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Research Article

Spatial-Temporal Differentials in Traffic and Music Generated Noise at Selected Sites in Kisumu City, Kenya

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Abstract

Despite its well-documented effects on health and wellbeing, noise remains one of the most poorly regulated type of pollution in African cities. Some studies have shown that automobiles and music stores are among the leading sources of noise pollution in African urban centers with equivalent sound pressure levels largely exceeding regulatory limits. These elevated noise levels exposes the public to auditory and non-auditory effects that impair health and quality of life. Regardless, research on road traffic and music-generated noise remain scarce in Kenya and Africa at large. This study sought to assess noise associated with traffic and music at 50 purposively selected sites in Kisumu city, Kenya. Sound Pressure Levels (SPL) were measured using EXTECH® digital sound level meter, recorded in a data sheet and analyzed descriptively on SPSS version 23. Results showed that the mean traffic-generated noise was 70.39 ± 10.10dBA, while music-generated noise was 86.35 ± 6.92dBA. Independent sample t-test showed that the mean SPL for music was significantly higher than traffic. There was considerable variability in traffic noise by site with highways having highest (76.25 ± 5.42dBA) followed by roundabouts (75.0 ± 4.97 dBA) and lastly by termini (71.60 ± 4.81dBA). Noise at resting parks varied with distance from high traffic zones. Both vehicular and music-related noise exceeded maximum permissible limits, but music-related noise was significantly higher than vehicular noise.

Keywords: Traffic; Noise; Music; Kisumu; Spatial

1. Introduction

Developing countries have been experiencing exponential growth in urbanization. Incidentally characteristic of industrialized countries, the phenomenon has shifted substantially to low and middle income countries [1]. This growth is not without negative consequences. In Africa, it is posited that rapid urbanization has become a threat to sustainable development due in part to rising pollution and unregulated informal economy [2].

Despite its well-documented effects on health, noise remains one of the most unregulated and disregarded types of pollution especially in developing countries [3]. The phenomenon is particularly of concern in urban Africa due to social and traffic-related noise compounded by poor noise regulation [4, 5].

Automobiles and music stores are among the leading sources of noise pollution in African urban centers. A study by Ebare et al (2011) [6] in a Nigerian city found that more than 90% of music stores generated noise levels exceeding 85 dB while Oyedepo and Saadu (2009) [7] reported that busy roads were the second-highest polluted acoustic environment after industrial areas, with sound pressure levels exceeding 90 dB(A). Elsewhere, Zaki (2012) [8] reported that ambient noise levels were highest in high-traffic density streets of Egypt.

These elevated noise levels have been associated with increased cardiovascular morbidity and mortality in the general population [9], increased adiposity and other markers of obesity [10, 11], risk of mortality from type 2 diabetes (12), respiratory mortality [12, 13] hearing impairment [14], hypertension [15] and other auditory and non-auditory effects [16, 17].

Exposure generally varies with time and place [18, 19] with roads and commercial areas being among the worst polluted and significant differences observed between diurnal and nocturnal sound pressure levels [20, 21]. Other factors affecting variability include prevailing meteorological conditions, road surface texture, gradient and circumambient topography; vehicle types, ages, speed, volume, break type, horns sound pressure, goods transported and driver behavior [15, 22].

Despite its importance to public health research on road traffic and commercial noise are rare in Africa and particularly Kenya. A literature search on PubMed (with search phrases *road traffic noise Africa* and *road traffic noise Kenya*) returned a few publications for Africa [7, 8, 23, 24] but none for Kenya. The alternative, but rather general search phrase, "urban noise Africa", returned slightly more publications but only six were relevant and most of these representing only one country-Nigeria [4-6, 25-27].

Narrowing the search phrase to *traffic noise Kenya* revealed a few more hits [3, 28]. Wawa and Mulaku (2015) [3] mapped environmental noise in Nairobi and listed road traffic among the leading noise sources but did not report corresponding noise levels while Goshu and colleagues (2017) [28] evaluated extent of in-vehicle music-related noise pollution in Nairobi and reported all exceeded local regulatory limits.

Surprisingly, no studies were found for Kisumu City, despite it being the third-largest in Kenya with considerably high traffic. Moreover, anecdotal evidence suggested high noise emanating from music stores and churches within the city. Against the backdrop of public health concern and paucity of literature, this study assessed geospatial distribution of traffic and music-related noise from selected sites in the Kenyan city of Kisumu.

2. Materials and Methods

2.1 Study area and design

Adopting descriptive cross-sectional design, the study was conducted in Kisumu city, the third-largest city in Kenya after Nairobi and Mombasa. Noise assessments were done at 50 purposively selected high traffic areas and noise-prone music centers within the city's CBD. Study locations were tagged with GPS coordinates using an android GPS application (*Mobile Topographer*, version 9.0.0) and the predominant noise source along with prevailing geospatial features in the area noted for further characterization of the sites.

2.2 Data collection and analysis

Noise assessments were taken as close to source as practicable without attracting undue attention using a factory calibrated EXTECH® digital sound level meter (model 407732). For traffic noise, 20 roadside readings of continuous A-weighted equivalent sound pressure levels ($\mathbf{L_{Aeq}}$) were recorded per site. The readings were captured as vehicles passed or in the case where traffic was continuous at intervals of 15-20 seconds.

For music-related noise 20 continuous A-weighted equivalent sound pressure level ($\mathbf{L_{Aeq}}$) readings were recorded at intervals of 15-20 seconds per site. Music-related noise were measured at music stores, promotional campaigns, inside public service vehicles and churches. Noise data was collected at mid-morning, afternoon and evening hours as these timelines corresponded with traffic volumes.

The data was analyzed on SPSS version 23. Arithmetic means with standard deviations and 95% confidence intervals were calculated and compared (Single-sample t-test, Independent sample t-test and One-way ANOVA with Games-Howell post hoc) across categories of sources and data presented on graphs and tables.

3. Results

3.1 Levels of traffic and music-related noise

Source	n	Mean (dBA)	STD	Min	Max
Traffic					
Highway	220	76.2500	5.42666	66.00	104.00
Parks	120	54.0667	5.13308	44.00	66.00
Roundabout	120	75.0000	4.97895	66.00	94.00
Terminus	100	71.6000	4.81580	65.00	87.00
Overall	560	70.3982	10.10289	44.00	104.00
Music					
Music stores	380	85.8211	6.73898	73.00	107.00
Church	20	98.500	.82717	97.00	100.00
In-vehicle	40	85.400	4.3133	77.00	94.00
Overall	440	86.3591	6.92381	73.00	107.00

Table 1: Levels of noise associated with traffic and music in Kisumu City.

As indicated in table 1 the mean (arithmetic) traffic-related noise was (70.3982 dBA). Further, the results of one-sample t-test indicated that mean (arithmetic) traffic noise was significantly higher than NEMA's stipulated (60dBA) value for commercial zones (t=24.35, df=559, p=0.000).

Music sources generated very high levels of noise and in many cases exceeded 100 dB(A). The most notorious being music stores (107dB LAmax) and church music (100dB LAmax). The Mean Music-related noise (**86.3591**dBA**)** was also significantly higher than NEMA's threshold (t= 79.857, df= 439, p=0.000) as per the results of single-sample t-test.

3.2 Spatial differentials in noise levels

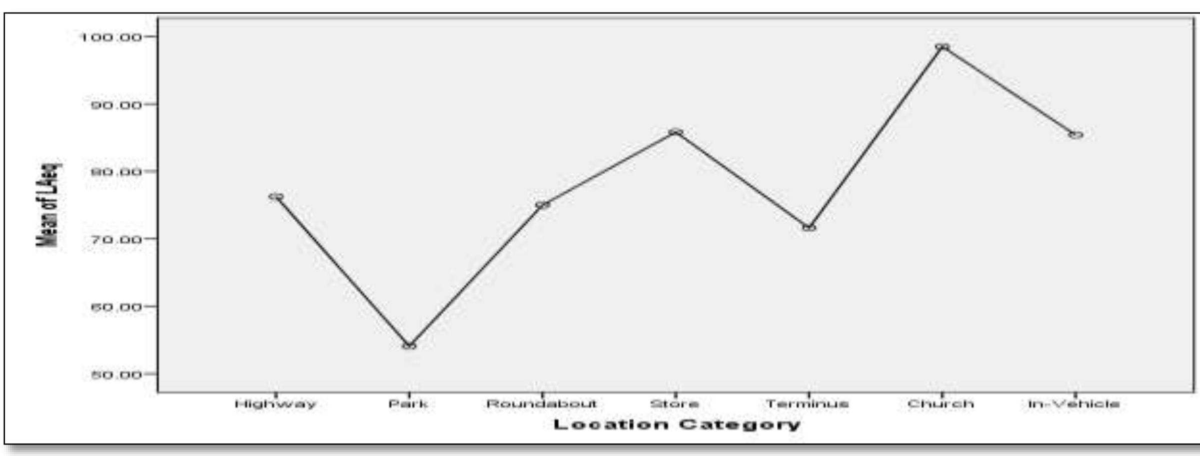

Figure 1: Means plot of noise levels across sites.

As illustrated (Figure 1) resting parks recorded the lowest noise levels, while the highest noise was associated with religious music. However, levels of noise at resting parks (Figure 2) also varied with proximity to CBD with the closest to the CBD (Oile) recording the highest mean SPL (61.20 ± 2.19089, CI: 60.175 - 62.225) and the farthest (Victoria) recording the lowest (46.75 ± 1.37, CI: 46.108 - 47.392). One-way ANOVA with multiple pairwise comparisons (table 2) revealed that the means differed significantly across all parks except Barclays-Aga Khan pair (F = 219.781, p = 0.000).

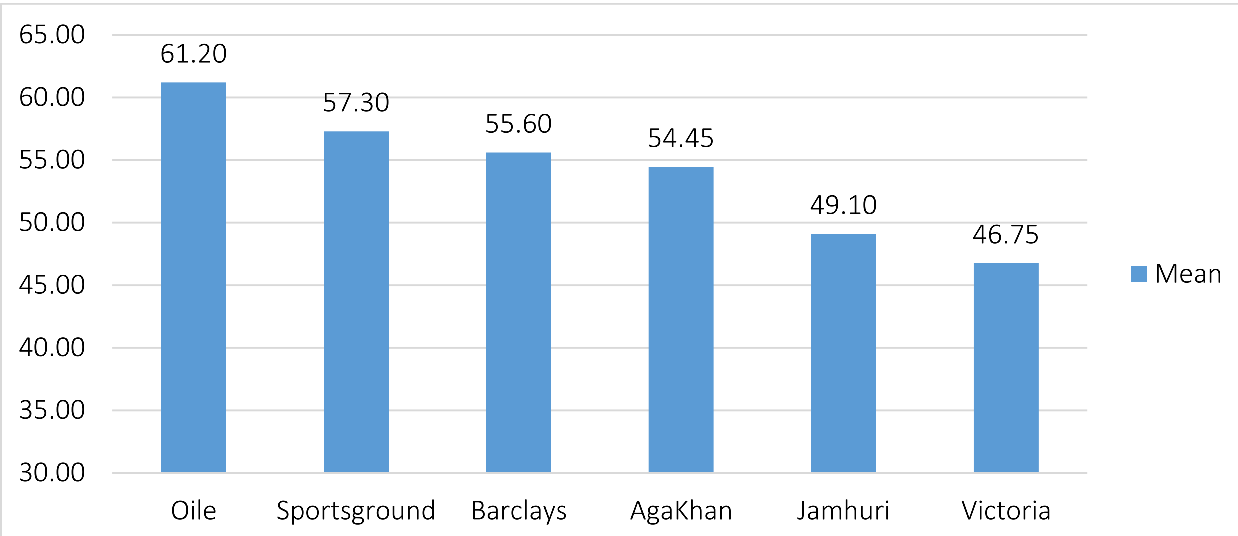

Figure 2: Variation in resting park noise with distance from high traffic zones.

Likewise, there was considerable variability in traffic noise by site, with highways having highest (76.25 ± 5.42dBA) followed by roundabouts (75.0 ± 4.97 dBA) and lastly by termini (71.60 ± 4.81dBA). One-way ANOVA with multiple pairwise comparisons revealed that these means differed significantly for highways vs. termini (p = 0.000), roundabouts vs. termini (p = 0.000) but not for highways vs. roundabouts (p = 0.056).

Further, independent sample t-test showed that the mean SPL for music-related sources was significantly higher than traffic (t= 29.577, df= 980.790, p=0.000, 95%CI: 14.90188-17.01987). Music was thus a leading source of environmental noise in the city.

Multiple Comparisons						
Dependent Variable: LAeq						
Games-Howell						
(I) Site_coded	(J) Site_coded	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Oile	Sportsground	3.90000*	.52666	.000	2.2758	5.5242
	AgaKhan	6.75000*	.76459	.000	4.4525	9.0475
	Barclays	5.60000*	.51299	.000	4.0060	7.1940
	Victoria	14.45000*	.57800	.000	12.6989	16.2011
	Jamhuri	12.10000*	.52566	.000	10.4781	13.7219
Sportsground	Oile	-3.90000*	.52666	.000	-5.5242	-2.2758
	AgaKhan	2.85000*	.61804	.002	.9327	4.7673
	Barclays	1.70000*	.24602	.000	.9598	2.4402
	Victoria	10.55000*	.36256	.000	9.4518	11.6482
	Jamhuri	8.20000*	.27145	.000	7.3857	9.0143
AgaKhan	Oile	-6.75000*	.76459	.000	-9.0475	-4.4525
	Sportsground	-2.85000*	.61804	.002	-4.7673	-.9327
	Barclays	-1.15000	.60643	.431	-3.0427	.7427
	Victoria	7.70000*	.66233	.000	5.6792	9.7208
	Jamhuri	5.35000*	.61719	.000	3.4346	7.2654
Barclays	Oile	-5.60000*	.51299	.000	-7.1940	-4.0060
	Sportsground	-1.70000*	.24602	.000	-2.4402	-.9598
	AgaKhan	1.15000	.60643	.431	-.7427	3.0427
	Victoria	8.85000*	.34240	.000	7.8032	9.8968
	Jamhuri	6.50000*	.24387	.000	5.7665	7.2335
Victoria	Oile	-14.45000*	.57800	.000	-16.2011	-12.6989
	Sportsground	-10.55000*	.36256	.000	-11.6482	-9.4518
	AgaKhan	-7.70000*	.66233	.000	-9.7208	-5.6792
	Barclays	-8.85000*	.34240	.000	-9.8968	-7.8032
	Jamhuri	-2.35000*	.36110	.000	-3.4443	-1.2557
Jamhuri	Oile	-12.10000*	.52566	.000	-13.7219	-10.4781
	Sportsground	-8.20000*	.27145	.000	-9.0143	-7.3857
	AgaKhan	-5.35000*	.61719	.000	-7.2654	-3.4346
	Barclays	-6.50000*	.24387	.000	-7.2335	-5.7665
	Victoria	2.35000*	.36110	.000	1.2557	3.4443
*. The mean difference is significant at the 0.05 level.						

Table 2: Levels of noise across resting parks (multiple comparisons).

4. Discussion

Despite its well-documented effects on health and wellbeing, noise remains one of the most poorly regulated type of pollution in African cities. This study assessed noise associated with traffic and music at 50 purposively selected sites in Kisumu city, Kenya.

Traffic-related noise exceeded the national environmental management authority's (NEMA) limit by over 10dBA but was considerably lower than those recorded in Nairobi (90-98 dBA) [29]. This might be due to heavier traffic density in Nairobi but could also be offset by the fact that the authors calculated logarithmic mean rather than arithmetic mean which often gives higher values. However, logarithmic means are appropriate only when measurements are continuous.

Traffic noise levels exceeding 70 dBA were associated with annoyance and work inefficiency in an Indian city [30], as well as a number of other health effects around the world [31, 32]. The levels of traffic noise reported in this study thus indicate the exposed populations were at risk of these effects.

Music-related noise exceeded state regulatory limits by over 26dBA with some sources emitting noise levels in excess of 107dBA. Similar noise levels were reported by Ebare et al., (2011) [6] in a Nigerian urban center. These elevated noise levels are risk factors to noise-induced hearing loss (NIHL), irritation and hypertension among other auditory and non-auditory effects [14, 15].

Noise levels varied significantly with place and source. Highest traffic-related noise were recorded at highways and parks close to busy roads. Vehicular noise is a function of many variables including vehicle type and speed [15, 22]. In this study, however, the variation in noise was unlikely caused by speeding as there was no significant difference between mean SPLs recorded at highways and roundabouts. Traffic density and vehicle types might explain the differentials.

While noise data in this study was cross-sectional, the measurements are useful proxies for chronic and/or acute exposure of the local public [25] especially in places with little or no noise surveillance. The findings of this study should thus interventions as well as further investigation. Methods to mitigate noise in urban centers have been proposed in previous studies. Ow and Ghosh (2017) [33] reported that cultivating trees along roads can reduce vehicular noise by up to 11 decibels. Others proposed low-noise tyres and pavements, speed regulations, traffic flow reduction and use of sonic crystals as barriers [34, 35]. City and national environmental authorities could explore these options for mitigation.

5. Conclusion

As Kenya strives towards universal health coverage, environmental noise should not be neglected. This study assessed levels and distribution of traffic and music-related noise in Kisumu city and evaluated noise against regulatory limits. Overall, both vehicular and music-related noise exceeded maximum permissible limits, but music-related noise was significantly higher than vehicular noise. The key contribution of this research to the public is the discovery of spatial differentials in environmental noise at resting parks in the city which should inform the public's choice of green space.

Recommendations

NEMA should step up enforcement of music-related noise regulations since this survey suggests gross violation. The county's department of health should take measures to protect the habitually exposed including improving vegetation along high traffic roads. Alternatively, the county government should provide additional resting parks outside high traffic zones. The public should use green spaces further from high traffic zones or considerably barricaded from traffic and music-related noise.

Further Research

Audiometric assessment for at-risk population especially those running music stores. More robust noise surveillance over longer durations, with continuous rather than intermittent, measurement should be conducted.

Limitations

This was a cross-sectional survey of noise levels within a limited period of time thus may not be taken as gold-standard since noise fluctuates widely across time.

Conflict of Interest

The authors declare no conflict of interest.

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