Method Article

A GIS – based method for assessment and mapping of noise pollution in Ota metropolis, Nigeria

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A B S T R A C T

A detailed method used for assessing and mapping noise pollution levels in Ota metropolis, Nigeria using ArcGIS 10.5 Software is presented in this paper. Noise readings were measured at a time interval of 30 min for each site considered using a precision grade sound level meter. The noise map developed was based on the computed values of average equivalent noise (L eq) for the selected locations. Results of this study show that the A weighted sound level (L eq), the background noise level (L b) and the peak noise level (L p) vary with location and period of the day due to traffic characteristics especially traffic volume, vehicle horns, vehicle mounted speakers, and unmuffled vehicles at road junctions, major roads, motor parks and commercial centres. Based on the U.S. Department of Housing and Urban Development (HUD) recommendations and standards, only 1 (1) out of the 41 locations considered is under normally acceptable situation, while 12 locations are under normally unacceptable and the noise levels of the rest locations are clearly unacceptable. Results of this study are useful as reference and guideline for future planning and regulations on noise limit to be implemented for urban areas like Ota Metropolis.

- Instrumentation used in this study for the environmental noise measurements consisted of a precision-grade sound-level meter – Model 8922 RS232.
- The Geographical Positioning System (GPS) device (model: Magellan eXplorist 310) was used to obtain the exact coordinates of each location where noise level readings were recorded.
- ArcGIS 10.5 software was used in this study to develop noise map for Ota Metropolis.

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Specifications Table

| Subject Area:       | Engineering                                      |
|---------------------|-------------------------------------------------|
| More Specific Subject area: | Mechanical Engineering, Environmental Engineering, Environmental Noise Control |
| Method Name:        | A GIS – Based Method for Developing Noise Map    |
| Name and reference of original method: | ArcGIS software – Esri: GIS Mapping Software |
| Resource Availability: | ArcGIS Software                                  |

Method details

Experimental procedures

Noise pollution is a significant environmental problem in many rapidly urbanizing areas [1,2]. In developing countries, like Nigeria, the problem of noise pollution is wide spread. There is no legal frame work upon which noise pollution can be abated. The high level of environmental noise reduces the quality of living [3] and the problem has to be tackled but first analyzed which is done by measuring the noise pollution level.

Instrumentation used in this study for the environmental noise measurements consisted of a precision-grade sound-level meter (according to IEC 651, ANSI S1.4 type 2 class standard) one 1/2-in. condenser microphone and 0.33-octave filter with frequency range and measuring level range of 31.5 Hz–8 kHz and 35–130 dB, respectively. The instruments were calibrated by the internal sound-level calibrator before making measurements at each selected site. The measurements were taken at street level (at road junctions, market centres, passengers loading parks, and residential areas). The instrument was held comfortably in hand with the microphone pointed at the suspected noise source at a distance above 1 m away from any reflecting object. $L_{Ai}$ (A-weighted instantaneous sound pressure level) measurements were recorded at intervals of 30 s for a period of 30 min, giving 60-meter readings per sampling location. This procedure was carried out for morning (7:00–9:00 a.m.), afternoon (2:00–4:00 p.m.) and evening (6:00–8:00 p.m.) measurements. A total of 41-locations were assessed for noise pollution level within Ota Metropolis [4]. From these readings, commonly used community noise descriptors such as the exceedence percentiles $L_{10}$ and $L_{90}$, the A-weighted equivalent sound pressure level, $L_{Aeq}$, the daytime average sound level, $L_D$, the noise pollution level, $LNP$, the traffic noise index, $TNI$, the noise climate (NC) and the noise exposure index (NEI) were computed.

These noise measures are defined as follows [5]:

$$L_{Aeq} = 10 \log_{10} \left( \frac{1}{N} \sum_{i=1}^{N} \left( \text{Antilog} \frac{L_{Ai}}{10} \right) \right)$$  \hspace{1cm} (1)

$$L_D = 10 \log_{10} \times \frac{1}{2} \left[ \text{Antilog} \frac{L_{Aeq(m)}}{10} + \text{Antilog} \frac{L_{Aeq(\bar{A})}}{10} \right]$$  \hspace{1cm} (2)
Table 1
Minimum (Lmin), Maximum (Lmax) and percentile noise exceeded (L10, L50, L90) at Selected Locations.

| Location                        | L\textsubscript{min} dB(A) | L\textsubscript{max} dB(A) | L\textsubscript{10} dB(A) | L\textsubscript{50} dB(A) | L\textsubscript{90} dB(A) |
|---------------------------------|-----------------------------|-----------------------------|---------------------------|---------------------------|---------------------------|
|                                 | M A E                       | M A E                       | M A E                     | M A E                     | M A E                     |
| Sifor Area                      | 66 65 61                    | 82 86 82                    | 72 88 76                  | 71 75 70                  | 66 68 63                  |
| Bells University Junction       | 63 66 69                    | 78 89 92                    | 77 84 80                  | 73 74 75                  | 69 69 72                  |
| Canaan Land                     | 65 65 63                    | 90 101 85                   | 80 88 78                  | 72 75 72                  | 67 69 67                  |
| May And Baker Close             | 45 43 31                    | 67 65 63                    | 56 56 55                  | 48 49 45                  | 46 45 41                  |
| High Court Area                 | 63 63 65                    | 86 89 83                    | 82 79 80                  | 77 75 76                  | 72 70 70                  |
| Nestle                          | 68 64 66                    | 88 82 97                    | 80 78 80                  | 75 74 74                  | 72 68 69                  |
| Iyana-Iyesi Market              | 59 60 77                    | 81 78 87                    | 74 72 82                  | 66 67 79                  | 63 62 78                  |
| Iyana-Iyesi Junction           | 69 69 72                    | 95 86 89                    | 84 83 85                  | 78 75 78                  | 73 71 74                  |
| Oju-Ore Junction               | 75 71 71                    | 105 93 87                   | 90 85 83                  | 81 76 78                  | 77 73 74                  |
| Joju Junction                   | 63 63 67                    | 89 84 84                    | 79 79 79                  | 74 73 73                  | 68 69 69                  |
| Joju Express Road               | 73 72 73                    | 88 94 94                    | 86 88 82                  | 80 80 77                  | 75 75 75                  |
| Sango Under Bridge              | 73 75 73                    | 102 113 110                | 91 96 87                  | 79 83 78                  | 75 77 75                  |
| Sango Car Park                  | 60 55 67                    | 92 89 94                    | 80 80 84                  | 68 71 73                  | 61 71 68                  |
| Fowobi Junction                 | 67 70 67                    | 93 87 87                    | 84 84 80                  | 76 76 76                  | 71 72 72                  |
| Toll Gate Express               | 67 65 71                    | 85 98 88                    | 86 76 85                  | 74 71 78                  | 60 77 67                  |
| Toll Gate Area                  | 70 70 73                    | 91 103 99                   | 86 86 92                  | 78 77 84                  | 73 72 76                  |
| Obasanjo Junction               | 68 70 70                    | 92 93 91                    | 85 90 85                  | 76 80 79                  | 71 72 74                  |
| Ota-Market Area                 | 66 68 67                    | 85 94 94                    | 82 84 83                  | 84 77 77                  | 70 72 71                  |
| Ogun State Internal Revenue     | 58 60 64                    | 89 81 85                    | 77 74 75                  | 67 67 69                  | 60 62 65                  |
| Ota Local Government Sct        | 63 63 63                    | 91 87 82                    | 77 75 77                  | 71 70 72                  | 66 65 67                  |
| Jack Ross Area (Road)           | 57 52 59                    | 86 84 82                    | 76 73 79                  | 69 66 70                  | 62 67 64                  |
| Chelsea (IDL)                  | 55 57 69                    | 99 83 90                    | 80 78 87                  | 72 71 82                  | 63 63 73                  |
| Ilamode Sec School A/R          | 67 65 65                    | 91 90 92                    | 83 84 90                  | 76 76 90                  | 72 72 74                  |
| All-Oyer Polytechnic Road       | 61 64 75                    | 84 95 94                    | 82 84 90                  | 76 74 81                  | 65 66 76                  |
| Oloko Palace Junction           | 66 65 69                    | 90 86 86                    | 80 78 80                  | 74 73 78                  | 70 68 73                  |
| Ijoko Road                      | 66 59 53                    | 90 84 95                    | 82 81 85                  | 74 77 79                  | 70 68 71                  |
| Ijako Tipper Garage             | 60 60 60                    | 82 88 89                    | 73 83 78                  | 67 70 72                  | 62 65 67                  |
| Ijoko Railway Station           | 59 64 53                    | 91 82 81                    | 81 80 78                  | 70 75 72                  | 62 69 65                  |
| Ilogbo Road                     | 61 64 63                    | 82 90 91                    | 76 87 86                  | 70 79 80                  | 66 68 74                  |
| Ijoko Market                    | 57 58 58                    | 77 80 79                    | 75 78 78                  | 67 73 70                  | 61 67 62                  |
| Ilo Road                        | 68 66 68                    | 93 88 87                    | 86 83 83                  | 80 79 78                  | 71 72 70                  |
| Owode Area                      | 64 65 56                    | 88 82 85                    | 80 80 80                  | 74 78 76                  | 68 68 66                  |
| Dalemo Junction                 | 65 64 63                    | 82 86 84                    | 78 82 81                  | 72 76 76                  | 68 68 69                  |
| Ilo-Awela Road                  | 60 62 66                    | 84 83 84                    | 74 81 82                  | 68 73 77                  | 63 66 71                  |
| Indomie                         | 71 73 68                    | 94 97 99                    | 87 91 94                  | 80 83 81                  | 75 76 73                  |
| Tower Aluminum Company          | 51 50 48                    | 79 72 71                    | 75 71 68                  | 59 64 59                  | 55 55 53                  |
| Kolokote Area                   | 55 51 52                    | 87 73 74                    | 81 61 70                  | 62 69 59                  | 63 56 54                  |
| Owode Area                      | 64 69 64                    | 92 91 90                    | 89 86 88                  | 78 80 79                  | 73 75 73                  |
| Idiroko Road (Chelsea Area)     | 61 67 65                    | 92 89 87                    | 86 87 83                  | 78 81 77                  | 70 74 70                  |
| Bells University Drive          | 49 52 50                    | 84 76 80                    | 76 73 76                  | 63 67 69                  | 54 58 56                  |
| Estate                          | 55 68 65                    | 96 93 97                    | 90 88 90                  | 78 79 78                  | 70 74 69                  |

Key: M – Morning; A – Afternoon; E – Evening.

\[
LN = 10\log_{10}\left[\frac{1}{2}\left(\text{Antilog}\frac{L_{\text{Aeq}(E)}}{10} + \text{Antilog}\frac{L_{\text{Aeq}(N)}}{10}\right)\right] 
\]

(3)

\[
\text{TNI} = 4 \times (L_{10} - L_{90}) + (L_{90} - 30) \text{ dB (A)} 
\]

(4)

\[
\text{LNP} = L_{\text{eq}} + a \times (L_{10} - L_{90}) 
\]

(5)
Table 2
Traffic noise Index (TNI), Pollution noise level (LNP) and Average Equivalent Noise Levels (L\text{Aeq}) for the Selected Locations.

| Location                      | TNI dB(A) | LNP dB(A) | L\text{Aeq} dB(A) |
|-------------------------------|-----------|-----------|-------------------|
|                               | M  | A  | E   | M  | A  | E   | M  | A  | E   |
| Sifor Area                    | 60 | 118| 85  | 79.29| 99.55| 85.74| 73.29| 79.55| 72.74|
| Bells University Junction     | 71 | 99 | 74  | 81.65| 92.35| 88.33| 73.65| 77.35| 80.33|
| Cannaan Land                  | 89 | 115| 81  | 90.65| 106.09| 86.06| 77.65| 87.09| 75.06|
| May And Baker Close           | 56 | 59 | 67  | 62.68| 64.42| 65.14| 52.68| 53.42| 51.14|
| High Court Area               | 82 | 76 | 80  | 88.52| 85.82| 86.71| 78.52| 76.82| 76.71|
| Nestle Area                   | 74 | 78 | 83  | 85.36| 85.32| 91.95| 77.36| 75.32| 80.95|
| Iyana-Iyesi Market            | 77 | 72 | 64  | 81.83| 78.93| 83.63| 70.83| 68.93| 79.63|
| Iyana-Iyesi Junction          | 87 | 89 | 88  | 92.44| 90.18| 91.89| 81.44| 78.18| 80.89|
| Oju-Ore Junction              | 99 | 91 | 80  | 102.18| 93.80| 88.59| 89.18| 81.80| 79.59|
| Joju Junction                 | 82 | 79 | 79  | 87.79| 85.20| 85.13| 76.79| 76.70| 75.13|
| Joju Express Road             | 89 | 97 | 73  | 93.16| 96.62| 87.73| 82.16| 83.62| 80.73|
| Sango Under Bridge            | 109| 123| 93  | 103.92| 115.57| 105.36| 87.92| 96.57| 93.36|
| Sango Car Park                | 107| 102| 77  | 95.82| 85.80| 96.73| 76.82| 78.60| 80.73|
| Fowobi Junction               | 93 | 90 | 74  | 93.88| 90.69| 85.48| 80.88| 78.69| 77.48|
| Toll Gate Express             | 104| 73 | 91  | 93.14| 92.11| 91.95| 77.14| 83.11| 79.95|
| Toll Gate Area                | 95 | 98 | 110 | 95.10| 100.98| 104.39| 82.10| 86.98| 88.39|
| Obasanjo Junction             | 97 | 114| 88  | 94.68| 103.59| 93.20| 80.68| 85.59| 82.20|
| Ota-Market Area               | 88 | 90 | 89  | 90.01| 93.03| 92.98| 78.01| 81.03| 80.98|
| Ogun State Internal Revenue Area | 98 | 80 | 75  | 92.51| 82.01| 82.50| 75.51| 70.01| 72.50|
| Ota Local Government Secretariat | 80 | 75 | 77  | 87.10| 83.30| 84.04| 76.10| 73.30| 74.04|
| Jack Ross Area (Road)         | 88 | 61 | 94  | 87.28| 78.87| 88.31| 73.28| 72.78| 73.31|
| Chelsea (IDL)                | 101| 93 | 90  | 95.43| 88.22| 95.15| 82.43| 73.22| 83.15|
| Igamode Sec School Area/Road | 86 | 90 | 108 | 91.27| 91.82| 100.52| 80.27| 79.82| 84.52|
| All-Over Polytechnic Road    | 103| 108| 102 | 94.53| 98.73| 99.43| 77.53| 80.73| 85.43|
| Olota Palace Junction         | 80 | 78 | 71  | 88.04| 85.59| 85.30| 78.04| 75.59| 78.30|
| Ijoko Road                    | 88 | 90 | 97  | 90.64| 91.03| 96.06| 78.64| 78.03| 82.06|
| Ijako Tipper Garage           | 76 | 107| 81  | 81.13| 94.91| 87.72| 70.13| 76.91| 76.72|
| Ijoko Railway Station        | 108| 83 | 87  | 97.05| 87.12| 86.89| 78.05| 76.12| 73.89|
| Ilogbo Road                   | 76 | 114| 92  | 82.45| 101.60| 94.49| 72.45| 82.60| 82.49|
| Ijoko Market                  | 87 | 81 | 96  | 83.70| 85.18| 88.62| 69.70| 74.18| 72.62|
| Ifo Road                     | 101| 86 | 92  | 97.85| 91.01| 92.40| 82.85| 80.01| 79.40|
| Igbara                      | 86 | 86 | 92  | 89.48| 88.48| 91.11| 77.48| 76.48| 77.11|
| Dalemo Junction              | 78 | 94 | 87  | 84.22| 91.93| 89.62| 74.22| 77.93| 77.62|
| Ilo-Awela Road               | 77 | 96 | 85  | 83.01| 91.64| 89.41| 72.01| 76.64| 78.41|
| Indomie Area                 | 93 | 106| 127 | 95.34| 101.67| 109.22| 83.34| 86.67| 88.22|
| Tower Aluminum Company       | 105| 89 | 83  | 88.59| 82.05| 78.66| 68.59| 66.05| 63.66|
| Kolokote Area                | 126| 52 | 82  | 100.30| 71.10| 80.29| 75.30| 64.10| 66.29|
| Owo Area                     | 107| 89 | 103 | 95.61| 93.88| 98.21| 83.61| 82.88| 83.21|
| Idiroko Road(Chelsea Area)   | 104| 96 | 92  | 98.07| 95.21| 92.26| 82.07| 82.21| 79.26|
| Bells Drive                  | 112| 88 | 106 | 93.56| 83.48| 91.48| 71.56| 68.48| 71.48|
| Estate                      | 120| 100| 123 | 104.57| 97.62| 106.85| 84.57| 83.62| 85.85|

Key: M – Morning; A – Afternoon; E – Evening.

\[ NC = (L_{10} - L_{00}) \]  
\[ NEI = (t_1/T_1 + t_2/T_2 + \ldots t_n/T_n) \]  

The noise descriptors for the selected locations at respective time of the day are presented in Tables 1–3. While noise measurements were carried out and recorded, proper counting and recording of number of cars, tricycles, motorcycles and trucks that pass point of measurement were made at the selected locations close to the road. Also, the prevailing environmental condition was noted so as to know the major sources of the environmental noise in the surrounding. The sampling locations for the noise pollution monitoring were divided into zones/areas based on the predominant infrastructure or based on the notable characteristics of the area. The Geographical Positioning System (GPS) points
were also collected for each location for accurate coordinates of the sampling points for the purpose of noise mapping.

**Geographical positioning system (GPS)**

The Geographical Positioning System (GPS) device (model: Magellan eXplorist 310) was used to obtain the exact coordinates of each location where noise level readings were recorded. The GPS was turned on at each location and the latitude, longitude and altitude readings were taken. GPS readings were taken where there is no signal obstruction.

The GPS system currently has 31 active satellites in orbits inclined 55° to the equator. The satellites orbit about 20,000 km from the earth’s surface. The GPS receiver gets a signal from each GPS satellite. The satellites transmit the exact time the signals are sent. By subtracting the time the signal was

| Location                  | NEI (M A E) | Noise Climate (M A E) | LDay (L<sub>d</sub>) | LNight (L<sub>n</sub>) |
|---------------------------|-------------|-----------------------|----------------------|-------------------------|
| Sifor Area                | 1.04 1.14 1.04 | 6 20 13 | 77.5 72.7 |
| Bells University Junction | 1.05 1.11 1.15 | 8 15 8 | 75.9 80.3 |
| Canaan Land               | 1.11 1.24 1.07 | 13 19 11 | 84.6 75.1 |
| May And Baker Close       | 0.96 0.97 0.93 | 10 11 14 | 53.1 51.1 |
| High Court Area           | 1.12 1.12 1.10 | 10 9 10 | 77.6 76.7 |
| Nestle Area               | 1.05 1.08 1.16 | 8 10 11 | 76.5 81.0 |
| Iyana-Iyesi Market        | 1.09 1.06 1.45 | 11 10 4 | 70.0 79.6 |
| Iyana-Iyesi Junction      | 1.16 1.12 1.16 | 11 12 11 | 80.1 80.9 |
| Oju-Ore Junction          | 1.37 1.26 1.45 | 13 12 9 | 86.9 79.6 |
| Joju Junction             | 1.10 1.07 1.07 | 11 10 10 | 76.1 75.1 |
| Joju Express Road         | 1.17 1.20 1.11 | 11 13 7 | 83.0 80.7 |
| Sango Under Bridge        | 1.35 1.49 1.70 | 16 19 12 | 94.1 93.4 |
| Sango Car Park            | 1.10 1.10 1.15 | 19 9 16 | 76.8 80.7 |
| Fowobi Junction           | 1.16 1.12 1.11 | 13 12 8 | 79.9 77.5 |
| Toll Gate Express         | 1.10 1.19 1.14 | 16 9 12 | 81.1 80.0 |
| Toll Gate Area            | 1.26 1.34 1.61 | 13 14 16 | 85.2 88.4 |
| Obasanjo Junction         | 1.15 1.22 1.17 | 14 18 11 | 83.8 82.2 |
| Ota-Market Area           | 1.20 1.25 1.47 | 12 12 12 | 79.8 81.0 |
| Ogun State Internal Revenue Ar | 1.37 1.27 1.61 | 17 12 10 | 73.6 72.5 |
| Ota Local Government Sect | 1.38 1.33 1.65 | 11 10 10 | 74.9 74.0 |
| Jack Ross Area (Road)     | 1.09 1.06 1.45 | 14 6 15 | 73.0 73.3 |
| Chelsea (IEL)             | 1.10 0.98 1.28 | 17 15 12 | 79.9 83.2 |
| Iganmode Sec School A/R   | 1.15 1.14 1.21 | 11 12 16 | 80.1 84.5 |
| All-Over Polytechnic Road | 1.11 1.14 1.22 | 17 18 14 | 79.4 85.4 |
| Oloja Palace Junction     | 1.20 1.16 1.42 | 10 10 7 | 77.0 78.3 |
| Ikoko Road                | 1.12 1.11 1.17 | 12 13 14 | 78.4 82.1 |
| Ikako Tipper Garage       | 1.00 1.10 1.10 | 11 18 11 | 74.7 76.7 |
| Ikoko Railway Station     | 1.20 1.17 1.34 | 19 11 13 | 77.2 73.9 |
| Ilogbo Road               | 1.04 1.18 1.19 | 10 19 12 | 80.0 82.5 |
| Ikoko Market              | 1.07 1.14 1.32 | 14 11 16 | 72.5 72.6 |
| Ifo Road                  | 1.18 1.14 1.13 | 15 11 13 | 81.7 79.4 |
| Igbala                    | 1.11 1.10 1.10 | 12 12 14 | 77.0 77.1 |
| Dalemo Junction           | 1.06 1.11 1.11 | 10 14 12 | 76.5 77.6 |
| Ifo-Awela Road            | 1.03 1.10 1.12 | 11 15 11 | 74.9 78.4 |
| Indomie Area              | 1.19 1.24 1.26 | 12 15 21 | 85.3 88.2 |
| Tower Aluminum Company    | 0.91 0.88 0.98 | 20 16 15 | 67.5 63.7 |
| Kolokote Area             | 1.00 0.85 1.02 | 25 7 14 | 72.6 66.3 |
| Osowode Area              | 1.29 1.28 1.51 | 16 11 15 | 83.3 83.2 |
| Idiroko Road(Chelsea Area)| 1.17 1.17 1.13 | 16 13 13 | 82.1 79.3 |
| Bells University Drive    | 1.10 1.05 1.30 | 22 15 20 | 70.3 71.5 |
| Estate                    | 1.13 1.11 1.32 | 20 14 21 | 84.1 85.9 |
transmitted from the time it was received, it can tell how far it is from each satellite and its receiver can determine the location of study in three dimensions which are east, north and altitude.

The eXplorist 310 version used in this study supports paperless geocaching and allows the use of more than 20 unique characteristics of each cache, including name, location, description, terrain, habitat and other details. The GPS is pre-loaded with the World Edition map. This unique preloaded map also includes geographical features (water features, urban and rural land use, and city centers).

Table A1 shows the geographical positioning systems coordinates while Table A2 shows the adopted codes for the selected 41 locations in Ota Metropolis.

Noise mapping

Noise mapping as a graphical representation of the sound level distribution existing in a given region, it is an efficient noise assessment method in urban areas. It also helps in visualization of the noise distributions in areas where land uses are very sensitive to noise. This is one of the modern ways to assess noise levels and it helps in planning to mitigate noise pollution effects [6,7].

According to the Directive 2002/49/EC of the European Parliament and of the Council, of 25 June 2002 relating to the assessment and management of environmental noise imposes to its Member States the elaboration of noise maps for cities with more than 250,000 inhabitants, this was due on 30 June 2007 [1,2,8]. Based on this directive, Ota metropolis with population of over 527,242 inhabitants is due to be presented with noise map. Fig. 1 shows the satellite view of Ota.

In this study, development of noise map using GIS for selected noisy areas (commercial centers, major road junctions, passenger loading parks, high-density residential areas) and low-noise areas (low density residential areas) are presented. The data collected at the 41 locations were used to develop a noise map for the study location - Ota metropolis. Ota is one of major cities in South-West Nigeria. It is located between latitude 6° 38’N to 6° 41’N and longitude 03° 8’E and 3° 12’E. Fig. 4 shows the satellite view of the study area.

ArcGIS 10.5 software was used in this study to develop noise map for Ota Metropolis. The Software makes use of Inverse Distance Weighting (IDW) interpolation method. IDW provides satisfactory results when the number of elevation points in an area is large and the points are uniformly distributed. Also, the known sample points are implicit to be self-governing from each other [9–11]. Generally, interpolation helps to predict the cell values in a pattern format using a given number of sample data. It is a good tool for prediction of unknown values for a given geographic point data which in this study is noise.

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![Satellite view of Ota](Image source: google Earth)
The IDW Interpolation method is used by taking into consideration the data obtained from noise sources and distances between them. For its prediction, IDW utilises the given values surrounding the predicted location. It predicts that each given point has a local influence that shrinks with space; thereby giving greater weights to points closest to the prediction location, based on distance decay effect. This process leads to the procedure being referred to as inverse distance weighted. This technique was applied to measure the spatial distribution and range of acoustics in the area for the

**Fig. 2.** Spatial variation mapping of noise levels in Ota metropolis for the morning period.

**Fig. 3.** Spatial variation mapping of noise levels in Ota metropolis for the afternoon period.
three periods of the day. Figs. 2–4 show the spatial variation mapping of noise levels in Ota metropolis for the morning, afternoon and evening periods of the day, respectively.

Results of this study show that the A weighted sound level (L_{Aeq}), the background noise level (L_{10}) and the peak noise level (L_{90}) vary with location and period of the day due to traffic characteristics especially traffic volume, vehicle horns, vehicle mounted speakers, and unmuffled vehicles at road junctions, major roads, motor parks and commercial centres. Based on the U.S. Department of Housing and Urban Development (HUD) recommendations and standards, only one (1) out of the 41 locations considered is under normally acceptable situation, while 12 locations are under normally unacceptable and the noise levels of the rest locations are clearly unacceptable.

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Appendix A

Table A1

| S/N | Location               | Latitude  | Longitude  | Elevation |
|-----|------------------------|-----------|------------|-----------|
| 1   | Sifor Area             | 6° 40' 57.8'' | 3° 10' 24.3'' | 75m       |
| 2   | Bells University Junction | 6° 41' 00.2'' | 3° 10' 38.2'' | 63m       |
| 3   | Canaan Land            | 6° 40' 55.7'' | 3° 10' 03.7'' | 63m       |
| 4   | May And Baker Close    | 6° 41' 07.2'' | 3° 10' 03.1'' | 62m       |
| 5   | High Court Area        | 6° 40' 52.7'' | 3° 11' 02.7'' | 55m       |
| 6   | Nestle Area            | 6° 40' 54.4'' | 3° 11' 29.2'' | 52m       |
| 7   | Iyana-Iyesi Market     | 6° 40' 48.0'' | 3° 11' 01.8'' | 64m       |
| 8   | Iyana-Iyesi Junction   | 6° 40' 83.9'' | 3° 11' 04.9'' | 65m       |
| 9   | Oju-Ore                | 6° 41' 18.2'' | 3° 13' 32.3'' | 73m       |
| 10  | Joju Junction          | 6° 41' 55.8'' | 3° 14' 16.7'' | 77m       |
| 11  | Joju Express Road      | 6° 42' 35.6'' | 3° 14' 16.5'' | 78m       |
| 12  | Sango Under Bridge     | 6° 42' 26.6'' | 3° 14' 33.7'' | 85m       |
Table A1 (Continued)

| S/N | Location                                | Latitude | Longitude    | Elevation |
|-----|-----------------------------------------|----------|--------------|-----------|
| 13  | Sango Car Park                          | 6° 42' 17.8"N | 3° 14' 45.2"E | 82m        |
| 14  | Fowobi Junction                         | 6° 41' 11.3"N | 3° 13' 10"E   | 81m        |
| 15  | Toll Gate Express                       | 6° 42' 19.3"N | 3° 14' 47.2"E | 80m        |
| 16  | Toll Gate Area                          | 6° 41' 32.6"N | 3° 15' 25.6"E | 80m        |
| 17  | Obasanjo Junction                       | 6° 40' 58.2"N | 3° 12' 35.0"E | 68m        |
| 18  | Ota-Market Area                         | 6° 41' 03.8"N | 3° 12' 55.7"E | 68m        |
| 19  | Ogun State Internal Revenue Area        | 6° 41' 35.6"N | 3° 14' 12.2"E | 80m        |
| 20  | Ota Local Government Secretariat        | 6° 41' 29.0"N | 3° 14' 12.1"E | 72m        |
| 21  | Jack Ross Area (Road)                   | 6° 40' 04.6"N | 3° 10' 52.6"E | 53m        |
| 22  | Chelsea (IDL)                           | 6° 40' 04.4"N | 3° 10' 53.2"E | 67m        |
| 23  | Iganmode Sec School Area/Road           | 6° 40' 56.3"N | 3° 10' 53.8"E | 88m        |
| 24  | All-Over Polytechnic Road               | 6° 41' 49.2"N | 3° 13' 59.8"E | 84m        |
| 25  | Olotra Palace Junction                  | 6° 41' 13.6"N | 3° 13' 59.9"E | 78m        |
| 26  | Ijoko Road                              | 6° 40' 57.4"N | 3° 12' 30.7"E | 68m        |
| 27  | Ijako Tipper Garage                     | 6° 44' 34.3"N | 3° 15' 59.9"E | 90m        |
| 28  | Ijoko Railway Station                   | 6° 44' 58.0"N | 3° 15' 38.4"E | 71m        |
| 29  | Ilogbo Road                             | 6° 44' 57.4"N | 3° 12' 53.4"E | 46m        |
| 30  | Ijoko Market                            | 6° 44' 34.2"N | 3° 15' 60.0"E | 92m        |
| 31  | Ifo Road                                | 6° 45' 00.9"N | 3° 12' 53.0"E | 47m        |
| 32  | Igabola                                 | 6° 42' 42.7"N | 3° 13' 75.0"E | 69m        |
| 33  | Dalemo Junction                         | 6° 42' 01.3"N | 3° 15' 08.1"E | 60m        |
| 34  | Ilo-Awela Road                          | 6° 41' 50.7"N | 3° 14' 20.9"E | 83m        |
| 35  | Indomie Area                            | 6° 41' 08.0"N | 3° 13' 05.9"E | 78m        |
| 36  | Tower Aluminum Company                  | 6° 40' 33.2"N | 3° 12' 06.5"E | 67m        |
| 37  | Kolokote Area                           | 6° 40' 28.5"N | 3° 12' 04.8"E | 74m        |
| 38  | Owoade Area                             | 6° 40' 53.4"N | 3° 12' 07.9"E | 69m        |
| 39  | Idiroko Road(Chelsea Area)              | 6° 40' 52.7"N | 3° 09' 23.7"E | 64m        |
| 40  | Bells Drive                             | 6° 44' 30.0"N | 3° 12' 55.0"E | 51m        |
| 41  | Estate                                  | 6° 40' 53.4"N | 3° 12' 07.9"E | 71m        |

Table A2
Codes Adopted for the Selected Locations.

| S/N | LOCATION          | CODE | PERIOD OF THE DAY | TIME OF THE DAY | DAY   |
|-----|-------------------|------|-------------------|-----------------|-------|
| 1   | SIFOR AREA        | TA1  | Morning           | 7:00–7:30 AM    |       |
|     |                   |      | Afternoon         | 2:00–2:30 PM    |       |
|     |                   |      | Evening           | 6:00–8:00 PM    |       |
| 2   | BELLS UNIVERSITY JUNCTION | TA1  | Morning           | 7:30–8:00 AM    |       |
|     |                   |      | Afternoon         | 2:30–3:00 PM    |       |
|     |                   |      | Evening           | 6:00–8:00 PM    | SATURDAY |
| 3   | CANAAN LAND       | TA1  | Morning           | 8:00–8:30 AM    |       |
|     |                   |      | Afternoon         | 3:00–3:30 PM    |       |
|     |                   |      | Evening           | 6:00–8:00 PM    |       |
| 4   | MAY AND BAKER CLOSE | BA1 | Morning           | 8:30–9:00 AM    |       |
|     |                   |      | Afternoon         | 3:30–4:00 PM    |       |
|     |                   |      | Evening           | 6:00–8:00 PM    |       |
| 5   | HIGH COURT AREA   | TA2  | Morning           | 7:00–7:30 AM    |       |
|     |                   |      | Afternoon         | 2:00–2:30 PM    |       |
|     |                   |      | Evening           | 6:00–8:00 PM    |       |
| 6   | NESTLE AREA       | TA1  | Morning           | 7:30–8:00 AM    |       |
|     |                   |      | Afternoon         | 2:30–3:00 PM    |       |
|     |                   |      | Evening           | 6:00–8:00 PM    |       |
| 7   | IYANA-IYESI MARKET | CA1 | Morning           | 8:00–8:30 AM    | SUNDAY |
|     |                   |      | Afternoon         | 3:00–3:30 PM    |       |
|     |                   |      | Evening           | 6:00–8:00 PM    |       |
| 8   | IYANA-IYESI JUNCTION | TA1 | Morning           | 8:30–9:00 AM    |       |
|     |                   |      | Afternoon         | 3:30–4:00 PM    |       |
|     |                   |      | Evening           | 6:00–8:00 PM    |       |
| 9   | OJU-ORE           | CA1  | Morning           | 7:00–7:30 AM    |       |
|     |                   |      | Afternoon         | 2:00–2:30 PM    |       |
|     |                   |      | Evening           | 6:00–8:00 PM    |       |
| S/N | LOCATION                   | CODE | PERIOD OF THE DAY | TIME OF THE DAY          | DAY       |
|-----|----------------------------|------|-------------------|--------------------------|-----------|
| 10  | JOJU JUNCTION              | T_{A1}| Morning           | 7:30–8:00 AM             |           |
|     |                            |      |                   | 2:30–3:00 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             | MONDAY    |
| 11  | JOJU EXPRESS ROAD          | T_{A2}| Morning           | 8:00–8:30 AM             |           |
|     |                            |      |                   | 3:00–3:30 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             |           |
| 12  | SANGO UNDER BRIDGE         | C_{A1}| Morning           | 8:30–9:00 AM             |           |
|     |                            |      |                   | 3:30–4:00 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             |           |
| 13  | SANGO CAR PARK             | T_{A3}| Morning           | 7:00–7:30 AM             |           |
|     |                            |      |                   | 2:00–2:30 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             |           |
| 14  | FOWOBI JUNCTION            | T_{A2}| Morning           | 7:30–8:00 AM             |           |
|     |                            |      |                   | 2:30–3:00 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             | TUESDAY   |
| 15  | TOLL GATE EXPRESS          | T_{A2}| Morning           | 8:00–8:30 AM             |           |
|     |                            |      |                   | 3:00–3:30 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             |           |
| 16  | TOLL GATE AREA             | C_{A1}| Morning           | 8:30–9:00 AM             |           |
|     |                            |      |                   | 3:30–4:00 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             |           |
| 17  | OBASANJO JUNCTION          | T_{A1}| Morning           | 7:00–7:30 AM             |           |
|     |                            |      |                   | 2:00–2:30 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             |           |
| 18  | OTA-MARKET AREA            | C_{A1}| Morning           | 7:30–8:00 AM             |           |
|     |                            |      |                   | 2:30–3:00 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             | WEDNESDAY |
| 19  | Ogun State Internal Revenue Area | R_{A1} | Morning           | 8:00–8:30 AM             |           |
|     |                            |      |                   | 3:00–3:30 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             |           |
| 20  | OTA Local Government Secretariat | R_{A1} | Morning           | 8:30–9:00 AM             |           |
|     |                            |      |                   | 3:30–4:00 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             |           |
| 21  | Jack Ross Area (Road)      | C_{A1}| Morning           | 7:00–7:30 AM             |           |
|     |                            |      |                   | 2:00–2:30 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             |           |
| 22  | Chelsea (IDL)              | B_{A1}| Morning           | 7:30–8:00 AM             |           |
|     |                            |      |                   | 2:30–3:00 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             |           |
| 23  | Iganmode SEC School Area/Road | T_{A2} | Morning           | 8:00–8:30 AM             |           |
|     |                            |      |                   | 3:00–3:30 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             | THURSDAY  |
| 24  | All-Over Polytechnic Road  | T_{A2}| Morning           | 8:30–9:00 AM             |           |
|     |                            |      |                   | 3:30–4:00 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             |           |
| 25  | Ologbo Palace Junction     | R_{A1}| Morning           | 7:00–7:30 AM             |           |
|     |                            |      |                   | 2:00–2:30 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             |           |
| 26  | Ijoko Road                 | T_{A2}| Morning           | 7:30–8:00 AM             |           |
|     |                            |      |                   | 2:30–3:00 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             | FRIDAY    |
| 27  | Ijako (Tipper Garrage)     | T_{A2}| Morning           | 8:00–8:30 AM             |           |
|     |                            |      |                   | 3:00–3:30 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             |           |
| 28  | Ijoko Railway Station      | C_{A1}| Morning           | 8:30–9:00 AM             |           |
|     |                            |      |                   | 3:30–4:00 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             |           |
| 29  | Ilogbo Road                | T_{A2}| Morning           | 7:00–7:30 AM             |           |
|     |                            |      |                   | 2:00–2:30 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             |           |
| 30  | Ijoko Market               | C_{A1}| Morning           | 7:30–8:00 AM             |           |
|     |                            |      |                   | 2:30–3:00 PM             |           |
|     |                            |      |                   | 6:00–8:00 PM             | SATURDAY  |
Table A2 (Continued)

| S/N | LOCATION                  | CODE | PERIOD OF THE DAY | TIME OF THE DAY       | DAY  |
|-----|---------------------------|------|------------------|-----------------------|------|
| 31  | IFO ROAD                  | TA2  | Morning          | 8:00–8:30 AM          |      |
|     |                            |      |                  | 3:00–3:30 PM          |      |
|     |                            |      |                  | 7:00–7:30 PM          |      |
| 32  | IGBALA                    | TA2  | Morning          | 8:30–9:00 AM          |      |
|     |                            |      |                  | 3:30–4:00 PM          |      |
|     |                            |      |                  | 7:30–8:00 PM          |      |
| 33  | DALEMO JUNCTION           | TA1  | Morning          | 7:00–7:30 AM          |      |
|     |                            |      |                  | 2:00–2:30 PM          |      |
|     |                            |      |                  | 6:00–6:30 PM          |      |
| 34  | ILO–AWELA ROAD            | TA1  | Morning          | 7:30–8:00 AM          |      |
|     |                            |      |                  | 2:30–3:00 PM          |      |
|     |                            |      |                  | 6:00–8:00 PM          | SUNDAY |
| 35  | INDOMIE AREA              | TA2  | Morning          | 8:00–8:30 AM          |      |
|     |                            |      |                  | 3:00–3:30 PM          |      |
| 36  | TOWER ALUMINUM COMPANY    | BA1  | Morning          | 8:30–9:00 AM          |      |
|     |                            |      |                  | 3:30–4:00 PM          |      |
|     |                            |      |                  | 6:00–8:00 PM          |      |
| 37  | KOLOKOTE AREA             | BA1  | Morning          | 7:00–7:30 AM          |      |
|     |                            |      |                  | 2:00–2:30 PM          |      |
|     |                            |      |                  | 6:00–8:00 PM          |      |
| 38  | OWODE AREA                | CA1  | Morning          | 7:30–8:00 AM          |      |
|     |                            |      |                  | 2:30–3:00 PM          |      |
|     |                            |      |                  | 6:00–8:00 PM          | MONDAY |
| 39  | IDIROKO ROAD (CHELSEA AREA) | TA2 | Morning          | 8:00–8:30 AM          |      |
|     |                            |      |                  | 3:00–3:30 PM          |      |
|     |                            |      |                  | 6:00–8:00 PM          |      |
| 40  | BELLS DRIVE               | RA1  | Morning          | 8:30–9:00 AM          |      |
|     |                            |      |                  | 3:30–4:00 PM          |      |
|     |                            |      |                  | 7:30–8:00 PM          |      |
| 41  | ESTATE AREA               | BA1  | Morning          | 7:00–7:30 AM          |      |
|     |                            |      |                  | 2:00–2:30 PM          | TUESDAY |
|     |                            |      |                  | 6:00–8:00 PM          |      |

Key: C A1 – Commercial Centres; TA1 – Road traffic area (Road junction); TA2 – Road traffic area (Major Road); BA1 – Industrial area; RA1 – Residential area.

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