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ARTICLE

Seismic Background Noise Analysis from the Seismic Station Located at the University of Abuja, Northcentral Nigeria

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Abstract: In October 2018, the Federal Government of Nigeria established several seismic stations in different places in the country. Three of these stations are located in the Abuja region (the Federal Capital Territory, or FCT) and are managed by the Nigerian Geological Survey Agency. Over the past few years, several low to intermediate earthquakes have been recorded within and around the Abuja region. These occurrences have provided valuable opportunities to study seismic earth noise using the dataset collected from the VolksMeter II seismometer installed at the University of Abuja. The data was processed using the Win QUAKE software to analyze the seismic background noise by identifying its sources. This analysis aimed to examine the seasonal and/or daily noise levels and check the seismometer's stability through spectral display. The physical examination and/or quantitative observation of the spectrum revealed that there was a distinct area with densely high ranges between 0.08 and 10 s, corresponding to a frequency range of 0.1Hz−12.53Hz. This assessment involved a full Fast Fourier Transform (FFT) calculation. The spectral analysis indicated the presence of noise burbles, primarily attributable to instrumental noise. These noise burbles were prominent in the east-west direction during the months of March, April, May, and June 2019, with frequencies of 0.03Hz, 0.04Hz, 0.03Hz, and 0.03Hz, respectively. A similar pattern was observed in the north-south direction, with noise peaks of 0.07Hz in the months of January, April, and July 2019. The findings from this study of seismic noise amplitude demonstrate a clear correlation with the global seismic noise models. The sources contributing to the station's noise levels encompass factors such as wind, geological influences, instrumental noise, and human activities including machinery and airport operations as well as vehicular traffic. These observations highlight the potential of using background seismic noise to quantify tremors and monitor their spatial variations, a task that remains difficult with traditional approaches.

Keywords: VolksMeter II, Seismic station, Background noise, Spectrum, University of Abuja.

1. Introduction

Tectonically, Nigeria is located in the transition zone between the West African continental plate and the Congo continental plate within the West African Mobile Zone (Fig. 1). Although this transition zone is classified as a stable seismic region, Nigeria has experienced a series of earthquakes ranging in magnitude of 4 to 5 since the early 1930s which led to in-depth studies into the seismology of the country [1]. Given Nigeria's relative seismic stability, there have been only a few seismological observatories/stations with a well-established tradition of data collection. However, due to the menace of earthquakes and the subsequent global attention given to it, the Federal Government of Nigeria has recently established

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several seismic stations across the country. The collected seismic dataset from these stations gives an opportunity to run multiple seismological studies, such as fault stability, seismic risk analysis, and seismic noise analysis. Three seismic stations are located in the Abuja region and are managed by the Nigerian Geological Survey Agency (NGSA), Abuja. These stations are distributed over the region as follows: (i) the Nigerian Geological Survey Agency (NGSA) in the Abuja Municipal Area Council, (ii) the University of Abuja in the Gwagwalada area council, and (iii) Veritas University in the Bwari area council (Fig. 2) [3].

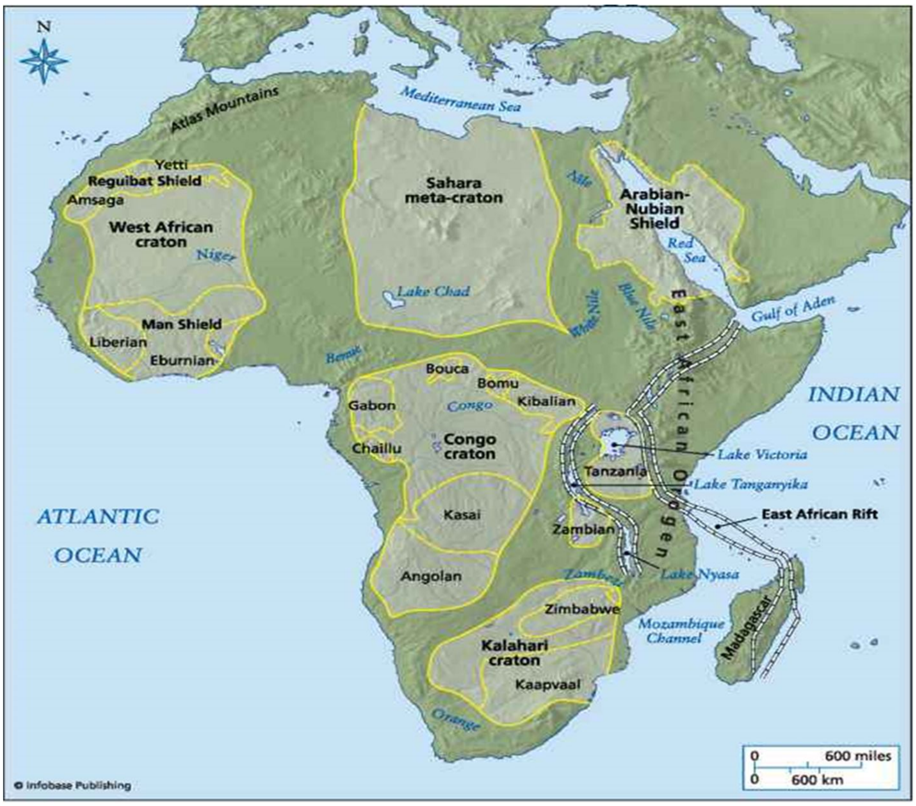


FIG. 1. Map of Africa showing cratons, orogens, rifts, and main geographic elements (modeled from [2]).

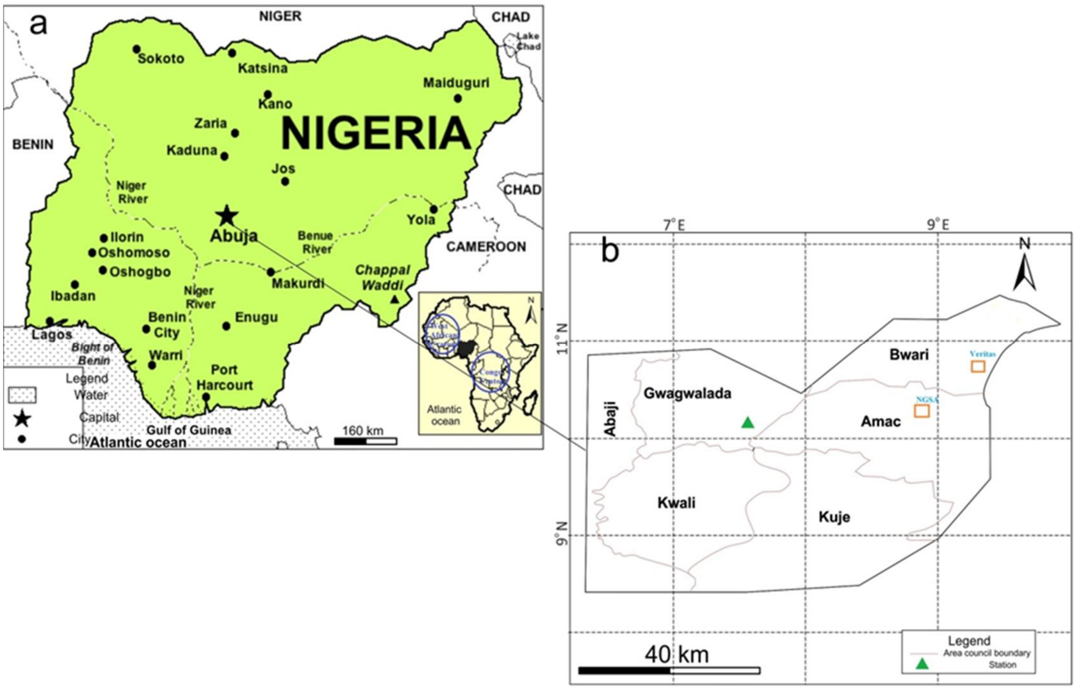


FIG. 2. Regional map of Nigeria shows the location of the Abuja region in the center of the country. Inset: Map of Abuja region showing the location of the three Seismic Stations [5].

The area underlain by the Precambrian rocks, specifically the Nigerian Basement Complex, [4] has not been previously subjected to any form of earthquake analysis or investigation.

This study aims to investigate the different sources of seismic noises at the University of Abuja station. To assess the performance of the station, its noise waveform is estimated by analyzing frequencies, amplitudes, and periods and then comparing these findings with the global noise model. Noise is the component of the signal that does not convey any meaningful information from the specified source and often interferes with the useful signal. Over the years, the analysis of results has revealed that noise is temporally or spatially variable, characterized by strong frequency dependence [6]. It can be treated as a function of location and time, varying with respect to day and season. Sensitive seismographs will record the ground motions even in the absence of earthquakes. These motions are called microseisms, describing the permanent Earth's surface vibration that can be generated primarily by wind, cultural noise at high frequencies, ocean waves, and atmospheric effects at longer periods [7], [8]. It should be noted here that the noise from anthropogenic and natural sources impedes the process of unsheathing the useful details required for further analysis. The lower the noise levels, the better the efficiency of the stations in detecting earthquake signals [6].

Despite Abuja's status as the capital of Nigeria, very little is known about seismic activities in the Federal Capital Territory (FCT) in relation to the geologic evolution of key tectonic features. Following the recent earth tremors that occurred in the Abuja region, studies have indicated that these tremors occurred due to the reactivation of old and new crustal fault systems [3]. Seismographs have been installed within Abuja to monitor seismic activities, both local and teleseismic. No seismic or vibration investigation for noise analysis has been previously conducted in this area. The present study aims to address this gap by analyzing seismic noise data provided by the University of Abuja station. Given that the VolksMeter II began recording data only in January 2019, it's crucial to gather seismic noise information as it can offer insights into the signal quality for future events. Enhancing the quality of seismic data often involves minimizing noise levels, making it imperative to quantify and comprehend seismic noise. [9]. Therefore, this study focuses on analyzing the seismic station's background noise, and, more importantly, aims to provide information on the sources contributing to the noise levels.

2. Location and Geology of the Study Area

The Abuja region is located in the center of Nigeria within the Federal Capital Territory (Fig. 2). It lies approximately between longitudes 6°46'E to 7°37'E and latitudes 8°21'N to 9°18'N (Fig. 2). On the east, it is bounded by the Nasarawa State, north by Kaduna State, west by Niger State, and south by Kogi State. It is composed of metamorphosed supracrustal exogenetic rocks, migmatite complex intrusive coarse-grained granite, and minor intrusions like rhyolites. Additionally, other formations such as quartzite, pegmatite, and quartz veins are present, as illustrated in Figure 3 [10]. Structural elements, such as foliations, joints, and faults are mostly common in the area on most of the rock types of present. The area records its highest temperature during the dry season, from November to March. The mean monthly temperature ranges between 25.80 and 30.20 ^{0}C and the mean annual rainfall in the Abuja region ranges from 1000 to 1600 mm [11]. Two major types of vegetation (forest and savanna) are found within the Abuja region. The forest is predominantly of woody plants, in which grasses are virtually absent.

3. General Historical Review of Seismicity in Nigeria

The earliest documented earth tremors in Nigeria were reported in Warri, in the Delta region of the country, in 1933. On December 8, 1984, a tremor was reported in Yola, Gongola State. In April 1990, there were reports of strange shaking of the earth in Jere town, Kaduna State. Some cracks, suspected to have been caused by volcanic eruptions, were noticed in September 1988 in Osererun hills in Gombe council area of Gongola State threatening about 10,000 inhabitants. Two hectares of farmland and many animals were lost. Five days after the 1984 tremor, in Ibadan, Ijebu-Ode, and Abeokuta, two main settlements 68 km to the southeast and 77 km to the southwest, respectively, were hit by a more ferocious tremor that left cracks in buildings.

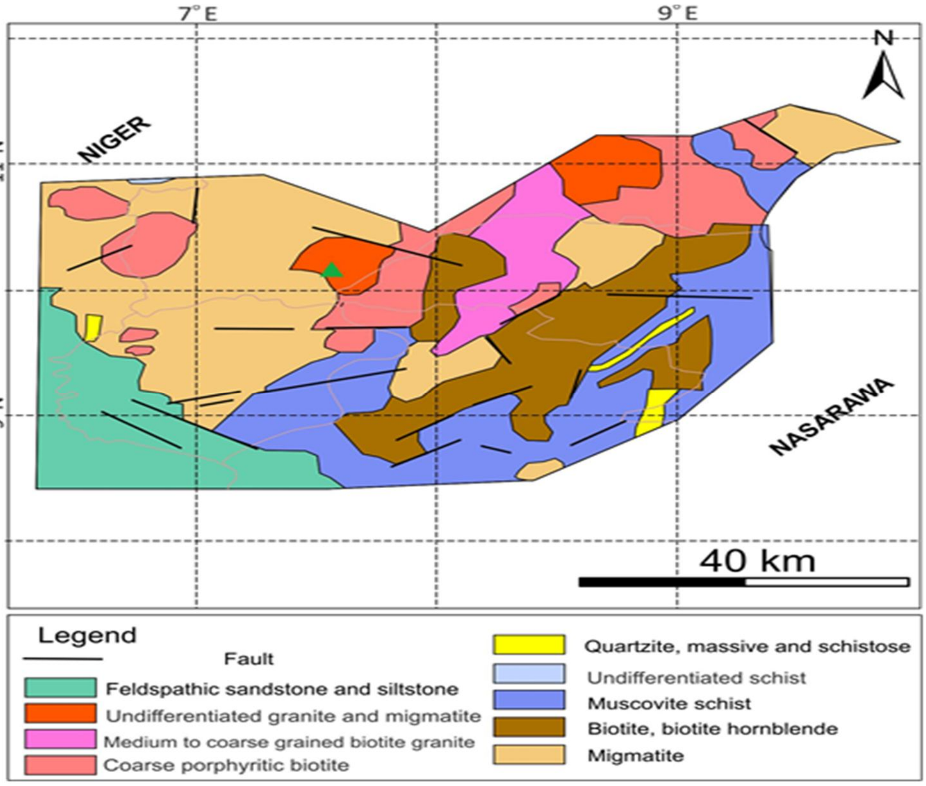


FIG. 3. Detailed geological map of Abuja Region (modified from Geological map of Abuja showing the rock types (outcrops) after [12].

The earthquake seismic event which lasted for only two seconds affected Sobo, Porogun, Oliworo quarters, the Ondo-Benin road, and neighboring villages. Thus, the Ijebu-Ode tremor spread very far. The geological composition of the area surrounding Ibadan primarily consists of rocks from the migmatite-gneiss-quartzite complex. This complex forms a significant portion of Nigeria's Precambrian basement complex. Migmatite gneisses are heterogeneous rocks made up of several distinct petrologic units [13], [14]. The two main rock types in the area are grey gneiss and granite gneiss. The granite gneiss which forms the hills in addition to a few level outcrops is intrusive into the grey gneiss. All the rocks have undergone strong deformation and as a result show microfolds, microfaults, and linear fabrics. In April 1988, panic gripped the inhabitants of Amauzu Ede-Obela in the Edema council area of Anambra State where about 12 km of land had cracked. Houses built with zinc also cracked. There are reports of annual tremors in some areas of Rivers State, especially during the month of April. Nigeria is not located in a seismically active region; however, a couple of historical and instrument earthquakes have been observed in the country as stated earlier. Despite the minimal impact of these earthquakes, with no loss of lives and only a few cases of structural damage, the importance of establishing a network of seismographic stations in the country for effective local earthquake monitoring has become evident. Figure 3 shows the seismicity of Nigeria from 1933 to 2018, seismic stations, and the suture zone (i.e. faults) therein.

There are, some confirmed and others not, faults, like the SW-NE trending Ifewara Zungeru fault which is believed to be responsible for the various earthquakes experienced in Southwestern Nigeria [15]. Several minor earthquakes had also been experienced in other parts of the country in 1939, 1964, 1994, 1997, 2000, 2006, 2016, and 2018 with intensities ranging from III to VI based on the modified Mercalli intensity scale. But only a few of these tremors like the 1990, 1994, and 2000 events were recorded instrumentally [15], [16]. Earthquakes that occurred on 28th July and 2nd August 1984 whose vibrations were felt in southwestern Nigeria towns of Ijebu-Ode, Ibadan, Abeokuta, etc., prompted the Federal Government of Nigeria through the Federal Ministry of Science and Technology to set up the National Technical Committee on Earthquake Phenomena (NTCEP) to advise it on measures to adopt to mitigate the effects of such occurrences. In 1995, the NTCEP recommended the establishment of the NNNSS with the initial plan for a central station in Abuja. However, later considerations led to the selection of Toro, along with the establishment of nine remote stations. The remote stations were to be sited at Abuja, Kaduna, Minna, Ile-Ife, Ibadan, Oyo, Nsukka, Awka, and Abakiliki. In the same vein, in 1989, Nigeria through the effort of the NTCEP indicated her interest in participating in the global cooperative program in Space Geodesy with the aim of providing insight into African plate tectonics, global geodynamics, and the study of earthquake mechanisms. The central and remote stations were subsequently constructed in 2001 and 2002. The remote causes of the Abuja Tremors were documented by [17]. He reported that the Abuja area falls within the diametrically opposite zone of all the major earthquakes that occurred around the world recently. The observed tremors in the Abuja region occurred on fault systems that are very close to failure because of the induced shear stresses from the large teleseismic events and anthropogenic factors are much smaller than the expected lithostatic loads. The author also affirmed that the presence of very high pore fluid pressure is another way in which the new and old faults might have been weakened, whereby they were strongly influenced by the dynamic stresses from these teleseismic sources events. Plates 2-4 below show the history of seismicity in Nigeria and its immediate environs from 1933 to 2018 and the recent earth tremor in the Abuja region (Plate 1).

Plate 2 depicts the locations of reported tremors: Mpape, Maitama, Gwarinpa, and Kubwa (from BBC Nigeria, pidgin).

Plate 3 shows a satellite view of the regions affected by tremor, with filtered aeromagnetic data overlay and associated structural discontinuities, indicating potential faults.

Plate 4 displays interpreted faults from aeromagnetic (red lines) and SRTM digital elevation maps (yellow), showing the general orientation (strike) of the upper-crustal discontinuities

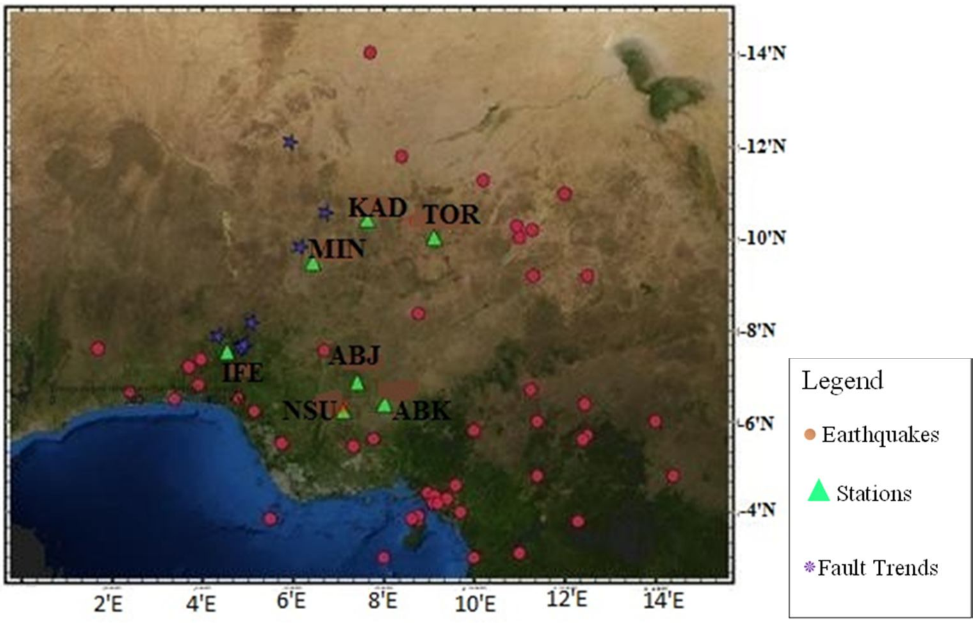
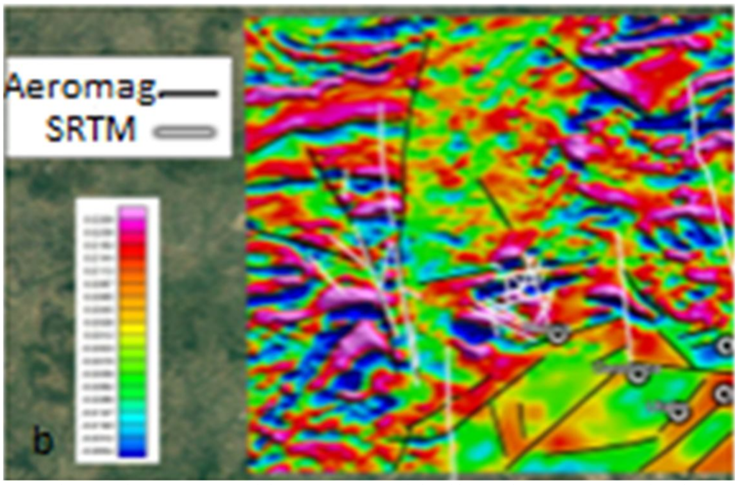


Plate 1. Seismicity of Nigeria and immediate environs from 1933 to 2018. Red balls represent earthquakes; Green triangles denote stations and blue stars show the trending of the Ifewara-Zungeru fault in Nigeria [3].

Plates 2. Locations of reported tremors: Mpape, Maitama, Gwarinpa, and Kubwa [3].



Plates 3. Satellite view of the regions affected by tremor, with filtered aeromagnetic data overlay and associated structural discontinuities, showing potential faults [3].

Plate 4. Interpreted faults from aeromagnetic (red lines) and SRTM digital elevation maps (yellow), showing the general orientation (strike) of the upper-crustal discontinuities [3].

4. Materials and Methods

4.1 Materials

The VolksMeter II (Plate 5) was used to carry out this study. It uses a unique, patented, Symmetric Differential Capacitor (SDC) array sensor to detect and measure minute accelerations and tilts. The sensor consists of two fixed printed circuit boards holding the transmitting and receiving capacitor plates and a moving Faraday shield array, mounted on the end of a pendulum. When subjected to accelerations or tilts, the shield array on the pendulum moves relative to the fixed plates and changes the amount of receiving plate that is exposed to or shielded from the transmitting plates. This, in turn, changes the overall capacitance of the sensor. A magnetic eddy damper, located below the sensor plates, damps oscillations of the pendulum. A direct Capacitance-To-Digital-Converter (CDC) chip converts the current capacitance of the sensor array to a 24-bit number. An interface board in the VolksMeter controls the CDC chip and formats the acquired data for transmission to the support computer, 1 or 2. The VolksMeter requires a dedicated support computer (Windows XP, 2000, or Vista) employing the user-friendly software tool WINSDER for data logging, display, analysis, and, optionally, networking. WINSDR produces Public Seismic Network (PSN) event files that can be viewed and analyzed using WinQUAKE. After 60 minutes WINSDR will close the data control dialog box and resume recording. This instrument may be installed on any hard, flat surface with a good connection to the earth and set up as shown in Plate 6.

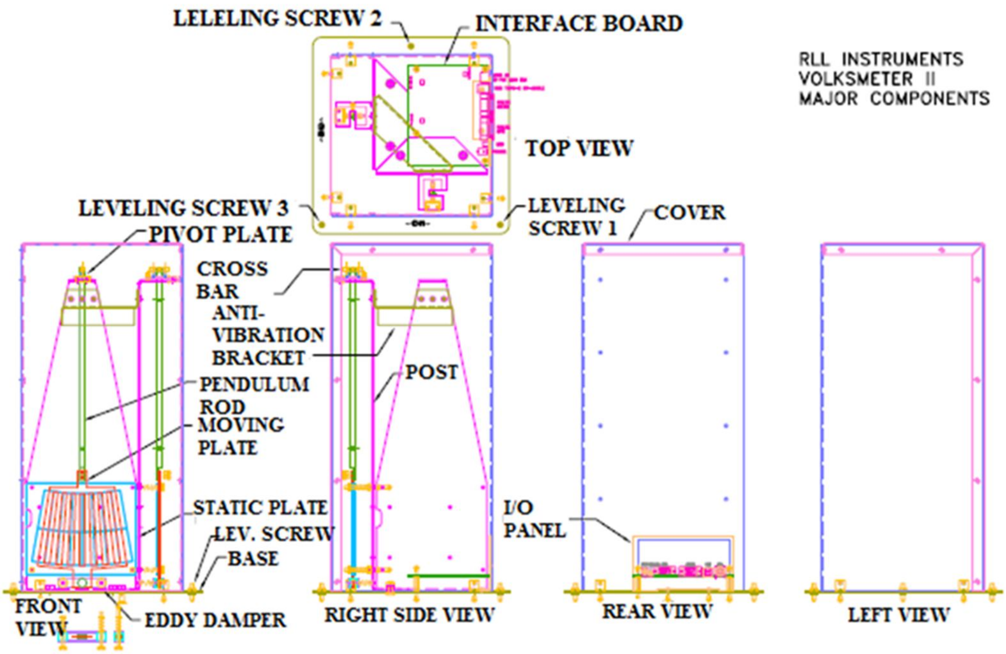


Plate 5. Schematic Diagram of VolksMeter II Major Components.

Plate 6: VolksMeter II Seismometer Setup.

4.2 Methods

4.2.1 Data Collection and Methods of the Study

The continuously recorded data from January to July 2019, from the VolksMeter seismometer station at the University of Abuja, formed the database for this study (i.e. the set of data used was selected from the long monitoring data recorded by the instrument within a period of seven months). Spectral analysis was done using WinQUAKE. Noise evaluation was done after filtering was computed from spectral analysis using WinQuUAKE to confirm the noise level at this station. The straight-forward procedure is presented below in Fig. 4. For the spectral component noise analysis, data was continuously recorded during 2019 for a seven-month period (January-July) with the exception of February which shows no record of events. Power spectral information was computed from the parameters such as frequencies, amplitudes, and periods. The location of the station lies within the Abuja of 430 elevations approximately with UTC station of latitude 8^0.98'N and longitude 7^0.18'E. A detailed description of the data processing procedure for the seismic noise was illustrated in Fig. 4. The data was saved in a format that was easily accessed through the directory in which Fast Fourier Transform (FFT) was calculated and filtered at various frequencies.

Data Selection

Data selections were made for each month from January to July, with the exception of February, which had no available records. The selection was based on the files with heavy size (usually with more than 370kb) except for January, which was only 34kb. This discrepancy in file size for January is due to a lower number of available records during that month. The time when the events were recorded was put into consideration to present full noise information for time variation.

Processing and Procedure Methods

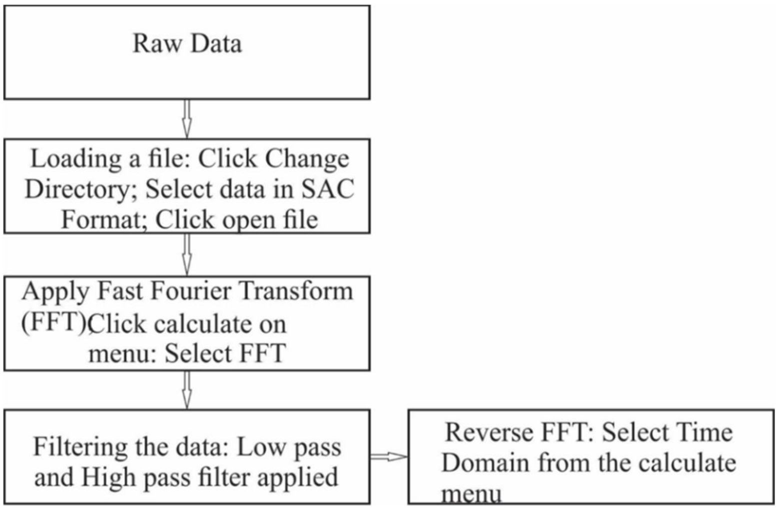


FIG. 4. Schematic representation of data processing steps.

The recorded waveform was opened and checked qualitatively in order to exclude any seismic event, such as an earthquake or explosion before processing. Thereafter, the data was transformed to a frequency domain using Fast Fourier Transformation (FFT) to produce the spectral plot of the seismic waveform. Further frequency filtering was applied to the data and the data was transformed back to the time domain.

5. Data Processing and Discussion

5.1 Data Processing

The Figures below present the computed seasonal fluctuations along with the average difference observed for various months at a given station. The results which are presented as shown in Figs. 5−11 were generated from the processing and procedure steps in Fig. 4. The label on top of the Figures provides information about the date of the record, UTC (Coordinated Universal Time) station, sampling rate per second, maximum and minimum, X & Y direction in kilo constants (kc), origin time, P-wave arrival time, S-wave arrival time, differences between P & S waves, distance (degree, kilometer, and minute), and magnitude. CH1 means channel 1 (E-W direction) and CH2 means channel 2 (N-S direction). The relative departure of the signals received on April 1st and July 2019 from other signals is due to noise variation caused by high amplitude which may not actually be the same. Drift usually occurs because of temperature differences which can cause equipment to tilt. Both events took place during the quiet period of 9:20 a.m. and 5:38 p.m., respectively (Fig. 9).

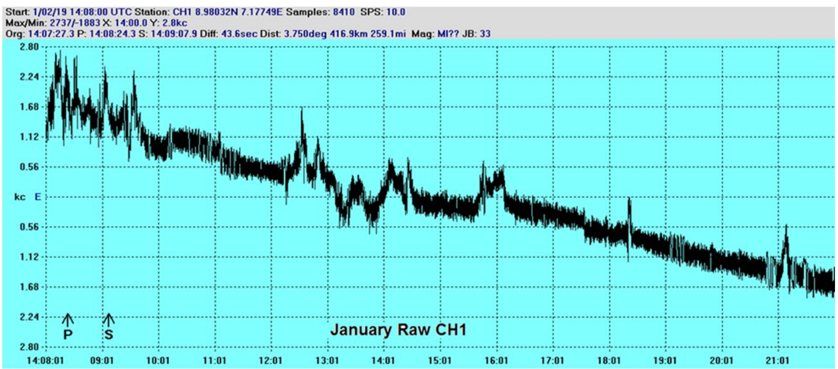


FIG. 5. January Raw channel 1 (E-W direction).

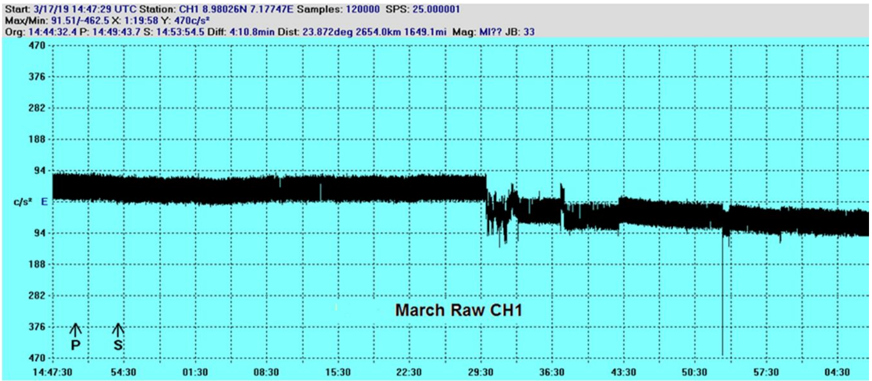


FIG. 6. March Raw channel 1 (E-W direction).

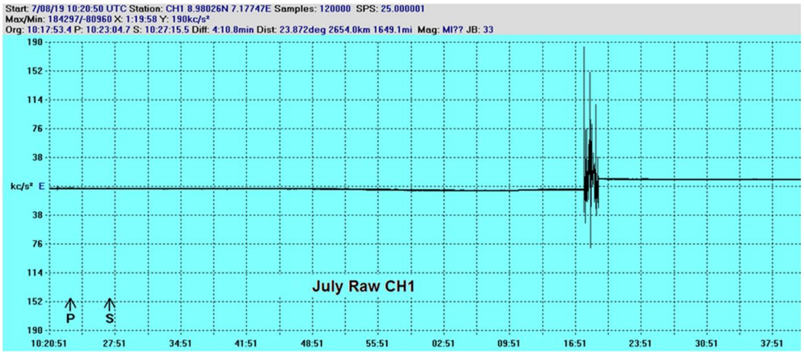


FIG. 7. July Raw channel 1 (E-W direction).

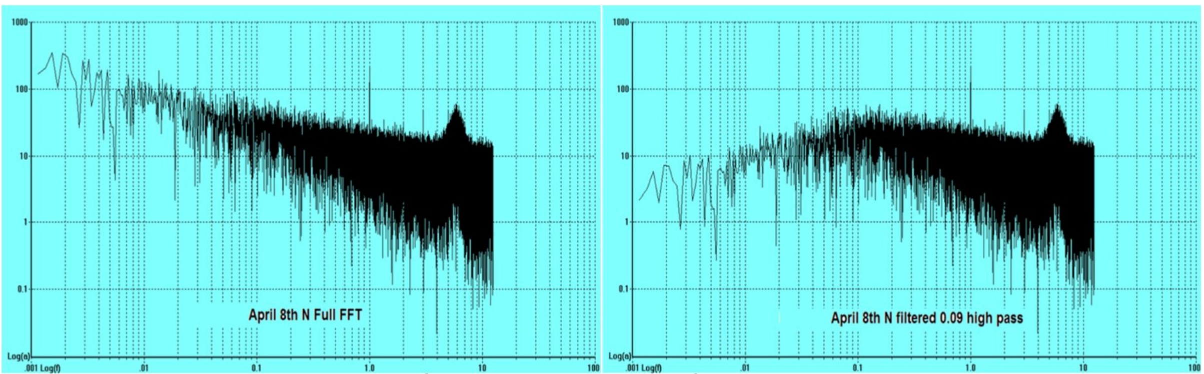


FIG. 8. (a) April 8th N Full FFT, (b) April 8th N filtered 0.09 high pass.

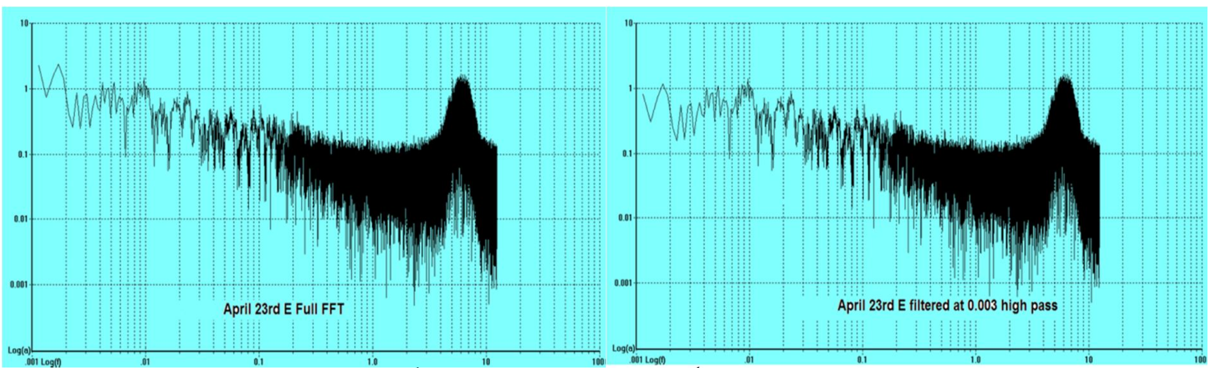


FIG. 9. (a) April 23rd E Full FFT, (b) April 23rd E filtered at 0.003 high pass.

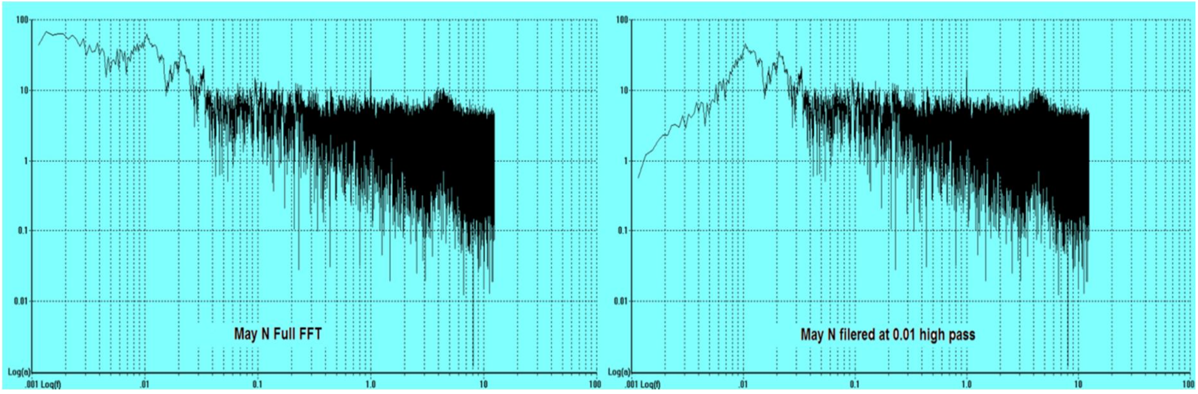


FIG. 10. (a) May N Full FFT, (b) May N filtered at 0.01 high pass.

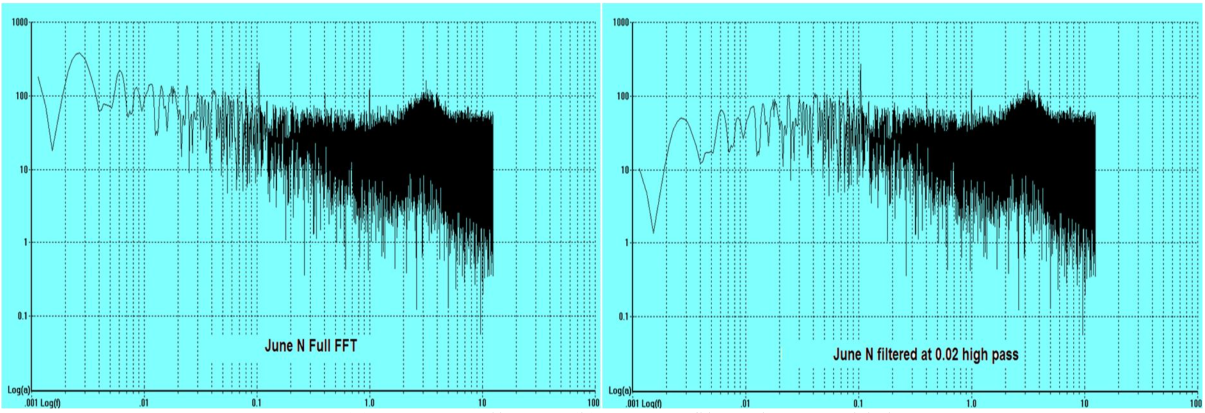


FIG. 11. (a) June N Full FFT, (b) June N filtered at 0.02 high pass.

5.2 Discussion

Since the frequency distribution of radiating seismic energy changes with the earthquake's size, the magnitude scales suffer intrinsic limitations, such as saturation and discrepancies between various scales. The center and the width of the selected band have been chosen based on the frequencies that are visibly excited during these months. For stations where no obvious seasonal variations are observed, the default 2–10 Hz band is chosen. The several non-secular (drift) features on the position data seismogram (Figs. 5−7) are believed to be probably due to temperature changes in the environment affecting the room that houses the seismograph. This means there is a diurnal variation associated with sunshine during the day for the January and March records which happen to be the period of dry season. The reverse form of these was also carried out but there is little or no difference.

In January 2019 event (Fig. 5), the peak at 3.9 Hz (0.25 s) along the local noise hump in the E-W direction is not well pronounced due to high noise. Cultural noise propagates mainly as high-frequency surface waves (>1−10 Hz, 1.0−0.1 s). This cultural noise results mainly from traffic, industry, and machinery [18].

In March 2019 (Fig. 6), careful observation shows that the hump pronounced at 5.3 Hz (0.19 s) in the E-W direction is not visible in the N-S direction due to high noise at the time (1:47 p.m.) of the recorded event. There is also a dramatic change within 1.0 Hz-10 Hz (1−0.1 s).

The hump at 5−6 Hz with the highest peak in the east-west direction for the 1 April 2019 record (Fig. 8). This is missing in the north-south direction probably because of temperature. Heat during the day and cooling at night can cause ground fluctuations that induce a tilt and long-period noise [18]. Filtered: N-S is 0.03 Hz high pass at 1 pole; E-W is 0.5 Hz at pole 1. But on 8 April 2019, the peak at 1 Hz (1 s), which is located relatively close to the local noise peak in the N-S record, appears sharp and highly pronounced. This is due to significantly lower noise levels on both sides of the peak, enhancing its visibility [Fig. 8 (a)]. This is suppressed at 1 Hz below the noise level in the E-W record. The hump at 5-7 Hz (0.2−0.14 s) with the highest peak at 6 Hz (0.16 s) as observed in both N-S and E-W direction [Fig. 8(b)]. The filtered results: N-S 0.09 high pass at pole 1; E-W 0.5 low pass at pole 1. There is a slight highest point at 0.23 Hz noticeable in E-W but mixed with noise in N-S for the 23 April 2019 spectral [Fig. 9(a)]. The highest peak at 1 Hz in N-S is missed out in the E-W record. Filtered: N-S is 0.003 Hz high pass at pole 1; E-W is 0.003 Hz high pass at pole 1 [see Fig. 9(b)].

In May 2019 [see Fig. 10(a)], a few sharp and strong peaks were observed. The records to which a high pass filter is applied do not significantly change as the spike observed might be indicative of the passage of a train or heavy machinery. The peak is visible at 2.4 Hz (0.4 s). In the E-W direction, there is a prominent peak at 4 Hz, while in the N-S direction, there is a low hump at 3 Hz (0.3 s). Filtered: N-S is 0.01 Hz high pass at pole 2; E-W is 0.003 high pass at pole 2 [Fig. 10(b)].

As for June 2019, a hump was observed at 3 Hz in the E-W direction and the N-S direction [Fig. 11(a)]. The strongest peak at 0.11 Hz is followed by another sharp peak at 1 Hz in the N-S record. Filtered: N-S is 0.02 high pass at pole 1; E-W is 0.5 low pass at pole 1. Finally, no noticeable peak that is strong except the hump around 2 Hz in N-S records for July 2019. Dramatic changes within a long range of area less than 0.1 Hz might be because of temperature. Filtered: N-S is 0.9 Hz low pass at pole 1 [Fig. 11(b)]; E-W is 0.5 Hz low pass at pole 1. Since the instrument is yet to record both local and teleseismic events, there could be apparent noise burbles primarily from the instrumental noise or cultural or wind/temperature generated as observed on the spectrum. This noise burbles area perhaps includes 0.03 Hz, 0.04 Hz, 0.03 Hz, and 0.03 Hz in the east-west direction of March, April, May, and June 2019, but 0.9 Hz and 0.3 Hz for April 1st and July 2019 spectral (Table 2). This is also noticed in the north-south of the area which includes 0.07, 0.07, and 0.07 Hz for January, April, and July 2019, respectively (Table 2). In assessing the noise within the hump, the estimation was carried out by averaging the data for April 8th, May, and June 2019, as the hump is present in both the E-W and N-S records (Table 1). This calculation involved determining the differences between the full FFT and filter application, i.e. the range of 0.4−0.29 s gives the difference of 0.12 s between the records, indicating that the source noise lies within the propagation of surface waves.

The analysis of hump peaks reveals that during the dry season of 2019, specifically in January and March, the periods (in seconds) of the hump peaks fell between 2 and 2.5 seconds (Table 1). Conversely, during the rainy season of 2019, from April to July, the hump peaks exhibited periods ranging from 0.165 to 0.727 seconds (Table 1). During the recorded events on 8 April, as well as in May and July, which occurred at 9:08 a.m., 9:59 a.m., and 9:20 a.m., respectively, the corresponding values for the hump periods were 0.099, 0.112, and 0.111 s. It's worth noting that there was a similar quiet period on 1 April 2019, around 5:38 p.m., with a hump period of approximately 0.101 s. Let us note that there are several peaks and lines that are common to the seismograms generated from the pendulum records which can be predicted to be derived from disturbances to the building that houses the instrument. Once the spectrum has been displayed, the frequency of any piece of it may be determined by placing the tip of the arrowhead cursor at the line or object of interest. The numerical value of the frequency/period corresponding to that position is then shown at the top of the frequency graph (VolksMeter II User's Manua).

TABLE 1. Hump peaks differences in period (s) across all periods.

Month	Lowest		Diff. Btw low & lowest E	Highest		Hump Low point E	Hump Peaks	
	E	N		E	N		E	N
January	0.309	0.288	2.991	820.8	814.1	3.3	2	-
March	0.146	0.11	0.354	502.2	874.9	0.5	2.5	-
April 1st	0.101	0.118	0.729	865.9	874.9	0.83	0.175	-
April 8th	0.099	0.113	0.641	523.2	656.0	0.74	0.167	0.172
April 23rd	0.090	0.083	0.7	592.0	742.2	0.79	0.165	-
May	0.112	0.111	0.888	865.9	749.8	1	0.350	0.310
June	0.101	0.110	1.009	477.0	376.6	1.11	0.727	0.388
July	0.111	0.113	0.847	874.9	512.6	-	-	0.727
Average	0.134		1.045	690.24		1.18		

TABLE 2. Noise burbles, frequencies, and amplitudes variations across all periods.

Month	Burbles (Hz)		Freq. (Hz)	Minimum amp.		Maximum amp. FFT ‘E	FFT ‘N	High amp. filter	
	E	N		E	N			E	N
January	0.1	0.07	0.2-5	0.3	1.8	912	110	912	90
March	0.03	0.03	0.04-12.53	0.003	0.1	10	110	4	60
April 1st	0.9	0.07	1.2-12.53	0.006	0.08	110	10	3	5
April 8th	0.04	0.07	0.2-12.53	0.005	0.26	7	70	8	70
April 23rd	0.04	0.04	0.2-12.53	0.005	-	4	9	2	7
May	0.02	0.02	0.1-12.53	0.01	0.1	2.14	69.38	2	60
June	0.03	0.03	0.1-12.53	0.06	-	-	6000	-	100
July	0.3	0.7	1-12.53	0.28	-	4000	-	4000	-
Average						720.7	911.2	703.9	49

It was observed from spectra that the records show strange abnormalities of frequencies. Findings showed that the sources of noise at the stations include wind, temperature, human activities close to the stations (vehicular traffic, machinery, and airport) geologic, and instrumental noise.

We recommend the installation of low-decibel rating air conditioning units at the observatory center to mitigate the noise generated by anthropogenic sources.

5.3 Comparison with Global Seismic Noise Models

The global earth noise models’ curves show high and low seismic background displacement alternating between low (20−200 s) and high (5−8 s) noise levels [7]. This study across the three stations revealed the noise levels to range between low (10−100 s) and high (0.2−0.1 s) showing relatively low noise levels of the global seismic noise model. The estimated minimum amplitudes are 0.3/1.8, 0.003, 0.005-0.8, 0.005/0.1, 0.06, and 0.28 for January, March, April, May, June, and July 2019, respectively (Table 2), which corroborated the work of [19] which concluded that area(s) with minimum amplitude is an indicator of low noise. The maximum amplitude values include 912, 10/100, 1.4 at a point but 10/110 higher at other, 2.2/69.4, 69.9, 10−4000 or 80−4000 on January, March, April, May, June, and July 2019, respectively (Table 2), which shows high noise levels. Based on the information deduced from the FFT magnitude against frequency plots on the spectrum, it can be concluded that the station and instrument noise are characterized by displacements in high and low seismic noise, with variations in periods (measured in seconds).

6. Conclusion

This research investigates the seismic background noise of the seismic station at the University of Abuja, FCT, Nigeria using WinQUAKE software. The analysis of seasonal background noise modulation helps differentiate processes of seismic noise generations associated with natural sources, at least climatic ones. Our study reveals that some subsurface vibrational features can be assessed through the temporal/ frequency analysis of continuous seismic data recorded by the three local seismic stations. Based on our observations, the motion of the ground vibrations is a plausible explanation of the observed high-frequency seismic noise, which suggests that seismometers can be used to monitor tremors. Furthermore, recent research conducted within an experimental framework using time-frequency analysis of ground vibration has revealed that certain seismic noise within the 10−150 Hz frequency range is attributed to rock motion [20]. The station noise level comprises both high and low values across the entire station showing an average noise level to be below the global high noise model at periods less than 10 s on both horizontal components. The qualitative analysis of waveform indicated that the area characterized by consistently high averages spans from 10 to 0.08 s (0.1−12.53 Hz). In the spectrum analysis, it was observed that the east direction patterns for January, March, and July resembled the north direction patterns in March. Additionally, the records for April 1st, 8th, 23rd, May, and June 2019 in both the east and north directions, as well as the north direction in July, exhibited similar characteristics, suggesting that the sources of noise are not uniform. The seasonal variations in noise are clearly evident in the monthly correlation analysis. However, it is worth noting that the station's noise appears to stem from a consistent set of diverse sources. We encourage VolksMeter users to generate a PSD corresponding to their quietest records, as this can help them assess the noise quality in their surroundings.

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