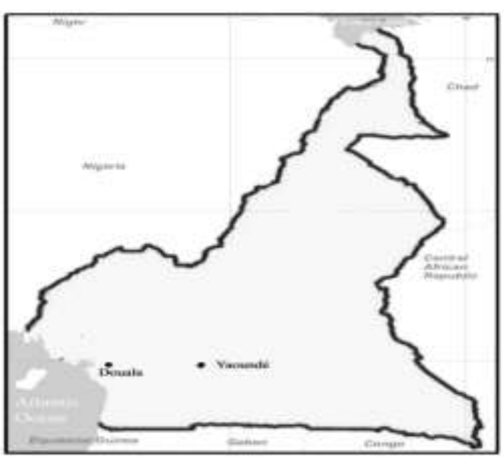

Figure 1 - Location of the city studied.

2.2 Materials

In this study, the indoor air speed, indoor relative humidity, $C0_2$ concentration, indoor temperature were measured byan Thermo-anemometer (model C.A1226) which gave the maximum, the minimum and the average of air temperature and air speed values accuracies. We also used a $C0_2$ Monitor (model CO200) which gave simultaneously $C0_2$ rate, air temperature and relative humidity values with accuracy of ±(5%rdg+50ppm), ±0.6°C and ±3%(10 to 90%) respectively and a sonde thermometer. The variousvalues of outdoor temperature, wind speed and relative humidity were collected fromthenationalweather station. All these equipments were calibrated before use to ensure reliability and accuracy in readings during the field studies.The main characteristics of the measurements system used are reported in Table 1.

Table 1
Characteristics of the measurement system.

$C0_2$ Monitor (model CO200)

Function	Range	Resolution	Accuracy
$C0_2$	0 to 9999ppm	1ppm	±(5%rdg+50ppm)
Temperature	-10 to 60°C	0.1°	±0.6°C
	14 to 140°F	0.1°	±0.9°F
Humidity	0.1to 99.9%	0.1%	±3 %(10 to 90%)
			±5 %(< 10% or >90%)

digital thermometer

Function	Range	Resolution	Accuracy
Temperature	-20°C to 0°C	1°C	±5.0% of rdg ±4 digits
	0°C to 400°C	1°C	±1.0% of rdg ±3 digits
	400°C to 1000°C	1°C	±2.0% of rdg

C.A 1226 Thermo-anemometer

Function	Range	Resolution	Accuracy	Measurement units
Air velocity	0.15to 3m/s	0.01m/s	±3%R+0.1m/s	m/s , fpm , km/h
	3,1 to 30m/s	0.1m/s	± 1%R+0.2m/s	
Temperature	-20 to +80°C	0.1°C	± 0.3%R+0.25°C	°C, °F
Air flow	0 to 99999m^3/h	1m^3/h	±3%R ±0.03*surf. duct(cm^2)	m^3/h, m^3/s, L/s, cfm

2.3 Research methodology

Thestudy took placethroughoutthe year during four seasons. Measurements ofvarious parameterswereinaccordance with international standards, UNI ENISO7730:2006. [17], UNI ENISO10551:2002 [18], and theASHRAEStandard55:2004[19] usingthe newadaptive approach.

International Journal of Emerging Technology and Advanced Engineering
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In mostcases, ventilation was controllednaturally.We used questionnaires toobtain quantitative dataonthe actual conditionsin thesehabitats. To achieve this objective, two data collection methodswere used including a questionnaireas subjectivemeasurement, and a physical measurement of someparameters that influence thethermal comfort conditions in buildings. In eachbuilding or habitat, in accordance with previous research works, from3 to 5 daysper season, sampling processes were carried out in each differentroom oroffice. Formulti storeybuildings, the offices chosen were those that presented a greater number of occupants.Theradialaverage temperatureis estimatedfollowingthe formula proposed byNagano[20]:

$T_r = 0{,}99T_a - 0{,}01$,at $R^2 = 0{,}99$ (1)

The thermal resistanceofclothing(I_{cl}) is determined according toISO7730:2006andthe formula proposed byMcIntyre[21]:

$I_{cl,men} = 0{,}13 + 0{,}727\sum I_{clu,i}$ and $I_{cl,women} = 0{,}05 + 0{,}77\sum Iclu,i$. (2)

Theoperative temperaturedetermined according tothe relationship[19]:

$T_o = A\,T_a + (1-A)\,Tr$, (3)
$A = 0.5$ for $V < 0.2$ m/s
$A = 0.6$ for $0.2 < V < 0.6$ m/s
$A = 0.7$ for $0.6 < V < 1$ m/s

PMV and PPDdetermined bysimulationfollowingthe relations established byFanger[9]:

$PMV=[0{,}303\exp(-0{,}036M)+0.028].L = a.L$ (4)
$PPD= 100-95\exp[-(0.03353PMV^4 +0{,}2179PMV^2)]$ (5)

2.3.1. Field measurement of environmental parameters

Measurementswere takenevery 15 minutesat a height of 1.1meters from the ground levelin strict accordance withthe prescriptions of theASHRAEStandard55[19] and ISO7730 Standard[17].The devices wereinstalled at 7:00 AMand measurements started at8:00 AM, so that each unitcould get adaptto the environment. Dataweretakenregularlyuntil 7:00 PM.These measurementsprovidedfour of thesixparameters established byMacpheson[22] such as air velocity, relative humidity, ambient temperature, andaverageradiant temperature. These parameters were then used to calculate the PMV and PPD index according to Fanger's model.

In most of the cases, a thermal uniformity was difficult to be achieved in buildings or habitats.Hence,in this study,measurement of the environmental parameters was conducted at various occupied points by the occupants who would be completing the questionnaires. Table 2 shows some examples of buildings analyzed. This study took place in several streets of Yaounde (Cameroon) and precisely in 55 habitats including 30 modern habitats and 25 traditional habitats.

Table 2
Some main characteristics of the analyzed buildings.

Type of Buildings	Type of Construction	Volume [m^3]	Floor area [m^2]	Height [m]	Window Exposition	Heating Terminal Device	Natural Ventilation
Modern	bond-stone	180	5x 8	4.5	S-ES	radiators	x
	board	96	4 x 6	4.0	S-SW	radiators	x
Traditional	earth	52.5	3.5x 5	3.0	E-ES	radiators	x

The traditional habitats were mostly with provisional and local materials (Wood, soil, brick etc.), while modern habitats were built with glasses, plasters, stones but also with clay brick. Fewexamples ofmodern andtraditionalhabitatsstudied and the materials usedare shown in Figures2 and 3.

Figure 2 - Example of modern buildings studied.

Figure 3 - Example of traditional habitat .

2.3.2. Subjective measurements

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During the study, questionnaires weredistributedtwice a day including in the morning, from 8 to 12am and in the afternoon,from2 to 6pm (occupants pausedfrom 12am to 2pm). About 920 copies were recovered representing just about 51% of individuals who accepted to answer the questionnaires and who were actually delivered the questionnaires.These questionnaires were written and developed in accordance with ISO 7730 [17] and ISO 10551 standards as explained before [18]. 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 height of each occupant. Finally, like in the previous research works, thanks to the questionnaires, it was also possible to find out the thermal sensation, thermal preference, and acceptance of the thermal control of air movement and humidity in the occupied areas. The exact number of questionnaires for each season issummarized in Table 3.

Table 3
Number of questionnaires as function of the analyzed season

Study	season	months	Number ofquestionnaires
1	long dry season	Mar-Nov	423
2	Small rainy season	May	258
3	Short dry season	July	100
4	largerainy season	Sep-Oct.	139

III. Results And Discussions

Wedecided onthe numberof townthat participated in thestudy and itappeared thatthe participation ratewas between(0.7% -6.2%) bydistrict. On average, more than74.6%of modernhabitatswerestudied. Characteristics of occupants and personal thermal variables from questionnaires are reported in Tables 4 and 5. We observed in these tables that among the 920 voters, 531 are men and 389 women. Their height varied from 1.48m to 1.99m. Their activities varied from 1 to 1.2met with an average of 1met and a standard deviation of 0.07in traditional habitats and 0.05 in modern habitats. The duration of habitats varied from 0 to 51 years, with an average of 29.5years and a standard deviation of 1.56 in traditional habitats against 10.5 years and with a standard deviation of 2.23 in modern habitats.

	City: Yaoundé		
Type of residence	**Modern**	**Traditional**	**Both types**
Gender			
Male	415	116	531
Female	272	117	389
Age (year)			
Maximum	70	68	70
Minimum	11	18	11
Mean	25	28	26.5
Standard deviation	7.34	5.23	4.36
Height (m)			
Maximum	1.99	1.91	1.99
Minimum	1.58	1.48	1.48
Mean	1.63	1.70	1.66
Standard deviation	0.15	0.18	0.12
Weight (kg)			
Maximum	130	102	130
Minimum	40	46	40
Mean	77	66	69
Standard deviation	18.9	9.56	8.54
Metabolic rate (Met)			
Maximum	1.2	1.2	1.2
Minimum	1.0	1.0	1.0
Mean	1.0	1.0	1.0
Standard deviation	0.05	0.07	0.06
Clothing (Clo)			
Maximum	1.3	1.05	0.36
Minimum	0.36	0.55	0.86
Mean	0.97	0.76	0.18
Standard deviation	0.21	0.13	
Years in the region			
Maximum	42.0	51.0	51.0
Minimum	0	21.0	0
Mean	10.4	29.5	18.4
Standard deviation	2.23	1.56	2.01
Type of construction			
In bond-stone	601	71	672
In board	5	13	18
In earth	81	149	230

Table 4
Synthesis of the average data.

Table 5
Synthesis of measured data in City.

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	City: Yaoundé		
Type of residence	**Modern**	**Traditional**	**Both types**
T_{out} (°C)			
Maximum	33.5	31.9	33.5
Minimum	18.5	8.1	18.1
Mean	25.3	25.1	25.0
Standard deviation	3.56	2.37	2.53
T_{in} (°C)			
Maximum	31.4	31.5	31.4
Minimum	18.8	17.9	17.9
Mean	25.7	24.8	25.1
Standard deviation	1.73	2.03	1.86
V_{out} (m/s)			
Maximum	3.1	3.1	3.1
Minimum	0.7	1.0	1.0
Mean	1.7	2.0	1.8
Standard deviation	0.89	0.64	0.79
V_{in}(m/s)			
Maximum	0.37	0.52	0.52
Minimum	0.05	0.01	0.01
Mean	0.11	0.11	0.10
Standard deviation	0.08	0.06	0.07
RH_{out} (%)			
Maximum	84.5	92.0	92.0
Minimum	66.0	61.0	61.0
Mean	78.1	76.6	77.6
Standard deviation	4.28	4.65	3.96
RH_{in} (%)			
Maximum	69.8	55.9	69.8
Minimum	41.5	41.2	41.2
Mean	49.3	46.6	47.6
Standard deviation	3.35	2.82	2.58
T_{mr} (%)			
Maximum	27.1	28.2	28.2
Minimum	18.5	17.	17.9
Mean	23.2	23.5	23.3
Standard deviation	1.7	1.93	1.88
T_o (°C)			
Maximum	26.7	28.1	28.1
Minimum	18.5	17.8	17.8
Mean	23.0	25.7	24.9
Standard deviation	0.96	1.38	0.99

3.1. Personal data: Age of voters

In180officesand habitats studied, ages of votersobtained were ranged from 11 to70 years.In Figure 4, it appears that inmodern homes, 42.8% of voters had an averageage from 11 to 20 years against32.1% in traditional homes. Generally,throughoutthe experimental study,the average ageof all voterswas 26.5 years, about 25 years in modern habitats with a standard deviation of 7.34 against 28 in traditional habitats with a standard deviation of 5.23. These averages show that most occupants were adults.

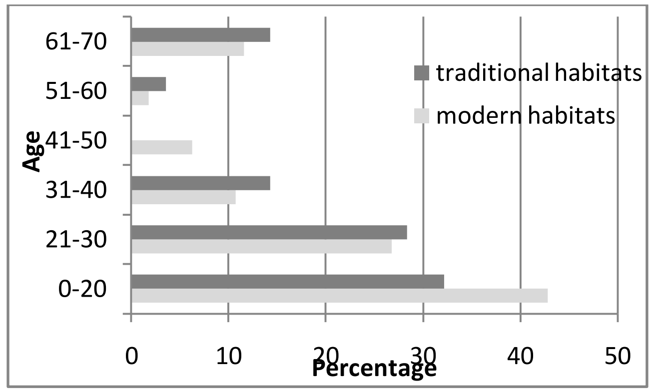

Figure 4 - Frequency distribution of participants by age and habitat.

3.2. Clothing thermal insulation values

Resistanceofclothingvaried according to sexof the individual and the climate(seasons). In this study, the majority of the thermal insulationobtainedvaried from 0.3cloto 1.3clo. By analyzingFigure 5, we found that 57.0% of womenhad avotingstrengthbeyond1cloclothing, against 38, 1% of men.

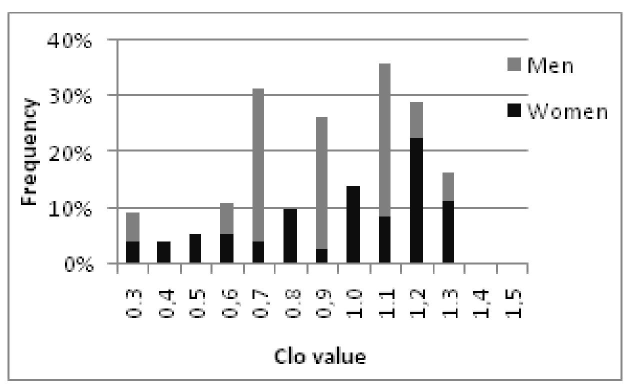

Figure 5 - Clo value frequency by gender during four seasons.

We deduced that the clothing resistance is greater in women than in men, especially in raining seasons. The

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average obtained was 0.86clo, with a standard deviation of 0.18.

3.3 Predicted Mean Vote (PMV) from instrumental data

In Figure6, it could be seen that there is a linear correlationbetween the PMV and indoor airtemperature. The PMV ranges varied from-2.03 to +1.94for indoor air temperaturesranging from16.4°C to28.5°C. There is a good correlation (R = 0.8182) between PMV and indoor air temperatures. The following correlation for PMV was found:

$$PMV = 0.3594\ T_a – 8.3106 \quad (6)$$

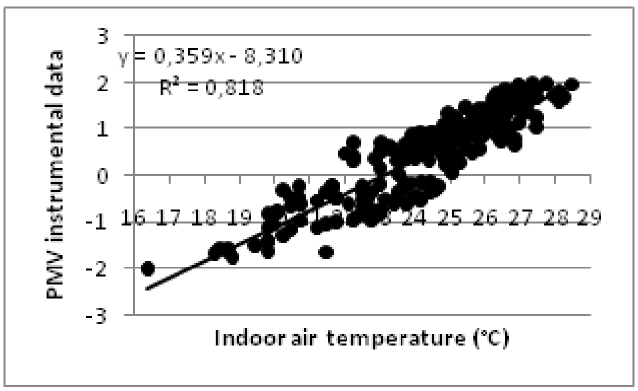

Figure 6 - PMV values as function of indoor air temperature.

The thermal neutral temperature was obtained forPMV =0. The average value for the different habitats of the thermal neutral temperature was found ranging from 23.1°C to 24.8°C.

3.4 Mean thermal sensation votes (MTSV) orPMV questionnaire

Figure (7a and 7b) show the dependence of the Mean thermal sensation votes (MTSV) or Predicted Mean Vote from questionnaireas function of the operative temperature (t_0), where a good linear relationship (R^2 = 0.804; R^2 = 0.714) were found:

MTSV (Yaounde, traditional living room) = 0.600 t_O - 14.25, R^2 =0.804 (7)

MTSV (Yaounde, modern living room) = 0.576 t_O - 14.02, R^2 = 0.714 (8)

Equations (7) and (8) were obtained from different operative temperatures (temperature of uniform air) ranged from 18°C to 28°C.

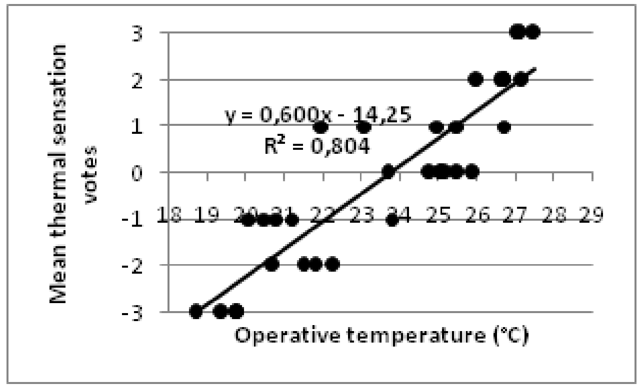

Figure 7a - Thermo neutral temperature traditional living room Yaoundé.

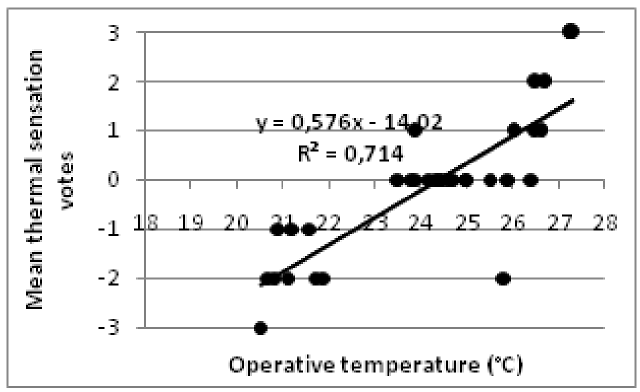

Figure 7b - Thermo neutral temperature modern living room Yaoundé.

The thermo neutral temperature was obtained forMTSV =0. This thermo neutral temperature was 24.3°C in modern habitats against 23.7°C in traditional habitats. The comfort parameter was given in Table 6. The differencebetween Comfort temperatures was 0.2°Caccording to the typeof residence. From these results, we could conclude that a comfortable habitats is not always a neutral area.

Table 6
Estimated comfort parameter.

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City: Yaoundé

Type of residence	Modern	Traditional	Average both types
Neutral Temperature (°C)	24.6	24.9	24.7
Comfort temperature (°C)	25.1	24.9	25.0
Therm0 Neutral temperature (°C)	24.3	23.7	24.0

3.5 Air velocity preference.

Figures (8a and 8b) give thepreferencesofairmovementaccording to the seasons.Duringthe long dry season, 42.1% of voters wantedan increase in air movementinmodern habitats against53.9% intraditional dwellings.Thesedifferencesmay arise from thestructureof these differenthabitats,but also from the moodof the occupants. During the greatrainy season, 69.2% of occupants opted for a reduction inair velocityinbuildings (modern living) against 33.0% intraditional buildings.

During the small rainy season, 63.5% of occupants in modern habitats did not want to change their area whereas occupants of traditional habitats wanted more speed in air (49.5%).

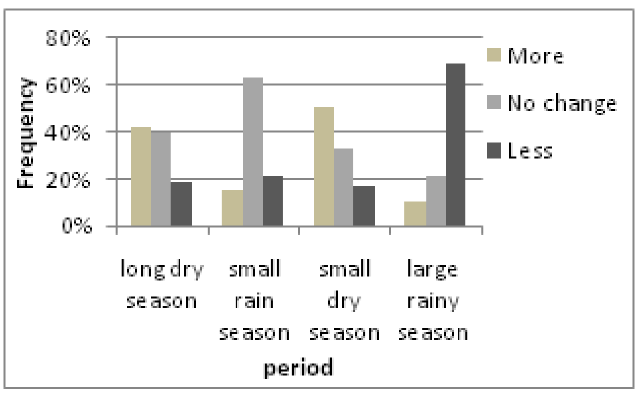

Figure 8a - Air velocity preferences in modern habitats during four seasons.

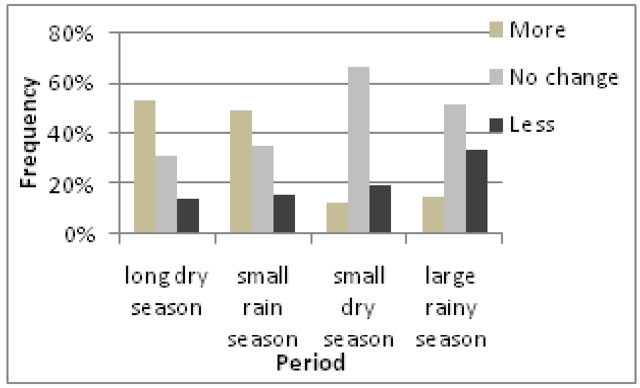

Figure 8b - Air velocity preferences in traditional habitats during four seasons.

When analyzing these different results, we concluded that preferences in terms of air speed varied according to seasons.

3.6.Thermal Acceptability and Thermal Preference Index

3.6.1 Thermal acceptability

These Figures (9a-9d) give the resultsof thermal sensationvotesobtained during thefield study, it appearedthat among the 423participants, duringthe long dry season(figure 9b), 72.1% found their habitatacceptable. Among the253participantsduring thesmall raining season(figure 9a), 74.2% found their environmentacceptable. During theshort dry season(9c) only 10% of participantsfound their habitatneutral. More than 46.2% individuals inmodern habitats voted for-1(slightly cold), 28.6% individuals in traditional habitats chooseindex +2(hot) and14.3% voted for +3(hot,). Finallyduring thehighraining season(9d), on139participants,89, 1% wasacceptablehabitats, 42.1% votedintraditionalindexo(neutral) against15.6% in modern. From this study, 77.5% of votingis acceptable environment. Compared to thatestablished inASHRAE55:2004 (which is 80%), it is possibleto assert thatthe environment is consideredcomfortable. These results are not surprising for more than 80% of occupants who expressed their thermal sensation were used to their habitats. The previous results proved that individuals used to their environment found it acceptable.

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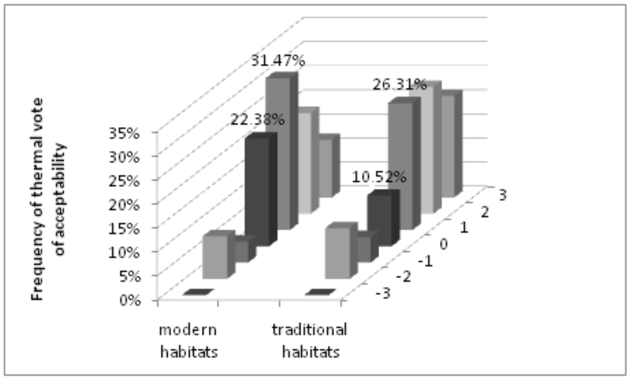

Figure 9a - Votes of thermal sensation during the long dry season.

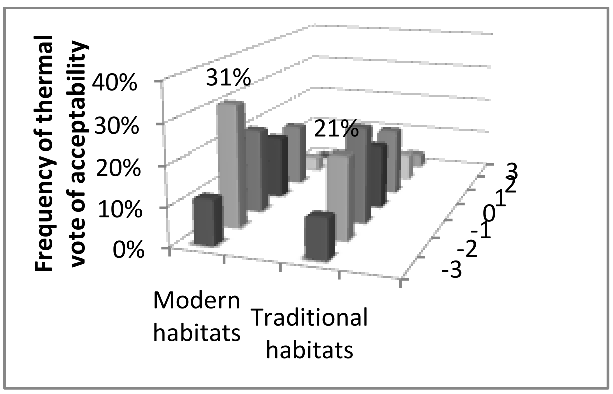

Figure 9b - Votes of thermal sensation during the small rainy season.

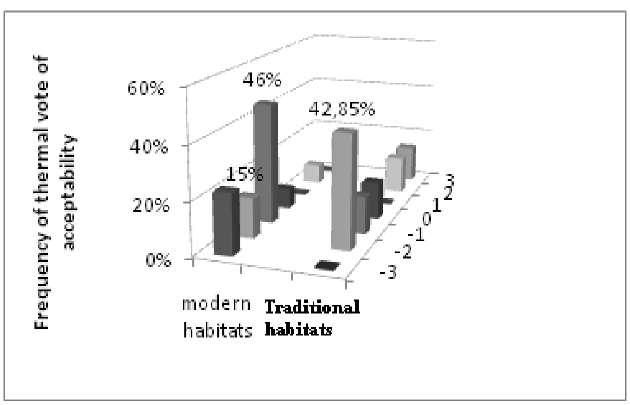

Figure 9c - Votes of thermal sensation during the small dry season.

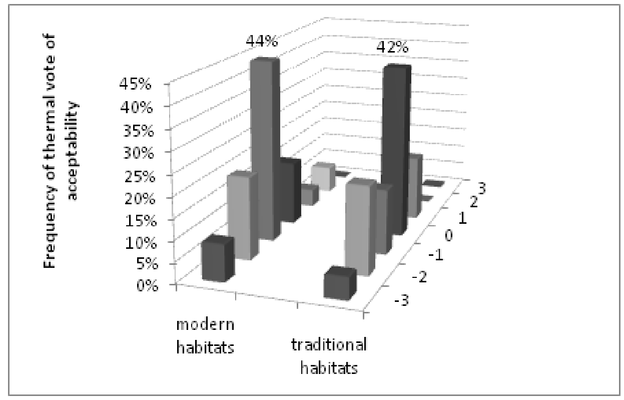

Figure 9d - Votes of thermal sensation during the large rainy season.

At the same time, local thermal comfort can be analysed. For an indoor air quality study, there are a number of empirical equations used by some authors, such as Simonson [23], over the last few years. Indices, like the percentage of dissatisfaction with local thermal comfort, thermal sensation, and indoor air acceptability were determined in terms of some simple parameters, such as dry bulb temperature and relative humidity. Thus, the agreement chosen by the ANSI/ASHRAE and ISO 7730 to establish comfort boundary conditions was about 10% of dissatisfaction. To meet the local thermal comfort produced by the inside air conditions, Toftum *et al.* (1998b) [24, 25] have studied the response of 38 individuals who were provided with clean air in a closed environment. As a result, the equation for the percentage of local dissatisfaction was developed as shown in Equation (9).

$$PD = \frac{100}{1 + e^{(-3.58\, +\, 0.18\cdot(30-t)\, +\, 0.14\cdot(42.5\, -\, 0.01 p_v))}} \quad (9)$$

The ASHRAE recommends keeping the percentage of local dissatisfaction below 15%, and the percentage of general thermal comfort dissatisfaction below 10%. As we can see, this PD tends to decrease when the temperature decreases and, consequently, these limiting conditions can be employed to define the optimal conditions for energy saving in the air conditioning systems. Consequently, Figure 10 shows indoor local thermal comfort conditions in accordance with previous indices.When local thermal comfort was analysed, it was found that the percentage of dissatisfied persons exceeded 40% in both type of habitat and, in particular, in modern habitat, due to its higher average temperature.

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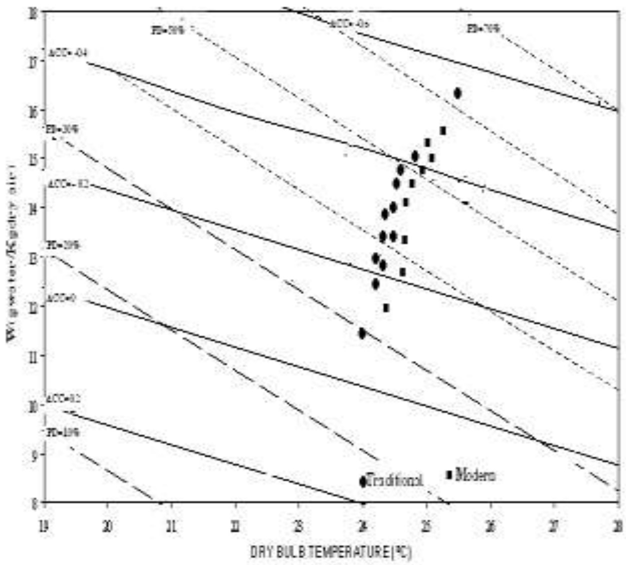

Figure10: Local thermal comfort conditions in yaounde

3.6.2 Thermal Preference

In Figures (11a -11d), thethermal preferencesof individuals in theirhabitats vary according to the different seasons. During the small rainy season (figure11a), index -2(cold) and -1(slightly cold) are the most preferred. In fact, 20.1% of individuals, voting index (-2), preferred an area more warmth, whereas 13.5% persons voting (-1) preferred a colder area. During the great dry season (figure11b), most habitants found their habitats very hot, that is why they voted for index (+3). These people who found their environment very hot preferred (47.4%) a colder area. However, during the small dry season (see figure 11c), habitants found their environment hot; this is why 50% of voters wanted their environment colder. Finally, during the great rainy season(figure11d), habitats had an internal climate slightly cold, that is why 66.2% of voters did not want to change their environment.

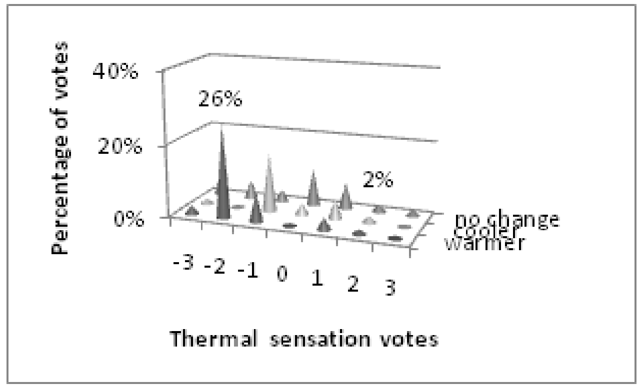

Figure11a - Votes of thermal preference during the Small rainy season.

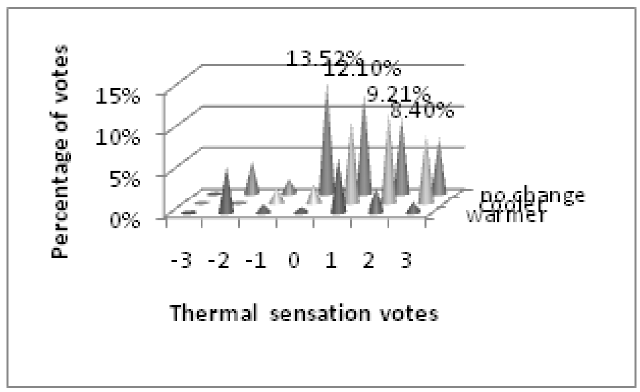

Figure11b - Votes of thermal preference during the great dry season.

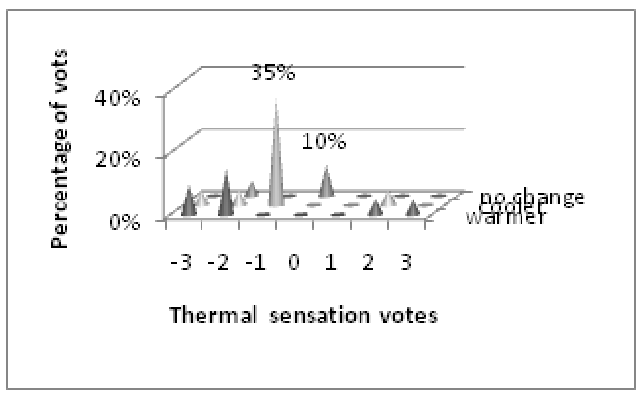

Figure11c - Votes of thermal preference during the Small dry season.

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459,ISO 9001:2008Certified Journal, Volume 4, Issue 2, February 2014)

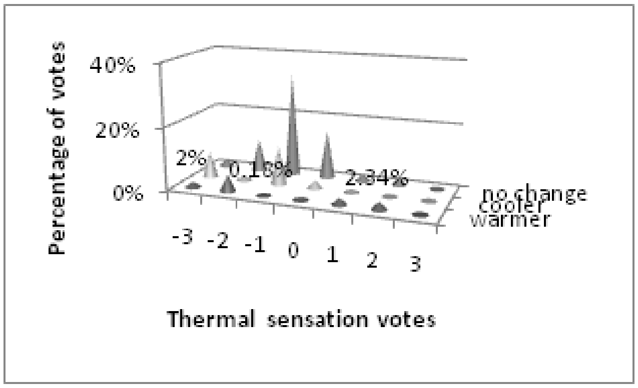

Figure11d - Votes of thermal preference during the great rainy season.

Table 7shows differentpreferences of individualsfollowingperiods of study.

Table 7
Thermal preferenceafterthe study periods.

Seasons	Thermal preference	Percentage of vote	Dominant index
Large dry season	colder	47.4%	+3(very hot)
Small rainy season	warmer	41.1%	-1(slightly cool)
Small dry season	Colder	50.0%	+2(hot)
Large rainy season	No change	66.2%	-1(slightly cool)

3.7 Internal environmental parameters

Figure 12shows the evolution of the average air temperatureandair speedover a period of49 days.The average temperatureobtainedvaried from21.5°Cto 26.5°C with a standard variation of 1.72. Air speed varied from0.017m /sto 0.45m/s with an average of 0.11m/s and a standard variation of 0.07. This speedwas unpredictable. Generally,we observed thattheair velocitywaslower in modern environment than in traditional environment.

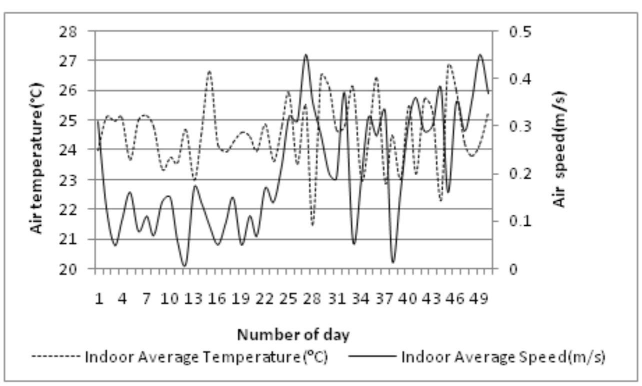

Figure 12 - Indoor average air temperature and Indoor average air speed in 49 days during dry

The relative averagehumidityas well asthe rate of CO2 is givenin Figure13. The variationofmoisture strongly depended not only on theplace of study,but also on the structure of the building and the microclimateof the environment.

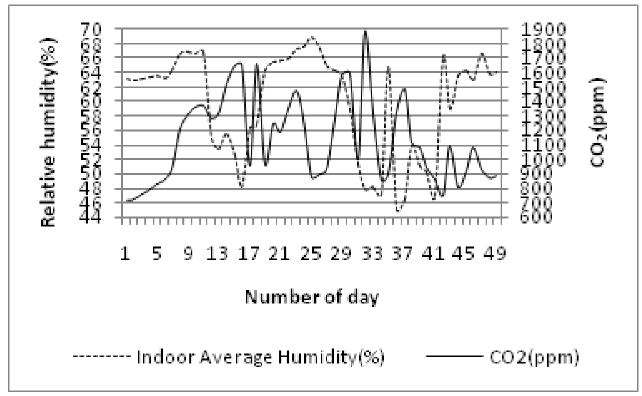

Figure 13 - Indoor average humidity and CO_2 in 49 days during dry and rainy season.

Theaverage of humidityvariedfrom 45.1% to68.8%, with an average of 47.6m/s and a standard deviation of 2.18. We deduced that this rangewas not similar to the one established by the standardASHRAE55(30% - 60%). CO2 levelsranging from717ppm to1884ppmand found average was801ppm. According to ASHRAE 62:1989(establishedCO2 <1000ppm), we deduced that some of thesehabitatswere highly pollutant. Pollution rateobtained was 69.8%for modern habitatsagainst30.2%for traditional habitats.

This differenceshows that in traditional housesmade with local materials and adapted to the type climate, there is less pollution.

Results showed that manexpressed his preferencesandthermal sensations in a naturallycontrolled. Thermal sensationsandperceptionsvaried from oneindividual to another, even if they were from the sameregionand subject to the sametype of climate. Thermal comfortwasportrayed usinga lot of physiological, psychological, physical, quantitative or qualitative parameters, more or lessuncertainand vague. Inthe modern homemade ofcement blocks, there is thermal discomfort, which requires the use of mechanical ventilation, source ofenergyin buildings.Somearchitectsneglects the microclimatic aspect.Thetraditional housesmust bebuiltwith materialsadapted to their environment.

IV. CONCLUSION

To sum up, in this work, it appears that the study of thermal comfort is important for human beings because they spend 70% of their time inside buildings. So they need a healthy and comfortable environment. This study was conducted during four seasons in modern and traditional habitats in Yaounde (Cameroon). We used the new adaptive approach. Questionnaires are formulated according to UNI and ISO 7730 and 10551. We established that:

- The comfort temperature varies seasonally and is higher in dry seasons.
- The difference of temperature of neutrality between modern and traditional habitats is 0,3°C.
- The difference of temperature of thermal neutrality between modern and traditional habitats is 0.59°C.
- Metabolism is higher in traditional and modern habitats.
- The relative humidity varies from 45.1% to 68.8% in both traditional and modern habitats, while the wind speed varies from 0,02m/s to 0.45m/s.
- The thermal sensations and preferences vary according to different seasons.
- The age of the individual influences the choice of preference and thermal sensations.

Therefore, it is very important to get comfort through a judicious choice of building materials and a good definition of an architectural policy construction which takes into account the type of climate, the type of materials and habits of the population. One can increase the thermal comfort without usingartificial air conditioning but simply by taking into account the structure and the material used.

Acknowledgements

The authors are grateful to the administration and all staff of the mission of promoting local materials (MIPROMALO) for having provided us with measuring devices. They also thank all those near and far who participated in the preparation of this work during the field study.

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