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Mapping Sound Levels at Selected Telecommunication Base Transceiver Stations, Churches, and Mosques in Port Harcourt, Nigeria

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ABSTRACT

Developing noise maps for cities would be useful for assessing and managing the impact of environmental noise on residents. This study was conducted to develop sound-level maps of parts of Port Harcourt in the Niger Delta region (5.317°N, 6.467°E) of Nigeria to inform impact assessment and management of noise pollution in the city. Using a GM 1352 Sound Level Meter (Benetech Inc., China) and a Garmin 76CX GPS (Garmin, USA), georeferenced sound-level data were collected from 100 telecommunication base transceiver stations (BTS), 50 Churches, and 6 Mosques within Port Harcourt and its environs. ArcGIS® v. 10.3.1 (ESRI Inc., USA) was used to develop the corresponding full-data point sound-level maps by the inverse distance weighting (IDW) spatial interpolation method. Results showed that the BTS sound levels in the residential areas (RA) ranged from 60.2–80.7 dB (A), the mixed residential areas (MRA) ranged from 53.3–75.5 dB (A), and the industrial areas (IA) ranged from 66.0–74.5 dB (A). These sound levels exceeded their WHO permissible limits of 50 dB (A) for RA, 55 dB (A) for MRA, and 70 dB (A) for IA. The sound levels at the mosques (53.3–58.7 dB(A)) also exceeded the permissible limit for RA. On the other hand, the sound levels at the churches—except one (53.4 dB(A))—were less than the permissible limit for RA. Thus, residents around telecom BTS and mosques are more likely to be at risk of noise pollution than residents around churches.

KEYWORDS: Environmental Engineering; Faith-Based Organizations; Noise Map; Noise Pollution; Telecommunication

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1. INTRODUCTION

There are many faith-based organizations in Nigeria, and Nigeria may be broadly divided along religious lines into predominantly Christian south and Muslim north. The Christians carry out their religious activities in the church while the Muslims do in the mosque. These activities include praise and worship. Praise involving singing, clapping of hands, and dancing is common among Christians while worship involving loud prayers is performed by both Christians and Muslims. According to the Christians, loud praise and worship is scriptural, citing Psalm 150:6 in the Holy Bible [Igoni, A.H. (2023) – An Anglican Faithful – personal communication]. Therefore, to make their praise and worship loud enough, the Christians use a variety of percussion and other musical instruments including microphones and loudspeakers, which are a system of variable conversion and manipulation elements that amplify the sound level. The Muslims also use microphones and loudspeakers during worship for the same reason, alluding to Al-Jumu'ah 62:9 in the Quran and Al-Isra' 7:110 [Tubonimi, C.Y. (2023) – A Muslim Faithful – personal communication]. Thus, loud praise and worship have become deeply entrenched in the Christian-Muslim tradition in Nigeria. This may explain why churches and mosques have been reported as major sources of noise pollution in the Port Harcourt metropolis by prior research (Omubo-Pepple *et al*., 2010). Even then, no studies have attempted to quantify the sound levels at these churches and mosques in the Port Harcourt metropolis. Therefore, further studies are needed because chances are that these sound levels may be below or above recommended permissible limits.

Apart from churches and mosques, telecommunication (telecom) base transceiver stations (BTS) are increasingly becoming another source of noise pollution in Port Harcourt. The advent of the global system for mobile communication (GSM) has brought about tremendous opportunities in Nigeria. It has improved governance, security, commerce, health system, and safety on the highways by conducting businesses without much mobility, which has provided job opportunities for the teaming unemployed youths. The opportunities provided by GSM applications in Nigeria are endless; for instance, families are now finding new ways of staying connected on the web.

Telecom services are made possible through radio links between the mobile stations (cellular phones) and the telecom BTS, which is a telecom infrastructure used to facilitate wireless communication between subscriber devices and the telecom operator's networks. In developed countries, telecom BTS are sometimes powered by renewable energy sources such as solar and wind (Chamola & Sikdar, 2016), electricity from the national grid, or a hybrid of both. In developing countries like Nigeria, where electricity supply is a major concern, more than half of the BTS are usually powered by internal combustion (IC) engines with huge operating costs (Goshwe *et al*., 2015). The remaining half connected to the national grid suffers due to the poor quality of the power supply and frequent outages lasting long hours, leading to heavy dependence on IC engines for power supply (Green Power for Mobile, 2013). The IC engines in turn contribute to noise pollution as well as air pollution because of the harmful gases emitted. The quality of GSM service depends on the BTS's proximity to a GSM subscriber; and in coping with the increasing teledensity in Nigeria, most of the BTS are located in residential areas. Across the Port Harcourt metropolis, it is an all-too-common experience to find BTS that are powered by high-capacity IC engines located in residential and mixed residential areas. These IC engines have the tendency to emit sounds of different intensities, which may be below or above recommended limits (NESREA, 2009).

Naturally, sound is not a problem because different species emit and use sound for various purposes including communication between partners or the detection of prey or predators (Sordello *et al.*, 2019). However, sound becomes a problem when it turns into noise, constituting a nuisance to both plant and animal life on earth (i.e., biodiversity). Noise is an unpleasant, usually loud sound that reaches the ear (Silvia *et al.*, 2003); and can be said to be an environmental stressor (Amal *et al.*, n.d). Noise pollution occurs when audible distracting sounds are projected from single or multiple sources leading to the obliteration of any natural process or causing human harm (Akintuyi *et al.,* 2014). Studies have shown that more than 20% of the world population lives under unacceptable noise levels; and in Europe, nearly 60% of the population is exposed to high noise levels during the day (Silvia *et al.,* 2003).

In Nigeria, the National Environmental Standards and Regulations Enforcement Agency (NESREA) is a parastatal of the Federal Ministry of Environment created by the NESREA Establishment Act 2007, signed into law by former President Umaru Yar'Adua, and has been published in the Federal Republic of Nigeria Official Gazette No. 92, Vol. 94 of 31 July 2007 (NESREA, 2014). One of the NESREA's 33

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gazetted regulations is the National Environmental Noise Standards and Control 2009; the purpose of which is to prescribe maximum permissible noise levels of a facility or activity to which a person may be exposed and to provide the control and mitigating measures for the reduction of noise. Nonetheless, since 2010, several public complaints on the issue of noise emitted by power-generating sets at BTS have been received by the Nigerian Communication Commission (NCC), the main regulator of the telecommunication industry in Nigeria (NESREA, 2011). The inability of the NCC to sufficiently address these complaints in line with their guidelines prompted the federal government of Nigeria to promulgate the National Environmental Standards for Telecommunication and Broadcast Facilities Regulations S.I. No. 11, 2011. This regulation states the permissible noise levels and setbacks for different environments and time frames.

Moreover, the World Health Organization (WHO) promotes actions against noise pollution (WHO, 1999). Environmental noise management is a part of environmental impact studies and of guidelines for urban development in various countries (Zanin & de sant'Ana, 2011). In 2002, the European Union presented its guidelines for environmental noise control and limits (King & Rice, 2009). Directive 2002/49/EC of the European Parliament Council of 25 June 2002 relating to the assessment and management of environmental noise requires member states to elaborate noise maps for cities with more than 250,000 inhabitants, due no later than 30 June 2007 (EC, 2002). However, in the Port Harcourt metropolis with an estimated population of 3,020,000 in 2020 (UN, 2019), only qualitative information could be found in the open literature on the sources, effects, and control of noise pollution (Omubo-Pepple *et al.*, 2010).

Generally, in the Niger Delta region and Port Harcourt metropolis in particular, a huge knowledge gap currently exists on the environmental impact of noise pollution on inhabitants. Therefore, the quantitative data on anthropogenic noise obtained in this study add to the existing knowledge base. The objectives of the current study were: (1) to determine geo-referenced sound levels at potential sources of environmental noise including churches, mosques, and power-generating sets at telecom BTS in and around Port Harcourt city and (2) to develop the corresponding full-data point sound-level maps for parts of Port Harcourt metropolis and its environs to inform environmental impact assessment and subsequent management of noise pollution in the city.

2. MATERIALS AND METHODS

2.1 Brief Description of the Study Area

Figure 1 shows the Port Harcourt metropolis and its environs in Rivers State, Nigeria. As stated, Christianity is the predominant religion in Port Harcourt with a few Muslim populations. Thus, there are more churches than there are mosques in the city. Port Harcourt has an estimated population of 3,020,000 in 2020 (UN, 2019). Its land mass covers 360 km2 with water occupying 9 km^2. It lies along the Bonny River and is located in the Niger Delta region of Nigeria at latitude 5.317°N and longitude 6.467°E. The city is host to a large number of telecoms BTS including those of MTN, GLO, AIRTEL, and 9-Mobile. According to NESREA (2009) land use classification scheme for noise levels, Port Harcourt is classified into the following land use areas: (i) residential (RA), (ii) mixed residential with some commercial and entertainment activities (MRA), (iii) residential and the industry or small-scale production and commerce (RIA), and (iv) industrial (IA).

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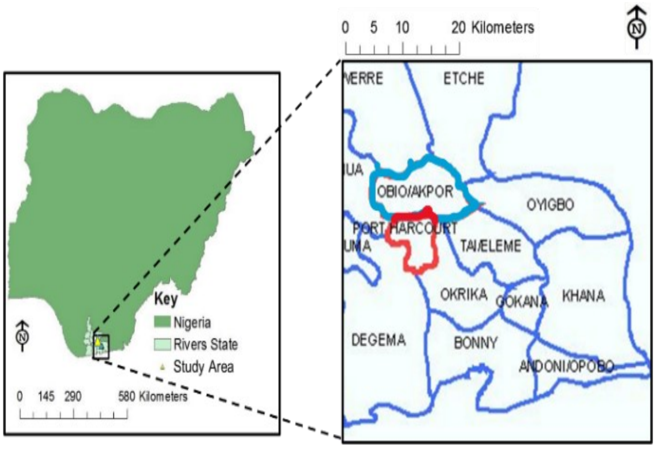

Figure 1: Map of the study area, Port Harcourt, Rivers State in the Niger Delta region of Nigeria (Datum and Projection: GCS/WGS 1984. Africa and Nigeria shape file source: ESRI®, CA, USA).

2.2 Noise Measurement

Noise measurements are normally reported in decibels (dB), which is logarithmic. Decibel can be defined in terms of sound power level (in W), sound pressure level (in Pa), and sound intensity level (in W/m^2). Here, we define decibel in terms of sound pressure level, which is a measure of the effective sound pressure of a sound relative to a reference value on a logarithmic scale. It is determined using the expression in Equation 1 (Sincero & Sincero, 1996).

$$L_p(dB) = 10.\log_{10}\left(\frac{P_{rms}^2}{P_{ref}^2}\right) \quad (1)$$

Where, L_p = Sound pressure level (dB); P_{ref} = Reference sound pressure (2 x 10^{-5} Pa) in air or other gases usually taken as the threshold of human hearing (at 1 kHz); and P_{rms} = RMS sound pressure being measured (Pa). Substituting P_{ref} = 2 x 10^{-5} (Pa) in Equation 1, we have equation 2.

$$L_p(dB) = \log_{10}\left(\frac{P_{rms}^2}{4.0\times10^{-10}}\right) \quad (2)$$

However, it is difficult for people to hear all frequencies or pitches of sound; thus, A-weighted decibels, dB(A), is normally used to describe sound pressure level based on what human ears can actually hear (Sincero & Sincero, 1996).

Using the simple random sampling design, a digital Sound-Level Meter, GM1352 (Benetech, China) was used to measure the sound levels at the churches, mosques, and telecom BTS. The device conforms to the International Electro-Technical Commission (IEC) 61672-1: 2013. It has a measurement range of 30–130dB(A), an accuracy of ±1.5dB, a frequency of 31.5Hz–8KHz, a resolution of 0.1dB, and A-weighting frequency weighting features. A calibration check was done on the Sound-Level Meter before and after use to avoid interference. To take the reading, the Meter was switched on and held at arm's length with the microphone pointing towards the sound source. A global positioning system (GPS), Garmin Max 76CX (Garmin, USA), was used to obtain geographic coordinates (i.e., Northings and Eastings) of the sampling points. The power button of the GPS was first switched on and placed in front with the top tilted upwards. The GPS receiver was then set for signals and signals were acquired at a fixed location. For the BTS, sampling was done between 6 am and 10 pm throughout the sampling period. For the churches and mosques, we targeted the peak periods including morning (5-10 am), afternoon (12-3 pm), and evening (4-8 pm) using 0, 5, 10, and 15m setbacks. It is important to state that the sound considered at the BTS does not include any other background/interfering sound because we maintained a very close distance (about 4cm) to the generator, making it extremely difficult for the Sound-Level Meter to pick up spurious sounds from the surrounding.

2.3 Development of the Full-data Point Noise Map

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The noise maps were developed using ArcGIS® v. 10.3.1 (ESRI Inc., USA). Data points were interpolated by the inverse distance weighting (IDW) method according to the methods described by Okparanma *et al.* (2014). However, the geographic coordinates of the data points were converted from the geographic coordinate system (GCS) to the Universal Transverse Mercator (UTM) of Nigeria Mina Mid-Belt national grid using Pocket Survey v. 10.1. Pocket Survey helps in converting from GCS to UTM and vice versa. The data was saved in comma-separated variables (CSV) file format in Excel® (Microsoft Inc., USA). The coordinates were imported into the ArcGIS® environment. Shapefiles were created for the digitization of roads and prominent features. The Ikonos Imagery was deployed into the ArcGIS® environment, which has a 0.2 m resolution. The roads were digitized and named with the help of the Ikonos Imagery.

Using the default class interval setting, the sound levels were demarcated into zones. These zones had different sound levels represented with colour ramps. In this study, we propose sound-level risk zones (RZ) based on NESREA's land use classification system. The sound-level data collected were then categorized into two broad RZ, namely: no-risk zone (NRZ) and high-risk zone (HRZ). Within the RA, areas with sound levels >50dB (A) were categorized as HRZ while areas with sound levels ≤50dB (A) were categorized as NRZ. For the MRA, areas with sound levels >60dB (A) were categorized as HRZ and areas with sound levels ≤60dB (A) were categorized as NRZ. For the IA, areas with sound levels >70dB (A) were taken as HRZ while areas with sound levels ≤70dB (A) were considered as NRZ.

3. RESULTS AND DISCUSSION

3.1 Setback compliance level by telecom BTS operators in Port Harcourt and its environs

Setback is the distance from the foot of the mast to the nearest residential property (NESREA, 2009). In this study, a setback compliance check was done only for the telecom BTS because there are little or no planning restrictions for faith-based organizations in the country. Of the 100 telecom BTS studied, 56 (representing 56%) were observed to be located within the RA, 40 (representing 40%) were within the MRA, 4 (representing 4%) were within the areas categorized as IA, and none within the RIA (Table not shown).

For the MRA, it was observed that the setbacks ranged from 1.47 to 10.20 m, with 39% of the setbacks in breach of the NESREA (2009) standard of 10 m (Table not shown). Within the RA, it was observed that the setbacks varied from 1.7 to 17.6 m, with 46% of those also in breach of NESREA (2009) recommended setback of 10 m (Table not shown). The implication of these setback violations is that residents around 39 and 46% of the BTS in the studied MRA and RA, respectively would be subjected to daily high-intensity sound levels from the BTS since sound level increases as the distance from the source decreases. On the other hand, in the IA, the setbacks ranged from 3.5–6.7m (Table not shown), with 100% of the setbacks within the recommended setback of 10 m (NESREA, 2009); indicating that there were no setback violations within the IA. This 100% compliance level might be because of the location of NESREA's office within the IA.

3.2 Full-data point sound-level maps of telecom BTS in Port Harcourt and its environs

Figure 2 shows the sound level contour map of the studied telecom BTS within the Port Harcourt metropolis and its environs. It shows the noise status propagated around the studied area. The yellow areas show the LRZ in the RA to be around Rumuepirikom, Fimie-Ama, and

Mgbuoba; with sound levels ranging from 60.2 to 63.6 dB(A). Here, these yellow areas are categorized as LRZ because the sound levels of 60.2 to 63.6 dB(A) only slightly exceeded the WHO (1999) and NESREA (2009) maximum permissible limit of 50 dB(A) for the RA. However, the brown areas are the HRZ in the RA around Mgboshimini, Rumuibekwe, and Elekahia; with sound levels between 72.0 and 80.7 dB(A). Here, the sound levels were on average 1.5 times higher than the maximum permissible limit of 50 dB(A). Considering the high sound level from the BTS in the Mgboshimini area (80.7 dB(A)) and its unsafe setback of 2.2 m, it is only a matter of time before residents in the area begin to feel the negative impacts of the noise. The impacts could range from headaches, annoyance, noise-induced hearing loss (NIHL), and disruption of communication and sleep, which may lead to high blood pressure and other cardiovascular diseases as reported by WHO (1999). These results also clearly show that the operators of these BTSs are not only non-compliant with the set standards but have gradually converted these spaces designated as purely RAs to MRAs and IAs. A similar study conducted by Omubo-Pepple *et al.* (2010) on the sources of noise pollution in the Port Harcourt metropolis confirmed that one of the main sources of noise pollution in Port Harcourt was power-generating sets. Therefore, there is a high priority for the control of noise pollution within these areas in the city.

In the MRA, it can be observed that the green–yellow areas with the least levels of sound were around Eagle Island, Rumuokuta, Ogbunabali, and Mile 2 Diobu, with sound levels ranging from 53.3 – 60.3 dB(A). Here, the sound emitted from the BTS around the Eagle Island (green) area (representing 2.5% of the sound levels) was within NESREA (2009) permissible limit of 55 dB(A) for MRA. This suggests that Eagle Island is within the NRZ of the MRA with no priority for intervention. The highest sound levels were observed in BTS hosted around Rumukalagbo, Aba Road, Mile 3 Diobu with sound levels ranging from 69.9 – 75.3 dB(A). These brown areas in the MRA are the HRZ with high priority for intervention. At Mile 3 Diobu area where the highest sound level of 75.3 dB(A) and a setback of 9.8 m were recorded, the residents in this area would be negatively impacted by the noise level, but some residents may not experience the chronic impact of the noise because: (1) some of the people are non-resident business operators who do not stay in the area 24 hours a day and (2) the safe setback of 9.8 m. Apart from the health impacts of the sound emitted due to non-compliance with set operating standards by the BTS operators, it is also evident that the MRA is being converted to an IA.

For the IA, Figure 2 shows that the yellow areas around Nkpogu and Amadi Street had sound levels ranging from 66 – 70 dB(A) and fall within the permissible noise limit of 70 dB(A). Therefore, these yellow areas are in the NRZ of the IA and require no urgent intervention. On the other hand, the brown areas around Trans-Amadi industrial layout had the highest noise level of 74.5 dB(A), but within a safe setback of 4.8 m. This suggests that the area falls within the HRZ of the IA, requiring a high priority for intervention. Undoubtedly, the sound level will negatively impact employees of companies within the IA, especially those who work longer than the normal working hours. To further compound the situation, the additional effect of the continuous sound from facilities owned by the companies could result in more serious health problems over time.

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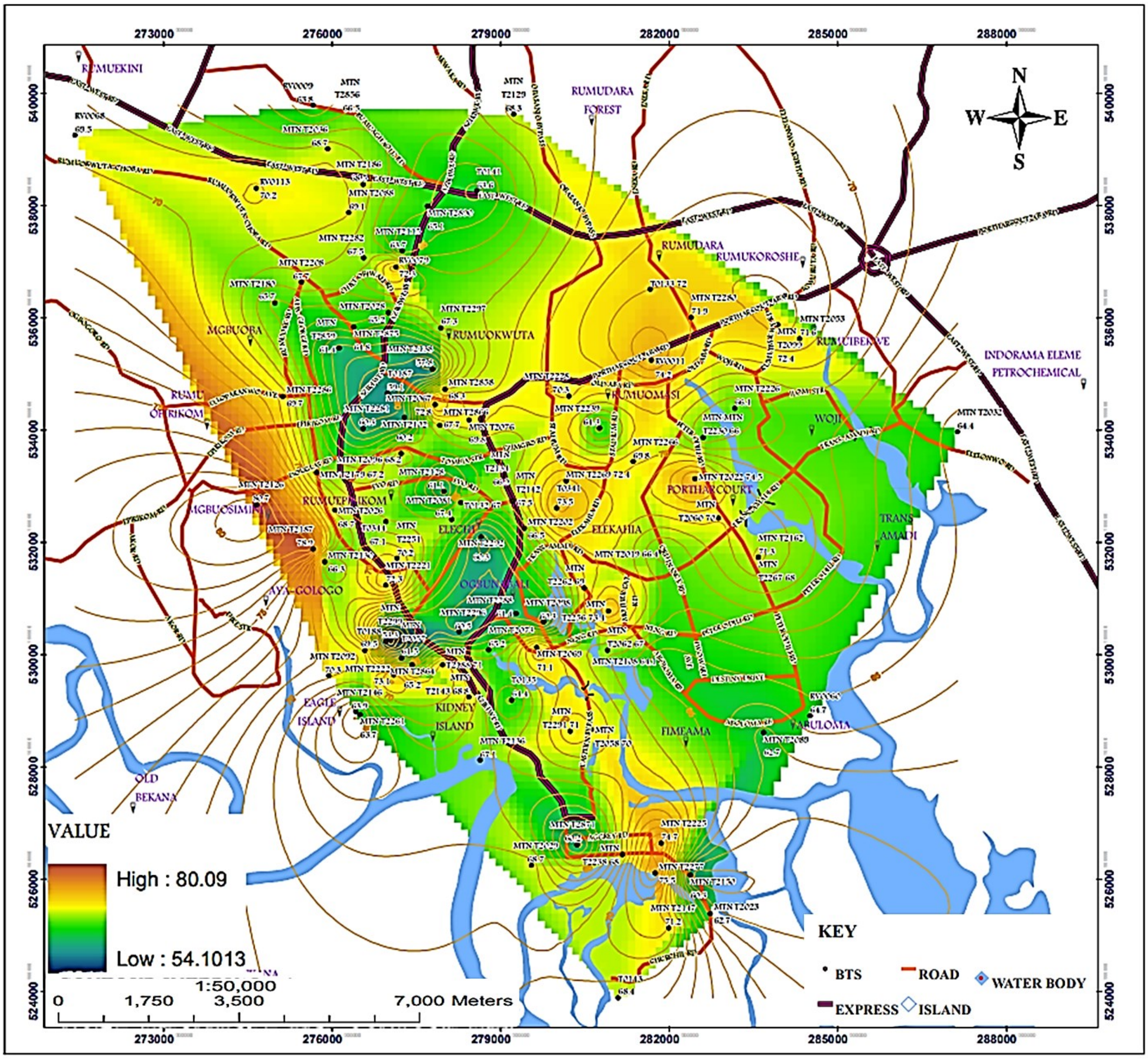

Figure 2: Sound-level contour map of telecom BTS within the Port Harcourt metropolis and its environs. (Contour interval = 1m).

3.3 Full-data point sound-level map of faith-based organizations in Port Harcourt and its environs

The tables of the sound levels detected at various setbacks and times of the day for the studied 56 faith-based organizations in Port Harcourt and its environs are not shown for anonymity reasons. However, the table is available on demand. In this study, only two faith-based organizations including churches and mosques were studied. A total of 50 churches and 6 mosques spread across Port Harcourt and its environs were covered. As stated, the dominant religion in Port Harcourt is

Christianity, which explains why more churches than mosques were covered in this study.

Figure 3 shows the corresponding full-data point sound-level map in areas categorized by NESREA as RA at zero setbacks obtained during the morning hours. Across the city, it is evident from Figure 3 that sound levels from a majority of the churches in the city are within the WHO (1999) and NESREA (2009) maximum permissible limits of 50 dB(A) for RA. This explains why there are bluer, greener, browner, and yellower areas than red and purple areas in the map (Figure 3). The few purple and red areas show areas with higher sound levels than the permissible level, which obviously are due to the relatively higher sound levels at the mosques and one of the churches in the affected areas.

Specifically, the highest sound level of 53.4 dB(A) was recorded at one of the churches along NTA Road, Mgbuoba, Port Harcourt while the least sound level of 40.1 dB(A) was observed in two churches around Mile 3 in Diobu, Port Harcourt. Apart from the slightly higher sound level of 53.4 dB(A) recorded at one of the churches along NTA Road, Mgbuoba, Port Harcourt, all the sound levels recorded at other churches were within the WHO (1999) and NESREA (2009) maximum permissible limit of 50 dB(A) for RA. Thus, a majority of the areas are within the NRZ while just a fraction of the areas is in the LRZ of the RA. This suggests that residents in a greater part of the area covered in the study would be at no risk of noise pollution while a few inhabitants would be at low risk of noise pollution due to the presence of churches in their neighbourhood.

More so, considering the sound levels at the three different setbacks chosen in this study (5, 10, and 15m) (Table not shown), it was observed that residents within the least setback of 5m from the churches would be at no risk of noise pollution since the sound levels at the 5m setback were well within the WHO (1999) and NESREA (2009) maximum permissible limits of 50 dB(A) for RA. Surprisingly, this observation is contrary to the widespread opinion that churches generally are a major source of noise pollution in the Port Harcourt metropolis and its environs (Omubo-Pepple et al., 2010). This observation is further corroborated by widely documented reports that only continuous exposure to sound levels of up to and above 80 dB(A) for up to 8 hours is capable of damaging tiny sensory hair cells in human ears and causing NIHL. Moreover, the duration of praise and worship in churches and mosques is hardly up to 8 hours continuously, making it extremely difficult for worshippers, let alone non-worshippers, to be exposed for up to 8 hours.

On the other hand, the sound levels of 53.3 to 58.7 dB(A) recorded at all the mosques studied slightly exceeded the WHO (1999) and NESREA (2009) maximum permissible limits of 50 dB(A) for RA. Thus, these areas fall within the LRZ of the RA. With this marginally high sound levels at the mosques, residents in the areas would be at mild risk of noise pollution, which is a warning sign that needs to be addressed before the risk increases from mild to severe.

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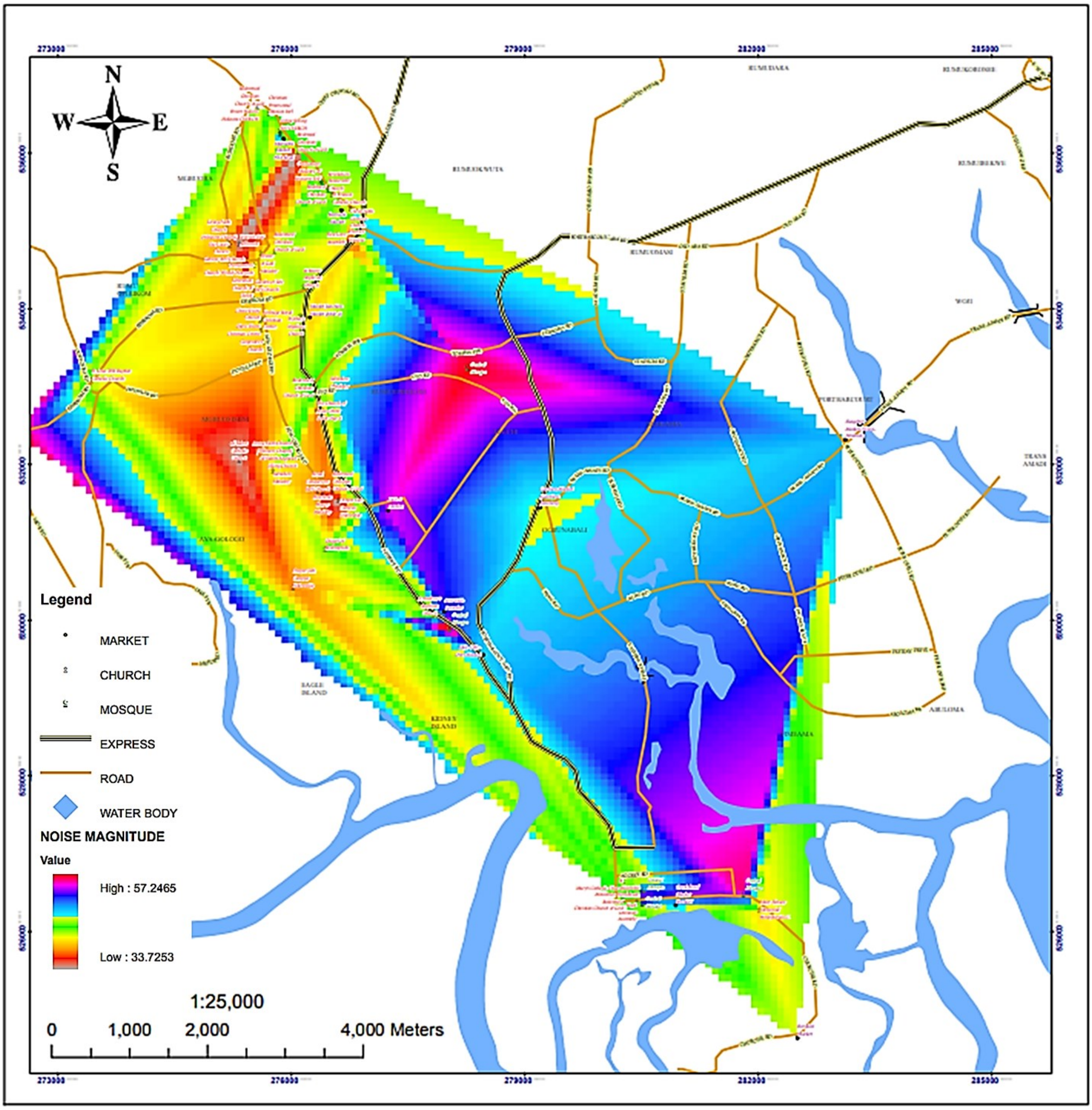

Figure 3: Full-data point sound-level map of faith-based organizations in areas categorized by NESREA as residential areas at zero setbacks during the morning hours in Port Harcourt and its environs.

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4. CONCLUSION

This study measured and mapped the levels of sound emitted by churches, mosques, and generators powering telecom BTS in the Port Harcourt metropolis and its environs. Results obtained show that the BTS sound levels in the residential areas ranged from 60.2–80.7 dB(A), the mixed residential areas ranged from 53.3–75.5 dB(A), and the industrial areas ranged from 66.0–74.5 dB(A). These sound levels exceeded their WHO permissible limits of 50 dB (A) for residential areas, 55 dB (A) for mixed residential areas, and 70 dB (A) for industrial areas. The sound levels at the mosques ranging from 53.3–58.7 dB(A) also exceeded the permissible limit for residential areas. On the other hand, the sound levels at a majority of the churches were less than the permissible limit for residential areas. Thus, residents around telecom BTS and mosques are more likely to be at risk of noise pollution than residents around the churches, which is a warning sign that needs to be addressed before the risk increases from mild to severe.

REFERENCES

Akintuyi, A. O., Raji, S. A., Adewuni, D., Wunude, E. O. (2014). GIS-Based Assessment and Mapping of Noise Pollution in Bariga Area of Lagos State, Nigeria. *Sokoto Journal of the Social Sciences.* 4(1), 154-167.

Amal, I., Oussama, J., & Nicolas, E. (n. d). Urban Noise Mapping: The Case of the City Of EI-Mina, North Lebanon.

Chamola, V. & Sikdar, B., (2016). Solar Powered Cellular Base Stations: Current Scenario, Issues and Proposed Solutions. *IEEE Communications Magazine*, 54(5) Doi: https://doi.org/10.110/mcom2016.7470944

EC (European Commission) (2002). 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, Official *Journal of the European Communities,* 189, 12-26.

Goshwe, Y., Kureve, D., & Okeleke, A. (2015). Performance Evaluation of Power in GSM BTS in Nigeria Using PV Solar System. *Journal of Energy Technologies and Policy, 5*(8): 2225-0573.

King, E. A. & Rice, H. J., (2009). The Development of a Practical Framework for Strategic Noise Mapping Applied Acoustics, 70, 1116-1127.

National Environmental Standards and Regulations Enforcement Agency (NESREA) (2014). Training Manual. Abuja, Nigeria

National Environmental Standards and Regulations Enforcement Agency (NESREA) (2009). *Noise Standards and Control,* 67(96):1299-1318.

National Environmental Standards and Regulations Enforcement Agency (NESREA) (2011). *Standards for Telecommunication and Broadcast Facilities,* 38(98):361-370.

Okparanma, R. N., Coulon, F., Mayr, T., & Mouazen, A. M. (2014). Mapping Polycyclic Aromatic Hydrocarbon and Total Toxicity Equivalent Soil concentrations by Visible and Near-Infrared Spectroscopy. *Environmental Pollution,* 192:162-170.

Omubo-Pepple, V., Briggs-Kamara, M., & Tamunobereton-ari, I. (2010). Noise Pollution in Port Harcourt Metropolis: Sources, Effects, and Control. *The Pacific Journal of Science and Technology,* 11(2):592-600.

Silvia, R., Ricardo, H. & Luis, C. J. (2003). Evaluation and Predication of Noise Pollution levels in Urban Areas of Cdiz

(Spain). *Acoustical Society of America Journal,* 114, 2439-2439.

Sincero, A. P., & Sincero, G. A. (1996). Environmental Engineering: A Design Approach. Prentice-Hall Inc., NJ, USA.

Sordello, R., De Lachapelle, F. F., & Livoreil, B., Vanpeene, S. (2019). Evidence of the environmental impact of noise pollution on biodiversity: A systematic map protocol. *Environmental Evidence,* 8(8): Doi: https://doi.org/10.1186/s13750-019-0146-6.

UN (United Nations) (2019). World Population Prospects 2019. Department of Economic and Social Affairs, United Nations, Geneva, Austria. Available at: https://population.un.org/wpp/ (accessed 05.10.2020).

WHO (World Health Organization) (1991). Report of the Informal Working Group in Prevention of Deafness and Hearing Impairment Programme Planning. WHO/PDH/91. Geneva. 18-21.