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The Factor of House Forms in Indoor Environmental Quality of Houses in Selected Cities in Oyo State, Nigeria

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ABSTRACT: *Indoor Environment Quality (IEQ) is a very important aspects of housing as it provides safety, physiological and social comfort for the occupants. The principal qualities of indoor environment established in literature are thermal comfort, ventilation, daylight and acoustic. However, there are other factors which have received very little attention in literature that may influence the quality of indoor environment. One of these factors is the building characteristics based on forms and types. This study therefore examined house forms and types as a factor in indoor comfort studies in selected cities in Oyo state, Nigeria.The study employed both observation and objective approaches to obtain ordinal and numeric data from 579 (2.5%) of 23,000 houses in the three selected cities using systematic random sampling. The ordinal data were gotten through observation schedule which were conducted to assess the physical, spatial and locational characteristics of residential buildings. This assisted in classifying the residential buildings into types and forms. The numeric data were gotten using three technical equipment of Kestrel 4500 Pocket Weather and Environmental Meter, Noise Dosimeter and Lux Meter to physically measure indoor climatic elements, noise level and illumination level respectively. The values from the technical equipment were subjected to the IEQ Calculator (Apartment) Software, for rating the indoor environmental quality of the studied houses. The preponderant residential building types were Brazilian rooming houses (58.7%), flats (32.8%), compound impluvium house (4.8%) and duplex (3.6%). These residential building types were formed in to buildings with deep interior (2.2%), compact buildings (18.2%), compact with enclosing courtyard buildings (13.6%) and linear buildings (65.9%). Results from the IEQ performance rating indicated that majority of the houses were worst (1 star) in IEQ performance scale. The house form with the best IEQ performance was the linear form (4 star) and the worst IEQ performance was the broad deep interior spaces (1 star). The study recommended that there is need to give more attention to indoor environmental quality especially at the conceptual stage of any residential building designs*.

KEYWORDS: Indoor Environmental Quality (IEQ), House types, House forms, IEQ performance, Building Characteristics

INTRODUCTION

Indoor environment is a very important aspects of housing. It provides accommodation and safety for people which can be conducive and suited for its intended use. It also provides both physiological and social comfort. Indoor environment is therefore a complex setting essential for psychological health, happiness and dignity of occupants. The comfort in an indoor environment is indeed a major concern for the occupants of building. Indoor comfort according to Lai, Mui, Wong and Law (2009) is synonymous with Indoor Environmental Quality (IEQ) and Authors have used the term Indoor Environmental Comfort (IEC); Satisfaction in Indoor Environment (SIE); Indoor Environmental Performance (IEP) and Evaluation of Indoor Environment (EIE) (Ayinla, 2018). Indoor environmental quality is an interaction between not just the ambient physical dimensions of indoor environment but also of social and spatial. The principal qualities of indoor environment are thermal, daylighting, air ventilation and acoustic. There is enough evidence to suggest that there are other factors which have received very little attention in research apart from the four environmental factors mention above that may influence the quality of indoor environment. One of these factors is the house forms. In the past, residential buildings were built to provide the barest necessities for the family and forms were simple and plain. However in the recent years, owing to advances in technology, building designs have altered greatly and forms have become more complicated. Studies have severally emphasized the spatial and physical qualities as singular influences on indoor environmental qualities. Very few have examined building characteristics based on forms and types as a factor in indoor environmental Quality.

Concept of Indoor Environmental Quality

The concept of comfort represents the state of a building occupants' satisfaction in relation to indoor environment. Early research in this area dates from the fourth century BC in Grece by Vitruvius Pollio when he established performance criteria starting from how to choose the proper site of a city or a building, to compliance criteria of space, lighting, ventilation, acoustics and orientation, solutions to preventing excessive moisture or mutual shading of buildings, and to economic criteria for construction of a building (Octay, 2002). These criteria now laid the groundwork to scientifically developing of study the environmental effects on buildings and their users. Interior comfort is made up of several components, studying the interaction between them, and how they affect the building and people. Therefore, interior comfort components are:

a) Thermal comfort relative to temperature, humidity, air velocity.
b) Acoustic comfort: noise from outside, inside, vibrations, and so on.
c) Visual comfort and lighting quality: vision, lighting, indicator of brightness, reflection, and more.
d) The quality of indoor air pollution, odour, fresh air supply, and more.

Some authors have attempted to define what Indoor Environmental Quality (IEQ) is. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers

(ASHRAE) in 2007 defines indoor comfort as the condition of mind that expresses satisfaction with the indoor thermal environment. Some scholars according to Ayinla (2018) were of the opinion that the definition does not addressed other ambient parameters such as ventilation, daylighting, and Acoustic, and also does not convey the complexity of comfort and all of its contextual and cultural influences. In 1997, Clement-Croome in the book titled "Naturally Ventilated Building" comprehensively defined comfort as the overall comfort of a building interior and health of its occupants, according to him, comfort is an interaction between not just the ambient physical dimension of indoor environment but also of social and spatial ones.

Approaches to indoor environmental quality assessment have taken different dimensions ranging from objective to subjective and even a combination of both the objective and subjective approaches. In the objective approach, technical measurement of physical factors is involved through the use of instrument to obtain values for indoor air temperature, relative humidity and air movement for assessment of thermal comfort, values for indoor daylighting, ventilation, $C0_2$ concentration and decibel level for visual, indoor air quality and acoustic comfort respectively as exemplified in the work of Chiang *et al.* (2001) and Chiang *et al*. (2002).

Subjective approach to indoor environmental quality received wider usage in literature. This approach adopted the use of occupants or residents' perception of their indoor environment to rate the indoor environmental quality. The ultimate interest is the occupant satisfaction and to a lesser degree, of the physical IEQ conditions. This approach uses survey tools, there are many survey tools available for studying IEQ satisfaction among occupants The two most widely used survey are the Building Use Studies limited (BUS) and Centre for the Built Environment (CBE) survey. For instance Aren (1998), Mohammed (2006) and Lai *et al.* (2009) have adopted subjective approach in their various studies of assessment of indoor environment.

Most residential buildings in Nigeria unconsciously adopted the concept of form follows function by the need to satisfy the socio-cultural demand of the residents without having in mind the preconceived form it would take. Housing fulfills the desire of a man to be able to provide a shelter for himself. Smi (2010) opined that house form is a state where the man has a feeling of achievement from owning a place he can use personally and develop to his taste and for his satisfaction psychologically. The form and structural construction of a house depends on the area and what is in vogue at the time. In the past, houses were built to provide the barest necessities for the family and forms were simple and plain. In recent times, due to advances in technology, building designs, and most especially residential buildings, have altered greatly without recourse to functions, hence, forms have become more complicated.

Dwyer (1981) in his book, *'People and Housing in Third World'* pointed out that there are two types of house forms: The rectangular and the circular house forms which may be an enclosed or detached types. Rectangular house form takes after the plot that contains the building which is rectangular in shape down to the spatial arrangement of the structure. Toronko (2007) stressed that the rectangular house form is conformed to

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the urban areas where housing construction regulations and architectural designs are observed. Dwyer (1981) further observed that in urban areas the rectangular forms reflect urban settlements which is either spontaneous or linear types. Rectangular house form has been modified into modern house types bungalow and storey buildings as a result of advancement in architectural design capability and appropriate use of building materials.

Circular house form according to Shall (2012) is much related to the rural dwellers who do not observe building regulation. The land is vast and free that the house owner design structures by themselves without following any regulations except the knowledge transferred from generation to generation. The shapes of the housed are mostly circular and the spatial arrangements of the rooms are as well. Space distribution is not the priority of the circular house form as most spaces were undefined for each activity in the house. However, factors such as socio-cultural, climate, economic and technology of the environment and the people according to Dwyer (1981) can modified the house form.

Study Area

The study was conducted in three (3) selected cities in Oyo State, Nigeria. These cities are Ibadan, Ogbomoso, and Kisi. Oyo State falls entirely within the warm humid climate. Each of these cities is socially and geographically unique because of the differences in their level of urbanization and micro climate respectively.

Ibadan is located on latitude $7^{0}23^{I}$N, longitude $3^{0}55^{I}$E, it is however within the rain forest region of Nigeria. Ogbomoso on the other hand, lies on $8^{0}10^{1}$ North of the equator and longitude $4^{0}10^{1}$ East of the Greenwich Meridian, within the derived Savannah region of Nigeria, while Kisi is located on latitude $9^{0}05^{I}$N and longitude $3^{0}51^{I}$E, and falls within the real Savannah with alternating wet and dry seasons. These peculiarities portends possible implications on their indoor environmental quality. The location of these cities are shown in figure 3.1.

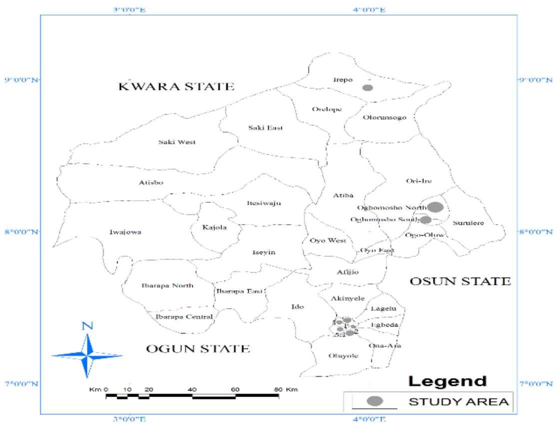

Figure 1: Location of Ibadan, Ogbomoso and Kisi on Oyo State Map
Source: Urban and Regional Planning Department, LAUTECH, Ogbomoso.

METHODOLOGY

The residential neighbourhoods in the study areas were classified based on the preliminary reconnaissance survey of the cities by the authors in the course of the study and the previous findings from earlier studies. The classification of residential neighbourhood in Ibadan metropolis was based on the previous studies of Ayeni (1994) and Adunola (2014). Ayeni (1994) classified Ibadan metropolitan residential neighbourhood into low, medium and high residential densities while Adunola (2011) identified One hundred and nineteen (119) residential neighborhoods of 19, 31 and 69 as low, medium and high residential densities respectively in Ibadan metropolis.

However in Ogbomoso, residential neighbourhoods were classified into low, medium and high residential densities based on the previous findings of Adeboyejo and Onyeneoru (2002). Reconnaissance survey of Kisi revealed that residential neighbourhood are distinctly classified into low, medium and high residential densities. The unit of analysis is the house and the data were collected through observation and technical measurement. In Ibadan, stratified random sampling was used to select 10 percent across the three residential densities in the identified 119 residential neighbourhoods. The 10 percent of the neighbourhoods selected were 2, 4, and 6 for low, medium and high residential densities respectively. The National Bureau of Statistics (2009) and the 2006 national census population data indicated an average of 885 houses in each of the 119 residential neighbourhoods making a total of 10,620 residential buildings in the twelve (12) selected neighbourhoods across the three residential densities in the ratio 1:2:3 for low, medium and high residential densities respectively. Records from the National Population Commission (2006) indicated that there were nine thousand, four hundred and eighty (9,480) and three thousand, one hundred and twenty (3120) residential houses in Ogbomoso and Kisi residential neighborhoods respectively. These make a total population of twenty three thousand, two hundred and twenty (23,220) residential buildings in the three selected cities in Oyo state. Taking 2.5% of this sample population, 581 houses was chosen as the sample size. This size was proportionally distributed across each of the three residential density areas. Therefore 87, 191 and 303 residential houses were selected in low, medium and high residential densities respectively for the study as shown in Table 1.

Table 1: Number of Residential Houses Selected from Each of the Three Residential Densities in Ibadan, Ogbomoso and Kisi.

Study area	Low		Medium		High		Total	
	No of buildings	No of buildings selected	No of buildings	No of buildings selected	No of buildings	No of buildings selected	No of buildings	No of buildings selected
Ibadan	1,770	44	3,539	89	5,310	133	10,620	264
Ogbomoso	1400	35	2,840	71	5,240	131	9,480	237
Kisi	320	08	1,239	31	1,560	39	3,120	77
Total	3,490	87	7,620	191	12,110	303	23,220	579

Source: Authors' compilation from field data, 2019.

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In the selection of houses in the high density area, the area was divided into segments and a random sampling was adopted. The houses in each of the segments were numbered serially from one to last number. A random sample was employed to pick and select from each segment. For the sampling of medium and low density residential areas, random sampling technique was also employed for the selection of the streets from a compiled list of streets. Then, a systematic sampling was used to select houses on each sampled street. A random start was generated between the first house and tenth house, the first house chosen was selected along with every 10th house thereafter until the end of the list.

In the selection of houses in the high density area, the area was divided into segments and a random sampling was adopted. The houses in each of the segments were numbered serially from one to last number. A random sample was employed to pick and select from each segment.For the sampling of medium and low density residential areas, random sampling technique was also employed for the selection of the streets from a compiled list of streets. Then, a systematic sampling was used to select houses on each sampled street. A random start was generated between the first house and tenth house, the first house chosen was selected along with every 10th house thereafter until the end of the list.

The types of data collected were ordinal and numeric. The ordinal data were gotten through observation schedule which were conducted to assess the physical, spatial and locational characteristics of residential buildings. This assisted in classifying the residential buildings into types and forms. The data collected included the building characteristics such as types, orientation, plan form, wall materials, roof materials, fenestration type, and fenestration size, presence of semi indoor space, internal arrangement of spaces. Furthermore, the residential buildings were measured and the measured values were translated into architectural drawings.

The numeric data were gotten using three technical equipment of Kestrel 4500 Pocket Weather and Environmental Meter, Noise Dosimeter and Lux Meterto physically measure indoor climatic elements such as temperature, relative humidity and air velocity; noise level and illumination level respectively. The values from the technical equipment was subjected to the IEQ Calculator (Apartment) Software, for rating the indoor environmental quality of the studied houses, the software was adopted for the measurement because it provided an easier alternative to estimate the indoor environmental quality (IEQ) in residential environment. This was done by imputing several indoor parameters such as air temperature, relative humidity, room floor area, room density, air velocity, illumination level, as well as acoustic level. The Indoor Environmental Quality (IEQ) of the apartment was therefore expressed via a 5-star bench marking scale. The result from IEQ calculator were presented in the form of five star bench scale, ranging from the best as five star to the worst as one star.

Data on physical characteristics of the housewere based on factors that are directly connected to Indoor Environmental Quality (IEQ), such as orientation, courtyard, form, fenestration type and size, internal arrangement, wall and roof materials. These factors were transformed into architectural drawings and subjected to form analysis to determine their types.

FINDINGS

Typology of Residential Buildings in the Study Area

The total number of residential buildings selected for survey in the study area as shown in Table 2 was 579 with 265 (45.8%), 237 (40.9%) and 77 (13.3%) selected from Ibadan, Ogbomoso and Kisi respectively. In all, 293 (50.60%) residential buildings were located in high residential density zones, 194 (33.5%) in medium residential density area, while 90 (15.5%) were located in low residential density area. Table 2 revealed the frequency analysis of the surveyed 579 residential buildings. The result showed that 28 (4.8%) were compound impluvium house, 129 (22.3%) Brazilian rooming house storey, 211 (36.4%) Brazilian rooming house bungalows, 98 (16.9%) were storey flats, 92 (15.9%) were bungalow flats and 21 (3.6%) were duplexes. The result showed that the majority (36.5%) of the residential buildings in the study area were Brazilian rooming house bungalow available majorly in high and medium residential zones.

Table 2: Residential building types in the study area.

City	Residential Building Types	Residential Density Zones			
		High	Medium	Low	Total
Ibadan	Compound impluvium house	-	-	-	-
	Brazilian rooming house storey	51(19.2%)	13(4.9%)	0(0%)	64(24.2%)
	Brazilian rooming house bungalow	61(23.0%)	27(10.2%)	1(0.4%)	89(33.6%)
	Storey flats	8(3.0%)	34(12.8%)	13(4.9%)	55(20.8%)
	Bungalow flats	11(4.2%)	13(4.9%)	18(6.8%)	42(15.8%)
	Duplex	0(0%)	0(0%)	15(5.7%)	15(5.7%)
	Sub-Total	131(49.4%)	87(32.8%)	47(17.1%)	265(100%)
Ogbomoso	Compound impluvium house	9(3.8%)	2(0.8%)	0(0%)	11(4.6%)
	Brazilian rooming house storey	21(8.9%)	14(5.9%)	2(0.8%)	37(15.6%)
	Brazilian rooming house bungalow	68(8.7%)	41(17.3%)	7(3.0%)	116(48.9%)
	Storey flats	7(3.0%)	13(5.5%)	6(2.5%)	26(11.0%)
	Bungalow flats	13(5.5%)	12(5.1%)	19(8.0%)	44(18.6%)
	Duplex	0(0%)	1(0.4%)	2(0.8%)	3(1.3%)
	Sub-Total	118(49.8%)	83(35.0%)	36(15.2%)	237(100%)
Kisi	Compound impluvium house	14(18.2%)	3(3.9%)	0(0%)	17(22.1%)
	Brazilian rooming house storey	18(23.4%)	10(13.0%)	0(0%)	28(36.4%)
	Brazilian rooming house bungalow	5(6.5%)	2(2.6%)	0(0%)	7(9.1%)
	Storey flats	5(6.5%)	8(10.4%)	3(3.9%)	16(20.8%)
	Bungalow flats	2(2.6%)	2(2.6%)	2(2.6%)	6(7.8%)
	Duplex	1(1.3%)	0(0%)	2(2.6%)	3(3.9%)
	Sub-Total	44(57.1%)	26(33.8%)	7(9.1%)	77(100%)
	Overall Total	293(50.6%)	196(33.9%)	90(15.5%)	579(100%)

Source: Authors' analysis from field data, 2019.

Figures 2 to 11 are examples of floor plans of a compound impluvium house, a Brazilian rooming house storey, a Brazilian rooming house bungalow, a bungalow flat, a storey flats and a duplex respectively as documented during the course of survey in the study area. The compound impluvium house was common house types in high density residential zones of Ogbomoso and Kisi cities. It accommodates large number of rooms arranged rectilinearly along the central courtyard with verandas overlooking the

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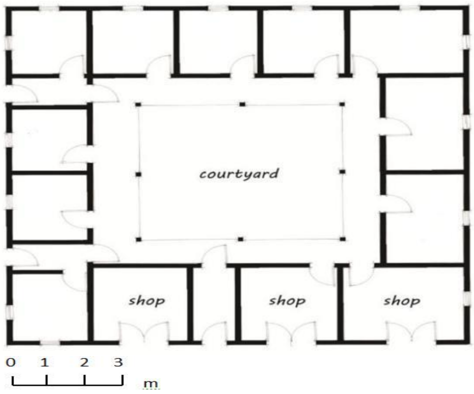
courtyard. The courtyard improves indoor comfort by offering climatically open air movement. It also serves other functions of privacy, a venue for communal meetings and other social gatherings. A typical examples are "Adewole compound"(Figure 2) and "Moberi compound" (Plate 1) in Ogbomoso, and "Baba Onilu Compound" (Figure 3) in Kisi.



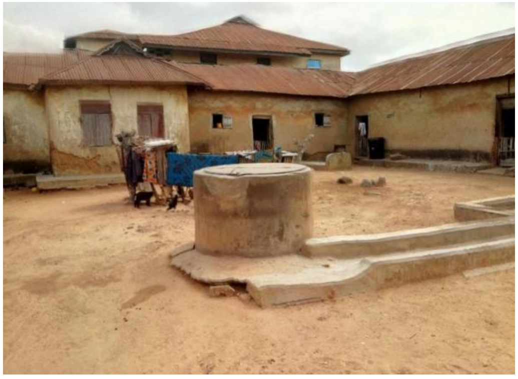


Plate 1: Courtyard of a typical compound impluvium house. Figure 2: Compound impluvium house. Adewole "Moberi Compound", Saja, Ogbomoso. Figure 2: Compound Akunko, Ogbomoso Source: Photograph by A.K Ayinla, 2019.
Source: Plan drawing by A.K Ayinla, 2019.

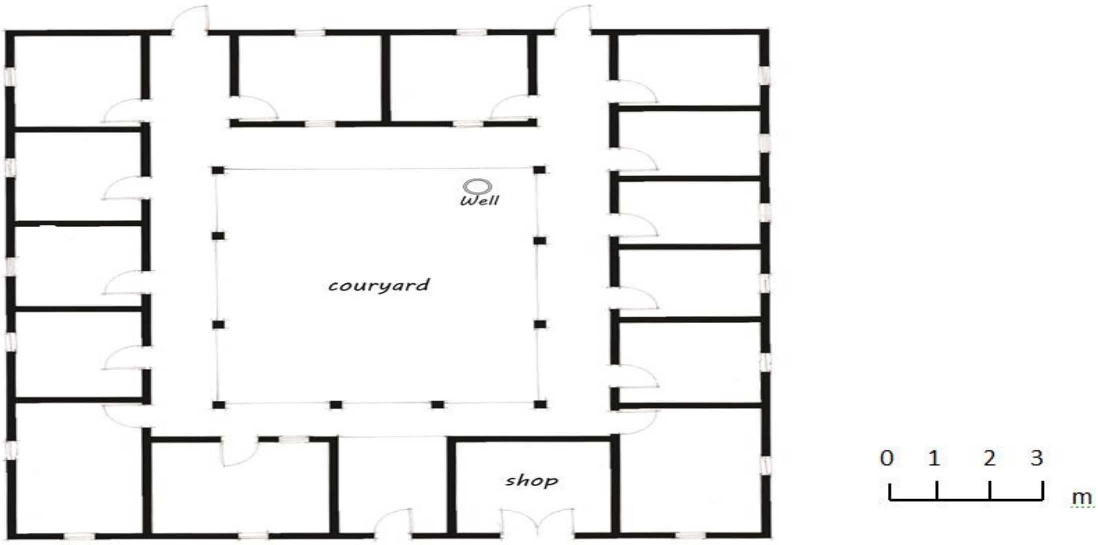


Figure 3: Compound impluvium house. "Baba Onilu Compound", Oju Oja, Kisi.
Source: Plan drawing by A.K Ayinla, 2019.

The Brazilian rooming house types are either available as storey or bungalow types. This residential building types are more dominant and popular in high and medium residential density zones. Brazilian rooming house in its common form, had rooms arranged linearly on both sides of an access corridor. It also had facilities like kitchen, toilets and bathrooms arranged at the backyard. Figure 4 and Plate 2 shows a typical Brazilian rooming house storey in Ibadan (Alhaji Ibrahim house, Sabo, Ibadan). Figure

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5 and plates 3 and 4 shows another Brazilian rooming house storey in Ogbomoso (Okolu house, Oke-Ado Akintola, Ogbomoso). A typical example of Brazilian rooming house bungalow is shown in Figure 6 and Plates 5 (Serekode house, Masifa, Ogbomoso).

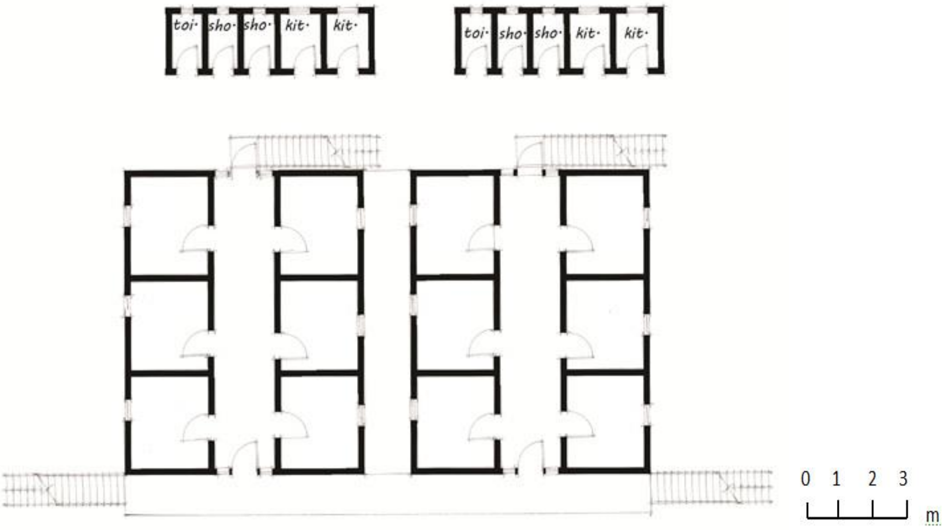

Figure 4: Brazilian rooming house storey. "Alhaji Ibrahim house", Sabo, Ibadan
Source: Plan drawing by A.K Ayinla, 2019.

Plate 2: A type of Brazilian rooming house storey. "Alhaji Ibrahim house",
Sabo, Ibadan. (Approach view).
Source: Photograph by A.K Ayinla, 2019.

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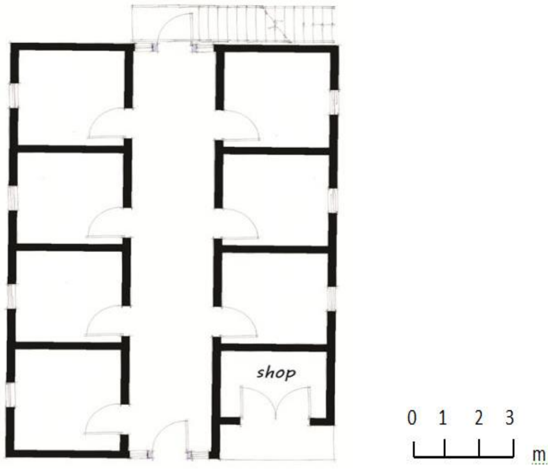

Figure 5: Brazilian rooming house storey. Okolu house,
Oke-Ado Akintola, Ogbomoso.
Source: Plan drawing by A.K Ayinla, 2019

Plate 3: Brazilian rooming house storey. Okolu house,
Oke ado Akintola, Ogbomoso. (Approach view)
Source: Photograph by A.K Ayinla, 2019

Plate 4: Brazilian rooming house storey. “Okolu house”,
Oke Ado Akintola, Ogbomoso. (Interior view)
Source: Photograph by A.K Ayinla, 2019

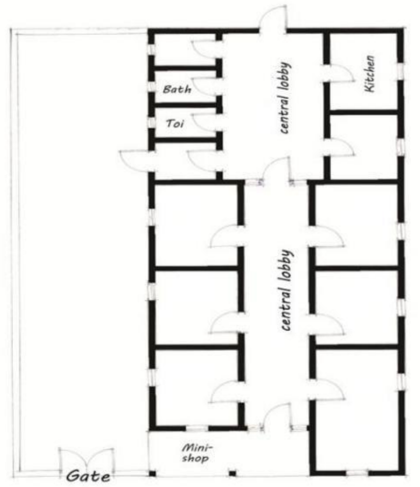

Figure 6: Brazilian rooming house Bungalow. “Serekode house”, Masifa, Ogbomoso

Source: Plan drawing by A.K Ayinla, 2019.

Plate 5: Brazilian rooming house Bungalow. “Serekode house”, Masifa, Ogbomoso (Approach view)

Source: Photograph by A.K Ayinla, 2019

Storey flat and bungalow flat residential building types are completely different from the compound impluvium house and Brazilian rooming house types; privacy and better circulation in the use of spaces are enhanced. This house types are predominantly common in medium and low residential density zones of the selected cities, flat may be of two, three, four or five bedrooms and it is also available as block of flats (more than one), storey or bungalow the number of bedrooms is used to define or denote the apartment. Figures 7 and 8, and Plate 6 shows a typical storey flats in Ibadan (Engineer Agbaje house, Oke Ado, Ibadan). Example of a bungalow flat in Ogbomoso is shown in Figure 9 and Plate 7 (Engineer Adekunle’s house, Low cost area, Ogbomoso).

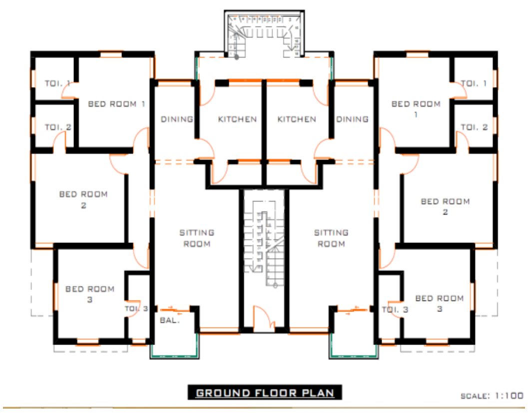

Figure 7:Storey flats “Engineer Agbaje house”,

Figure 8: Storey flats “Engineer Agbaje house”,

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Oke Ado Ibadan. (Ground floor plan) **Oke ado, Ibadan. (First Floor Plan)**

Source: Plan drawing by A.K Ayinla, 2019 Source: Plan drawing by A.K Ayinla, 2019.

Plate 6: A typical Storey flats (Engineer Agbaje house), Oke-Ado, Ibadan. (View 1)

Source: Photograph by A.K Ayinla, 2017.

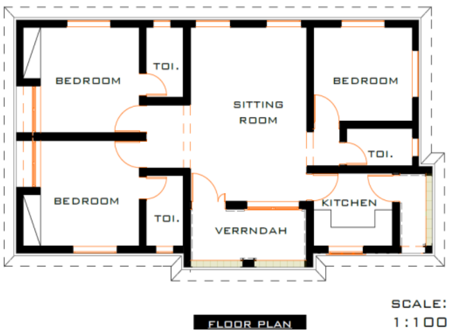

Figure 9: Typical bungalow flat "Engr. Adekunle's house" **Plate 7: Typical bungalow flat "Engr. Adekunle house"**

Low cost area, Ogbomoso. **Low cost area, Ogbomoso**

Source: Plan drawing by A.K Ayinla, 2019. Source: Photograph by A.K Ayinla, 2019

Duplex is a later development over other residential building types in the study area. It is largely used by the elites to cater for their access to more amenities and privacy within the house. It is common in the low residential density zones. In this residential building types, spaces are differentiated with each for specific activity. A distinguished feature

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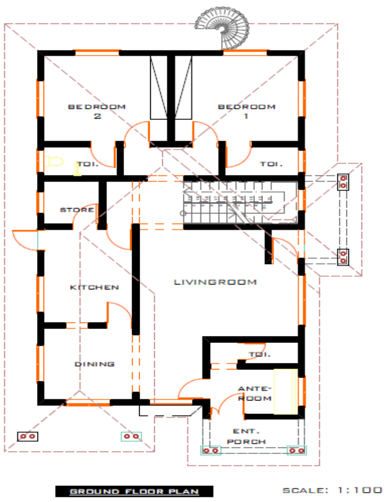
of this residential building type is that, it can be more than a floor which can be connected with staircase. Figures 10 and 11 (Engineer Abdulrasaq house) in Adasobo area, Kisi and Plate 8 (Mr Abiodun Adewale house) in Aduin area, Ogbomoso shows typical duplex in kisi and Ogbomoso. Generally, the distribution of residential building types in the study area was similar to the findings of Ayinla (2011) and Adunola (2011).



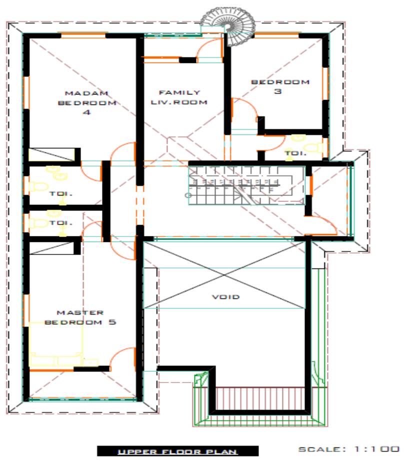


Figure 10: A Duplex house type. Engineer Abdulrasaq house. Figure 11: A Duplex house type. Adasobom area, Kisi
(Ground floor plan) Adasobo area, Kisi. (First floor plan)
Source: Plan drawing by A.K Ayinla, 2019 Source: Plan drawing by A.K Ayinla, 2019

Plate 8: A Duplex house type. (Mr. Abiodun Adewale house), Aduin area,Ogbomoso.
Source: Photograph by Tajudeen Gazali Obasanjo, 2019

Residential Building Forms in the Study Area

The analysis of forms of the buildings as indicated in Table 3 provided a categorization of the buildings into form types. Those with broad and deep interior spaces were 13 (2.2%). Compact buildings were 106 (18.2%), compact with enclosing impluvium courtyard buildings were 79 (13.6%), and linear buildings were 383 (65.9%).

Table 3: Forms of residential buildings in the study area.

City	Residential Building Types	Residential Density Zones			
		High	Medium	Low	Total
Ibadan	Broad Deep Interior Spaces	1(0.4%)	0(0%)	4(1.5%)	5(1.9%)
	Compact Design	8(3.0%)	44(16.6%)	8(3.0%)	60(22.6%)
	Compact Design Enclosing Court Yard	4(1.5%)	3(1.1%)	21(7.9%)	28(10.6%)
	Linear	118(44.5%)	40(15.1%)	14(5.3%)	172(64.9%)
	Sub-Total	131(49.4%)	87(32.8%)	47(17.7%)	265(100%)
Ogbomoso	Broad Deep Interior Spaces	5(2.1%)	2(0.8%)	0(0%)	7(2.9%)
	Compact Design	15(6.3%)	10(4.2%)	5(2.1%)	30(12.6%)
	Compact Design Enclosing Court Yard	12(5.0%)	10(4.2%)	8(3.3%)	30(12.6%)
	Linear	86(36.0%)	63(26.4%)	23(9.6%)	172(72.0%)
	Sub-Total	118(49.4%)	85(35.6%)	36(15.1%)	239(100%)
Kisi	Broad Deep Interior Spaces	0(0%)	1(1.3%)	0(0%)	1(1.3%)
	Compact Design	4(5.2%)	9(11.7%)	3(3.9%)	16(20.8%)
	Compact Design Enclosing Court Yard	18(23.4%)	1(1.3%)	2(2.6%)	21(27.3%)
	Linear	22(28.6%)	15(19.5%)	2(2.6%)	39(50.6%)
	Sub-Total	44(57.1%)	26(33.8%)	7(9.1%)	77(100%)
	Overall Total	293(50.4%)	198(34.1%)	90(15.5%)	581(100%)

Source: Authors' analysis from field data, 2019.

Indoor Environmental Quality Performance of House types and forms in the Study area.

To assess the Indoor Environmental Quality performance of the various house types with different forms in the study area, IEQ calculator described in the methodology was used to describe the IEQ situation in these residential buildings in Ibadan, Ogbomoso and Kisi. The assessment was done during the afternoon period. The afternoon period was chosen because it was established to be discomfort period of the day (Ayinla, 2018). The calculator was expressed with a 5 star bench marking scale of 5 star as the best, 4 star as the above average, 3 star as the average, 2 star as the below average and 1 star as the worst.

The indoor Environmental Quality Performance during the afternoon period in the study area as shown in Table 5 indicated that majority of the house (96.7%), of which, 46.3% were from Ibadan, 41.2% were from Ogbomoso and 12.5% were from Kisi were worst (1 star) in IEQ performance scale. Another 3.1% houses, out of which, 1.4% were from Ibadan, 0.9% were from Ogbomoso and 1.2% were from Kisi were below average (2 star) in IEQ performance scale.

The IEQ performance of houses across the cities of Ibadan, Ogbomoso and Kisi as shown in Table 5 indicated that Ibadan, greater percentage of houses (97.3%) were rated worst (1 star) in IEQ performance scale, out of which, 24.3% were from Brazilian rooming house story, 31.9% were from Brazilian rooming house bungalow, 19.8% were from flats, 15.5% and 5.7% respectively were from bungalow flats and duplex. Another 2.3% houses were below average (2 star) in IEQ performance scale, of which, 1.5% and 0.8% respectively were from Brazilian rooming house bungalow and storey flats. There was only one house (0.4%) among the bungalow flats with best (5 star) in IEQ performance scale.

In Ogbomoso, 9.7% houses were rated worst (1 star) in IEQ performance scale, out of which, 4.7% were from compound impluvium house, 15.5% were from Brazilian rooming house storey, 47.6% were from Brazilian rooming house bungalow, 9.9%, 18.9% and 1.3% respectively were from from storey flats, bungalow flats and duplex. Another 2.1% were below average (2 star) in IEQ performance, of them, 1.3% were from Brazilian rooming house bungalow and 0.4% each were from Brazilian rooming house house storey and storey flats.

The situation in Kisi was similar to what obtained in Ibadan and Ogbomoso, greater percentage of houses (90.8%) were worst (1 star) in IEQ performance scale, of which, 19.7% each were from compound impluvium house and storey flats, 31.6% were from Brazilian rooming house storey, 7.9% each were from Brazilian rooming house bungalow and bungalow flats and 3.9% were from duplex. Another 9.2% houses were below average (2 star) in IEQ performance, out of which, 5.3% were from Brazilian rooming house storey, 1.3% each were from compound impluvium house, Brazilian rooming house storey, 1.3% each were from compound impluvium house, Brazilian rooming house bungalow and storey flats.

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Table 5: Indoor environmental quality calculator (Afternoon)

City	Residential Building Types	IEQ Performance (Morning) (%)					Total (%)
		Worst (1 star)	Below Average (2 star)	Average (3 star)	Above average (4 star)	Best (5 star)	
Ibadan	Compound impluvium house	-	-	-	-	-	-
	Brazilian rooming house storey	64 (24.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	64 (24.3%)
	Brazilian rooming house bungalow	84 (31.9%)	4 (1.5%)	0 (0%)	0 (0%)	0 (0%)	88 (33.5%)
	Storey flats	52 (19.8%)	2 (0.8%)	0 (0%)	0 (0%)	0 (0%)	54 (20.5%)
	Bungalow flats	41 (15.6%)	0 (0%)	0 (0%)	0 (0%)	1 (0.4%)	42(16.0%)
	Duplex	15 (5.7%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	15 (5.7%)
	Sub-Total	**256(97.3%)**	**6 (2.3%)**	**0 (0%)**	**0 (0%)**	**1 (0.4%)**	**263 (100%)**
Ogbomoso	Compound impluvium house	11 (4.7%)	0 (0%)	0(0%)	0(0%)	0(0%)	11 (4.7%)
	Brazilian rooming house storey	36 (15.5%)	1 (0.4%)	0(0%)	0(0%)	0(0%)	37 (15.9%)
	Brazilian rooming house bungalow	111(47.6%)	3 (1.3%)	0(0%)	0(0%)	0(0%)	114 (48.9%)
	Storey flats	23 (9.9%)	1 (0.4%)	0(0%)	0(0%)	0(0%)	24 (10.3%)
	Bungalow flats	44 (18.9%)	0 (0%)	0(0%)	0(0%)	0(0%)	44 (18.9%)
	Duplex	3 (1.3%)	0 (0%)	0(0%)	0(0%)	0(0%)	3 (1.3%)
	Sub-Total	**228(79.9%)**	**5 (2.1%)**	**0(0%)**	**0(0%)**	**0(0%)**	**233 (100%)**
Kisi	Compound impluvium house	15 (19.7%)	1 (1.3%)	0(0%)	0(0%)	0(0%)	16 (21.1%)
	Brazilian rooming house storey	24 (31.6%)	4 (5.3%)	0(0%)	0(0%)	0(0%)	28 (36.8%)
	Brazilian rooming house bungalow	6 (7.9%)	1 (1.3%)	0(0%)	0(0%)	0(0%)	7 (9.2%)
	Storey flats	15 (19.7%)	1 (1.3%)	0(0%)	0(0%)	0(0%)	16 (21.1%)
	Bungalow flats	6 (7.9%)	0 (0%)	0(0%)	0(0%)	0(0%)	6 (7.9%)
	Duplex	3 (3.9%)	0 (0%)	0(0%)	0(0%)	0(0%)	3 (3.9%)
	Sub-Total	**69(90.8%)**	**7 (9.22%)**	**0(0%)**	**0(0%)**	**0(0%)**	**76(100%)**
	Overall Total	**553(96.7%)**	**18 (3.1%)**	**0 (0%)**	**0 (0%)**	**1 (0.2%)**	**572(100%)**

Source: Authors' analysis from field data, 2019

However, the quality of indoor environment with respect to the house forms in the study area as shown in Table 6 indicated that the majority of the houses (76.6%), of which, 57.3%, 12.2% and 7.1% respectively were linear, compact design and Compact Design with courtyard felled below average IEQ performance scale (2 star). Another 11.3% were worst (1star), out of which, 5.21% were of compact design form, 2.26% houses were linear and 1.9% each were with broad deep interior spaces and Compact design with courtyard in their form. The houses with average IEQ performance (3 star) were 9.2%, of which, 4.5%, 3.6% and 1.0% respectively were of Compact design with courtyard, linear, and compact design forms. Those houses with above average (4 star) IEQ performance were 2.3% with 1.1% each were compact design and linear in form, while 0.2% were compact design with courtyard in their form. The houses with the best IEQ performance rating (5 star) were 0.7% with all in linear form.

Residential building Forms	**IEQ Performance (Morning) (%)**					**Total (%)**
	Worst (1 star)	**Below Average (2 star)**	**Average (3 star)**	**Above average (4 star)**	**Best (5 star)**	
Broad Deep Interior Spaces	11(16.9%)	0(0%)	0(0.0%)	0(0.0%)	0(0.0%)	5(1.9%)
Compact Design	30(46.0%)	70(15.9%)	6(11.30%)	6(46.2%)	0(0.0%)	60(22.8)
Compact Design with courtyard	11(16.9%)	41(9.4%)	26(49.1%)	1(7.7%)	0(0.0%)	28(10.6%)
Linear	13(20.0%)	330(74.8%)	21(39.6%)	6(46.2%)	4(100.0%%)	170 (64.6%)
Total	**65 (11.3%)**	**441(76.6%)**	**53 (9.2%)**	**13(2.3%)**	**4(100.%)**	**576 (100%)**

Table 6 : Indoor environmental quality Performance of house forms
Source: Authors' analysis from field data, 2019

CONCLUSION AND RECOMMENDATION

The preponderant residential building types in the three cities were Brazilian rooming house bungalow (36.4%), Brazilian rooming house storey (22.3%), storey flats (16.9%), bungalow flats (15.9%), compound impluvium house (4.8%) and duplex (3.6%). These residential building types were formed in to buildings with deep interior (2.2%), compact buildings (18.2%), compact with enclosing courtyard buildings (13.6%) and linear buildings (65.9%). Results from the IEQ performance rating indicated that majority of the houses were worst (1 star) in IEQ performance scale. The implication was that these houses were below average in terms of indoor environmental quality performance. The house form with the best IEQ performance was the linear form, follow by the compact design with courtyard, then the compact design,while the form with the worst IEQ performance was the broad deep interior spaces.

Arising from this findings, it is being recommended that the need to give more attention to indoor environmental quality especially at the conceptual stage of any residential building designs. Furthermore, flats with linear form is being recommended as the best combination for attainment of indoor environmental quality in the study area and contexts similar to it.

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