A SURVEY OF SMARTPHONE-RECORDED OUTDOOR NOISESCAPE AT THE 1000-HOUSING ESTATE, MAIDUGURI, BORNO STATE, NIGERIA.

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ABSTRACT
The outdoor noisescape noise levels of weekday, weekend and week components of the two sites at the 1000-Housing Estate, Maiduguri, Borno State, Nigeria were recorded with a smartphone installed with sound pressure level SPL software. Recordings were made at the top of the hour for the first location and at the half hour mark for the second location from 0600 to 2400 for three separate weeks in March, May and June 2021. It was observed that commencing from 1500, the evening weekday noisescape rises from 73.7 dBA to an evening peak of 81.7 dBA between 1600 and 1800. This rise is attributed to higher foot and vehicular traffic transiting the estate as school children and working residents return home from their daily schedules. Contribution from the highway is significant as commuters try to beat the 1800 security closure of the highway. The pattern gradually drops from the evening peak to 80.9 dBA by 2000 and 79.1 dBA by 2100. These results show that the deduced noisescape patterns at the two sites were above the EPA limits of 50 dBA for mornings and 35 dBA for evenings, rise from early morning low to reach peaks at about noon, which thereafter decline to afternoon lows. A substantive amount of the outdoor noisescape noise levels is attributed to the vehicular traffic on the Maiduguri – Damaturu highway. Thus, the contribution of highway traffic is approximately estimated to vary from 5.3 dBA at noon, to 21.9 dBA in the afternoon and 2.7 dBA late in the evening.

Keywords: Survey, Outdoor Noisescape, 1000-Housing estate, Maiduguri.

INTRODUCTION

Noise is the sum total of all the unwanted sounds encountered within a particular environment. Sound is the objective function of the air pressure variations set into vibrations by all the human and nonhuman activities in and around the environment. Noisescape gives a schematic representation of the time variation of the background noise in an environment over which additional sounds are superimposed. Noise does not only disturb sleep, interrupt conversation, and create stress and annoyance in the general, it also reduces the efficiency and output of workers as well (Sinha and Sridharan, 1999). The noise impacting an environment changes with time, depending on the activities occurring within the environment and its surroundings. These activities are both human, (like human foot and vehicular traffic, normal conversation between individuals, media entertainment etc) or non-human (like the rustle of wind-blown tree branches/leaves, singing of birds on trees or flying, or other domesticated animals). Other noises emanate from electrical appliances such as air conditioners, ceiling fans, and electric power generator etc. To mitigate the adverse effects of noise in Nigerian, the National Environmental (Noise Standards and Control) Regulations 2009 fixed that for daytime (0600 to 2200) and night time (2200 to 0600), noise limits in residential buildings must not exceed 50dBA and 35 dBA respectively. The measurement of noise for the purpose of environmental assessment including livability is achieved using a sound level meter whose functionalities and performances are specified by the International Electro-technical Commission, IEC 61672-1, 2013 and the American National Standards Institute, ANSI, S1.4/Part1, 2014. These specifications are matched by handheld smartphones, both android- and the iOS-operated systems that have computing powers comparable to those of desktop computers. Sound is measured using either

their built-in or externally connected microphones. Aumond et al., (2017) and Celestina et al. (2018) considered the devices adequate for noise monitoring and measurement under specific conditions.

This study investigates the outdoor noise levels at two points located within the 1000-Housing Estate, Maiduguri with the aim of understanding its pattern and eventually mapping the noisescape. The 1000-Housing Estate was established between 2009 and 2010, comprising 1000 houses, as a medium density accommodation for mainly government employees and a few indigenes of the state. The houses comprise 1-, 2-, 3- and 4-bedroom flats, some with servants (boys) quarters. The estate is situated along the Maiduguri – Damaturu highway. It therefore has significant vehicular traffic, both morning and early evening. Recent security challenges in the northeastern region of the country have resulted in the restriction of entry into the town on this road between 1800 and 0800 daily. Due to the epileptic supply from the mains, most residents use electricity generating sets. A limited number of houses additionally generate their electricity via solar power. Typically, generator electricity is deployed between 1800 and 2300. A private nursery/primary school with play ground caters for the children of residents as well as from surrounding suburbs. Numerous mosques with public address systems are scattered across the estate with a Friday weekly mosque about 750 m to the west of the estate outside it walls. The runway of the Maiduguri Airport is about 2 km to the east.

METHODOLOGY

Two locations were selected for the measurement of noise in the 1000-Housing Estate. These are the entry gate, marked as S1, and the Roundabout, marked as S2 (Fig. 1). Location S1 was selected in order to capture the influence of the heavy vehicular traffic passing by as well as the human and vehicular traffic entering and exiting the estate. It is about 30 m from the highway. Two-minute duration recordings were made at the top of the hour for every hour from 0600 to 2400. The second location, S2, is about 750 m from S1. This was selected far into the estate to capture noise mostly coming from within the estate. A two-minute recording was made at the half-hour mark from 0630 to 2330. The recordings were made with a Techno® model KB7 Spark 3 smartphone installed with a sound pressure level software application. The Keuwlsoft® SPL meter, version 2.9.5 was downloaded from the Google® Playstore®. Recordings were made for three weeks, between 16th and 22nd March, 5th and 11th May, and 8th and 14th June, 2021. The slow, L_{A10}, the fast, L_{A90}, and the average, L_{AEq} components of the noise signal were recorded (Tables 1).

Fig. 1. The 1000-Housing Estate showing the perimeter wall (red outline) and recording points S1, the Gate, and S2, the Roundabout.

RESULTS AND DISCUSSION

Table 1. Average components of the noise signals recorded at Site 1, the Gate, and Site 2, the Round About of the 1000-Housing Estate, Maiduguri. Data recorded between 16th to 22nd March, 5th to 11th May, and 8th to 14th June, 2021.

Site 1	Site 2						
Time	LA10	LAEq	LA90	Time	LA10	LAEq	LA90
600	38.6	49.7	56.1	630	43.7	54.4	62.4
700	50.6	61.6	67.9	730	48.3	56.1	64.7
800	53.0	64.3	72.1	830	50.7	61.1	70.1
900	54.6	67.3	73.6	930	51.9	64.0	70.4
1000	58.3	69.3	75.0	1030	38.7	46.7	60.7
1100	55.4	67.3	75.3	1130	35.3	40.6	54.6
1200	57.6	67.6	75.3	1230	35.7	41.7	58.1
1300	51.3	62.1	72.6	1330	41.7	50.6	64.1
1400	52.3	62.1	72.1	1430	47.6	55.9	65.4
1500	54.3	64.1	71.7	1530	51.9	64.4	71.0
1600	57.9	67.4	75.7	1630	53.0	66.3	73.6
1700	57.0	69.0	77.3	1730	51.7	63.1	71.0
1800	55.7	66.6	73.1	1830	50.4	58.7	68.9
1900	54.1	68.3	75.9	1930	50.9	59.6	68.0
2000	51.3	66.4	74.4	2030	52.0	57.1	68.4
2100	53.0	65.0	74.0	2130	45.9	54.4	65.6
2200	46.4	56.9	64.1	2230	33.3	37.3	46.7
2300	41.0	50.7	57.6	2330	27.3	31.1	41.1
2400	25.9	30.3	37.0				

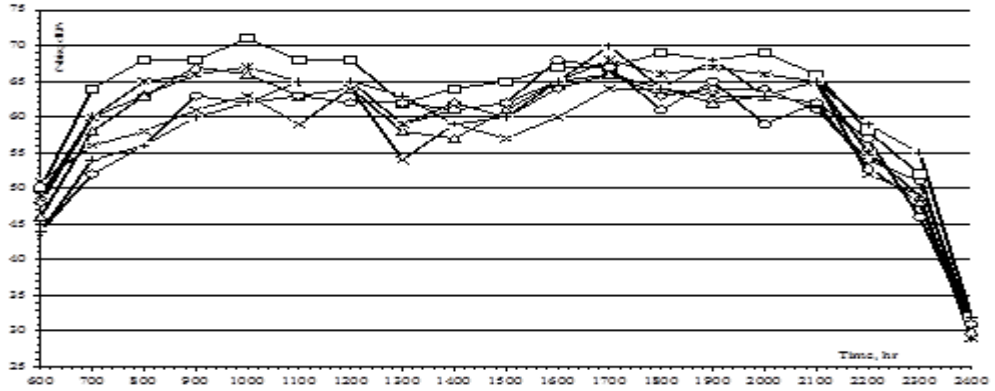
The data was checked for the occurrence of possible unusual noises from events such as political rally, wedding party etc capable of producing a spike. The graphs of L_{AEq} for the two recording sites, Figs. 2a and b, show the level of consistency exhibited by the data. Data from Site 1 show scatter between 0700 and 1200 while data from Site 2 exhibit scatter at 0630 and 1930. Plots of the three noise components (Figs. 3a and b) show the data being coherent, with the slow, L_{10}, and fast, L_{90}, components evenly enveloping the average component, L_{AEq}. The results were in agreement with that of Shallangwa et al., (2019). Table 2 gives the adjusted weekday, weekend and week averaged data. Fig. 4a gives the weekday (black), weekend (red) and week (blue) noisescape patterns for Site 1, the gate of the estate. The defined weekday noisescape consists of two sections, the morning and evening sections. The morning noisescape rises from 63.7 dBA, between 0600 and 0700, well above the EPA set limit of 50 dBA, to a late morning peak of 82.9 dBA between 1000 and 1100. The rise is attributed to residents waking up, performing their morning chores of devotion, bathing and breakfasting. It is however principally attributed to residents moving out of the estate in private cars and commercial tricycle transportation means, and on foot, to drop off school children and working spouses, as well as residents going out for commercial and other activities. It also receives contribution from vehicular traffic on the main thoroughfare to and from the town, the Maiduguri – Damaturu highway. The morning pattern thereafter gradually drops from the peak to 73.7 dBA between 1300 and 1500. The drop is attributed to reduced foot and vehicular traffic transiting the estate, but with the

contribution from vehicular traffic from the highway persisting.

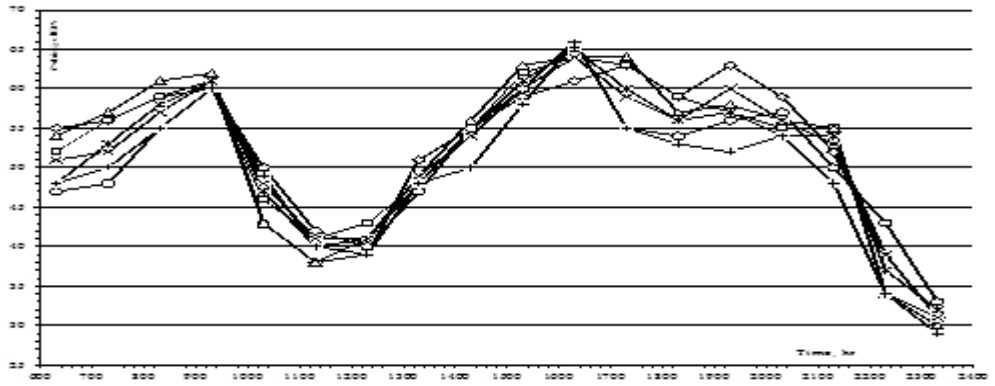
Table 2. Adjusted average weekday, WkDy, weekend, WkEd and week noise levels at Site 1, the Estate Gate, and Site 2, the Round About.

Site 1, Noise Level, dBA				Site 2, Noise Level, dBA			
Time	WkDy	WkEd	Week	Time	WkDy	WkEd	Week
0600	63.7	59.2	62.4	0630	68.1	64.7	67.1
0700	76.1	69.7	74.3	0730	70.5	64.7	68.8
0800	79.3	71.2	77.0	0830	74.9	71.2	73.8
0900	81.3	76.7	80.0	0930	77.3	75.2	76.7
1000	82.9	79.7	82.0	1030	58.1	62.7	59.4
1100	79.7	80.7	80.0	1130	52.5	55.2	53.3
1200	80.3	80.2	80.3	1230	54.5	54.2	54.4
1300	74.1	76.7	74.8	1330	63.7	62.2	63.3
1400	75.3	73.7	74.8	1430	69.9	65.2	68.6
1500	77.5	75.2	76.8	1530	77.5	76.2	77.1
1600	79.9	80.7	80.1	1630	78.1	81.2	79.0
1700	81.5	82.2	81.7	1730	77.5	71.7	75.8
1800	80.7	75.7	79.3	1830	72.1	69.7	71.4
1900	80.9	81.2	81.0	1930	73.3	69.7	72.3
2000	81.1	74.2	79.1	2030	69.3	71.2	69.8
2100	79.1	74.2	77.7	2130	68.3	64.2	67.1
2200	70.3	67.7	69.6	2230	48.9	52.7	50.0
2300	63.7	62.7	63.4	2330	43.9	43.7	43.8
2400	42.9	43.2	43.0				

Commencing from 1500, the evening weekday noisescape rises from 73.7 dBA to an evening peak of 81.7 dBA between 1600 and 1800. This rise is attributed to higher foot and vehicular traffic transiting the estate as school children and working residents return for the end-of–the-day official engagement. A sizeable number of residents also exit the estate for social and other activities as well as visits from outsiders for similar activities. Contribution from the highway also persists as commuters try to beat the 1800 security closure of the highway. The pattern gradually drops from the evening peak to 80.9 dBA by 2000 and 79.1 dBA by 2100. Within this time interval, transit into and out of the estate as well as other noise generating activities within the estate persists, and the drop is attributed to mainly the absence of the contributions from the highway. The pattern thereafter rapidly drops to 70.3 dBA by 2100, 63.7 dBA by 2300 and 42.9 dBA by 2400. This is still above the EPA limit for night. The rapid decline is attributed to residents retiring at the end of the day, with exited residents returning while visitors to the estate exit. The absence of contribution from the highway still persists.

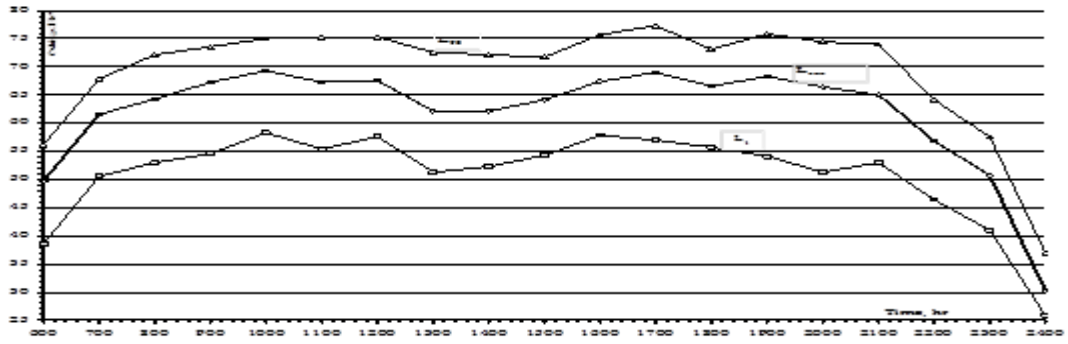


a.



b.

Fig. 2. Plot of L_{AEq} for (a) Site 1 and (b) Site 2 exhibiting consistency.



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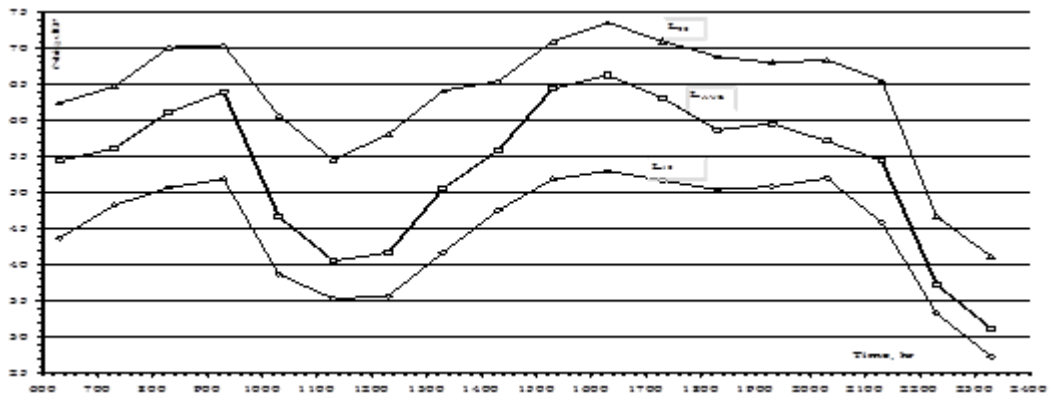


b.

Fig. 3. Plots of the slow, L_{A10}, the average, L_{AEq} and the fast, L_{A90}, components of the noise signal for (a) Site1 and (b) Site 2 showing data coherency.

The weekend noisescape pattern reveals a similarity with the weekday pattern, also consisting of a morning peak separated from an evening one by a much deeper afternoon decline. Compared to the weekday pattern which starts 63.7 dBA, it starts at a lower value of 59.2 dBA between 0600 and 0700 which rises to a peak of 80.7 dBA between 1000 and 1200. This rise is attributed to similar activities as for the weekday pattern but at lower magnitude, mainly reduced transit into and out of the estate in the absence of school and official work, indicative of restfull weekends.

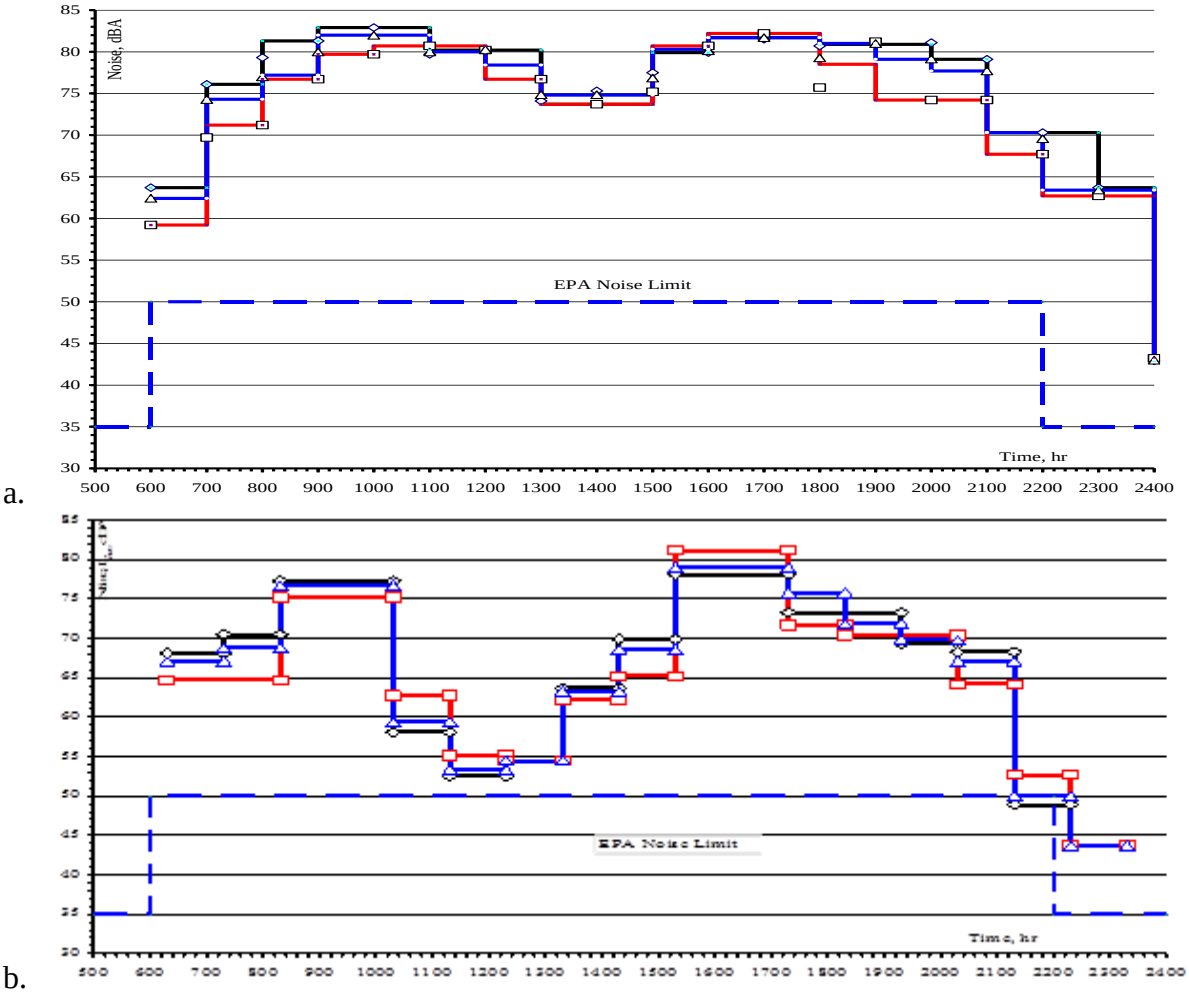


Fig. 4. Noisescapes at (a) Site 1, Gate of the 1000-Housing Estate and (b) Site 2, Round About, centre of the housing estate. Black and red lines are the weekday and weekend patterns respectively, while blue lines are for the whole week. Broken blue plot is the EPA noise limit.

The pattern drops between 1200 and 1500. This is attributed to reduced intra-estate transit at the middle of the day. This drop is less than that for weekday, and signifies that there is more active weekdays in comparison to weekends. From 1500, the weekend pattern rapidly rises to reach an evening peak of 82.2 dBA between 1600 and 1800. This is higher than the weekday evening peak, and is attributed to higher transit activities at the estate as the residents utilize the weekend for more

social rather than formal activities. The contributions from the highway persist as the entry and exit into the town is only closed at 1800. The pattern gradually declines from the peak to 74.2 dBA between 1900 and 2100, and more rapidly thereafter to 43 dBA at midnight as residents retire for the end of the day.

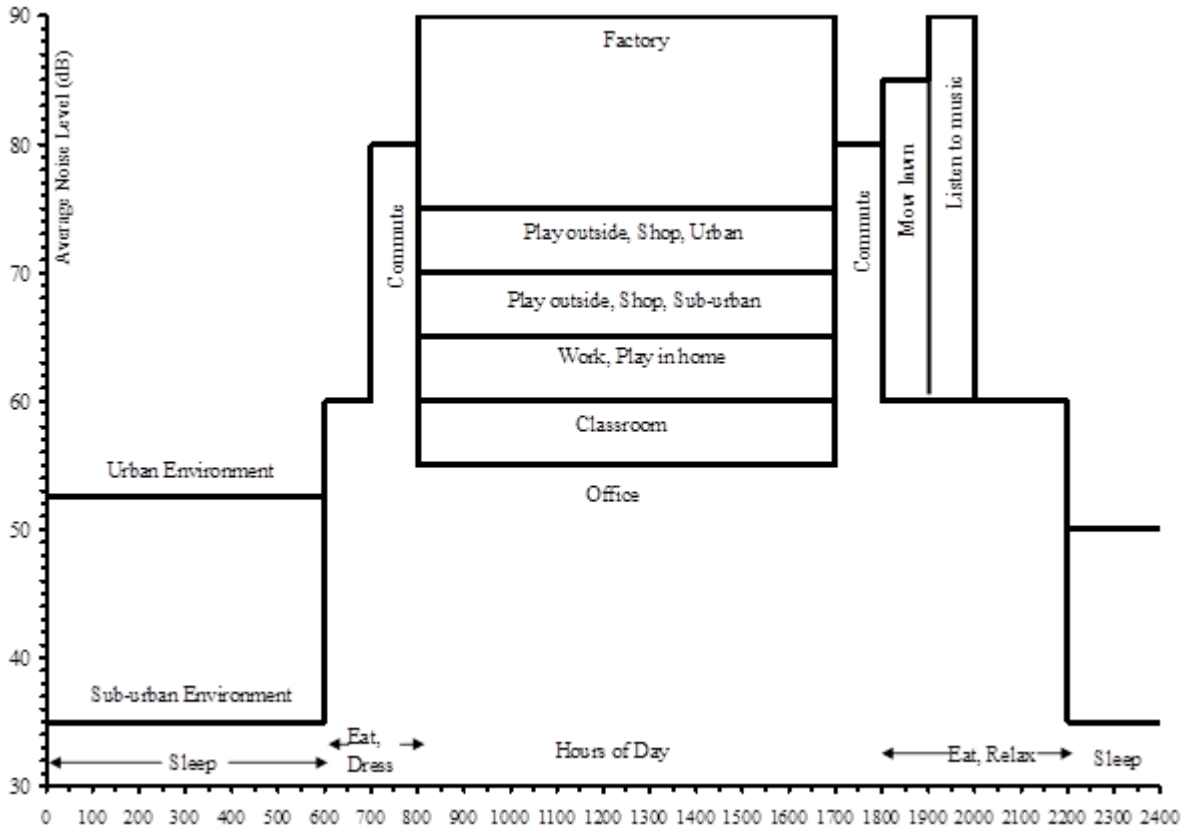
The week noisescape follows a mid-course pattern between the weekday and weekend patterns. It shows a persisting noisescape that exceeds the EPA limit from as early as 0600 to 2400. Fig. 4b gives the weekday (black), weekend (red) and week (blue) noisescape patterns for Site 2. Although the three patterns broadly appear similar to those observed at Site 1, displaying a late morning peak separated from an evening peak by a midday decline, they differ slightly in a few aspects. While the three patterns at Site 2 start at 64.7, 67.1 and 68.1 dBA respectively, those at Site 1 start at lower values of 59.2, 62.4 and 63.7 dBA. This is attributed to closer proximity of Site 2 to the sources of the noise compared to Site 1. Contributions coming from the highway are low on the account of lower morning traffic. Secondly, while the weekend pattern at Site 1 is only higher than the weekday pattern between 1100 and 1200, and between 1500 and 1800, the weekend pattern for Site 2 is higher than the weekday pattern between 1030 and 1230, 1530 and 1730, 1930 and 2030, and between 2130 and 2230. This is attributed to more social activities that are noise generating at weekends than at weekdays, and which extend late into the evening. Next, the midday decline in the noisescape patterns for this site is deeper compared to that of Site 1. This decline is attributed to the cessation of many of the usual activities residents are engaged in, indicative of a more restfull environment. Lastly, while the two peaks from Site 1 are nearly equal, indicative of equivalent levels of noise generation, the evening peaks at Site 2 is higher the morning peak. This is attributed to more social activities that generate noise, which gradually decline till 2130, as well as to the absence of traffic from the highway closed for the night. From 2130 the noisescape sharply declines to 43.7 dBA as residents end the social activities and retire for the day. Finally, comparison of the peaks and declines at the two recording sites allows the impact of the traffic from the highway on the noisescape to be estimated. These amounts to 5.3 dBA at noon, about 21.9 dBA in the afternoon and 2.7 dBA in the evening.

The weekday, weekend and week noisescapes mapped for the two sites in the 1000-Housing Estate exhibit certain similarities with those for urban and suburban environments mapped by the US EPA (US EPA, 1981). Both show two peaks periods separated by decline (Fig. 5). While the decline in the case of the latter occurred in the early evening, those of the former occur in the afternoon. The US EPA patterns however appears to define only the broad outlines of the noisescapes while the patterns for the 1000-Housing Estate shows more details. Although defined from hourly data captured in two-minute windows that fall short of five-minute window determined to be optimum (Lavandier and Barbot, 2003), the details the noisescapes indicate that the used timing window are still able to define the observed features.

The mapped noisescape patterns also show similarities with patterns for three students' hostels in the University of Maiduguri determined from hourly data recorded in similar two-minute windows by Ashalva et al., (2021). These also show two peaks separated by afternoon declines. While all the evening peaks at the hostels and at Site 2 are higher than the morning peaks, the two peaks of Site 1 are nearly

equal. This is likely the impact of the traffic noise from the highway.

Although the noise limits are exceeded at the two recording sites, the situations within the residents are dependant on whether or not the openings to the residents are opened or closed, and if closed, the situation will additionally depend on the materials of the panelings used on the openings, as attenuation of outside noise will depend on these materials. With appropriate paneling therefore, it is possible to achieve the limit noise levels within residents in the estate. Glass and wood, the most common paneling materials, have attenuations of 2.6 and 3.8 % respectively (Stanciu, et al., 2011). These would attenuate the peak noisescapes of 82 and 79 to 79.87 and 76.00 dBA within the rooms. A flush door with double wood panel would attenuate the midnight noisescape of 43 to 39.79 dBA well above the 35 dBA limit.



By comparing results obtained to that of a standard SPL meter the precision and accuracy of the smartphone and the attached microphone can be ascertained and monitored.

The noisescape patterns defined here for the two outdoor locations determine the livability of the estate. Even though the noisescape determined exceeds the regulatory set limit, measurements within the houses practically assesses the livability in the estate. Furthermore, many more recording locations both outdoor and indoor are more likely to bring out more detail noisescape patterns of the estate and highlight any variations that may exist.

CONCLUSION

The outdoor noise patterns at two locations at the 1000 Housing Estate were surveyed using a smartphone device. Three components of noise signal were estimated from the data, namely, the weekday, weekend and week noisescape patterns, and all three components show that the pattern can be divided into two parts, the morning and evening patterns, and that grown and decline. The weekday patterns differ from the weekend patterns – the morning pattern is higher than the evening pattern. The noisescape pattern defined from the data rises from 62.4 dBA at 0600 to a peak of 82 dBA between 0900 and 1100. The rise is attributed to such activities of the residents of the estate performing morning domestic chores, commuting from the estate in private and commercial transportation means and on foot, to drop off school children and working spouses, for commercial and other activities, with contributions from vehicular traffic on the Maiduguri – Damaturu highway. The slight drop of the pattern to 74.8 dBA between 1300 and 1500 is attributed to reduced foot and vehicular traffic transiting the estate, but with the contributions highway persisting. The second rise of the noisescape pattern reaching a lower peak of 81.7 dBA between 1400 and 1800 is accredited to (i) higher foot and vehicular traffic transiting the estate as school children and working residents return (ii) residents and visitors transiting the estate for social and other activities (iii) persistent traffic as commuters try to beat the 1800 security closure of the highway. The noisescape thereafter declines and reaches 43 dBA at 2400 as residents end social engagements and retire for the day. At the Roundabout, deep within the estate, the outdoor pattern varies in similar manner as at the gate, with magnitudes of contributions from activities and their time lines differing. The similarities is attributed the same activities as at the gate. The contributions of the activities occurring at the gate and the highway on the noisescape recorded at the Roundabout are muted. Similarly, the impacts of the activities occurring within the estate are muted at the gate. This allows the contribution of traffic on the highway to be estimated. They vary from 5.3 dBA at noon, to about 21.9 dBA in the afternoon and 2.7 dBA late in the evening.

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