IMPACT OF ATMOSPHERIC PARAMETERS AND NOISE TEMPERATURE ON DIGITAL TERRESTRIAL TELEVISION SIGNAL STRENGTH OVER KARSHI AREA, ABUJA, NORTH-CENTRAL, NIGERIA

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Abstract

In this paper, the impact of atmospheric parameters (atmospheric temperature, pressure, relative humidity and wind speed) and noise temperature on digital terrestrial television signal strength over Karshi area, Abuja, North-Central part of Nigeria has been examined. Measurements were taken for a period of nine months (April 2019 – December 2019) to cover the commencement of rainy period and towards the end of rainy period. The results showed that atmospheric and noise temperature as well as wind speed weakly influenced the signal strength while relative humidity strongly influenced the signal strength. The effect of atmospheric pressure over the signal strength was not consistent during the period of measurement. The signal strength of AIT, NTA, Channels TV and ETV were negatively affected by the atmospheric temperature up to about 88.8%, 25.6%, 16.5% and 93.2%, respectively; the noise temperature up to about 85.3%, 13.4%, 5.9% and 90.7% respectively and wind speed by about 89.2%, 26.8%, 16.3%, and 92.4% respectively. However, the signal strength was affected positively by the relative humidity up to about 87.9%, 18.7%, 10.1% and 92.4% respectively, while the atmospheric pressure affected NTA and Channels TV negatively by about 21.3% and 26.8%, respectively and affected AIT and ETV positively by about 22.7% and 26.8%, respectively. Findings from this study will be of help to satellite link designers, policy makers, antenna modelers and other TV transmission equipment designers on how to mitigate the effect of some of the atmospheric components on digital terrestrial signal strength reception in Nigeria.

Keywords: Digital Terrestrial Television; Signal strength; Noise Temperature; Atmospheric parameters

1. Introduction

The quality of terrestrial television signal received by viewers is of keen interest to stakeholders in the broadcast world [1], but this is dependent on some factors especially the external ones such as atmospheric parameters. One of the factors that influence the quality of digital signal reception is the noise such as atmospheric noise, galactic noise, thermal noise etc [2].

According to [3], the condition of the atmosphere can cause loss of signal. Also, weather components in addition to building and vegetation, affect radio wave propagation and can combine in different ways to make radio signals to be heard far away beyond its ordinary range or resulting in signal interference [4-5].

The weather components such as the wind, air temperature and atmospheric water content may combine in many ways to affect the quality of signal receptions [6]. It was reported in [7] that air temperature, relative humidity and atmospheric moisture have serious influence on UHF radio propagation links in the South Western Nigeria.

The medium of propagation for both analogue and digital terrestrial television is the troposphere, where most weather phenomena take place; this makes it very important to carry out researches on the influence...
of key meteorological parameters in the troposphere on digital terrestrial television signal strength[8-12]. Thus, assessing the impact of the major atmospheric parameters on the signal reception in Abuja environs, being one of the fully digitized cities in Nigeria is necessary and is the major focus of this work. The uniqueness of the present work is that, it is the first of its kind in this location and will serve as one of the databank needed for the actualization of good quality of signal for the digital terrestrial broadcasting (DTB) in Nigeria by the Nigeria Broadcasting Commission (NBC).

2. Materials and methods

Karshi is located in the Federal Capital Territory, a satellite town situated in the Abuja Municipal Area Council in Nigeria. Its geographical coordinates are 8° 49' 40" North, 7° 33' 0" East and at an altitude of about 840m above sea level. Its vegetation is guinea forest savanna, with rainy seasons from April to September and the dry season from October to March. It has some high mountains and a few trees and short grasses.

The experimental set-up mounted in Mathson Space International School, Karshi, Abuja is made up of a CATV signal strength meter connected to a Yagi antenna mounted on a vertical pole from the height of 5m, and fixed in one constant direction to measure the signal strength of the Nigeria Television Authority, Abuja (NTA-567.25 MHz), African Independent Television, Abuja (AIT-535.2 MHz), Channels television, Abuja (Channels -615.25 MHz) and Entertainment television, South Africa (ETV - 564 MHz) as presented in Fig 1a. The set-up also include an automatic weather station, which measures the temperature, relative humidity, atmospheric pressure and wind speed (Fig. 1b) and a non-contact digital infrared thermometer (Fig.1c) for taking the measurement of the noise temperature of the antenna mounted outside on a pole from height 3m above the ground. The base station or receiver (Fig. 1d) of the weather station has an internal memory which allows it to store the data it has measured in every 30 minutes. The measurements of all the parameters were done simultaneously every 30 minutes from 5.00 am in the morning hour to 9 pm in the evening hour. These hours have been chosen to manually collate data from the signal strength daily for a period of 9 months (April 2019 to December 2019). Apart from the signal strength meter, other equipment collects data automatically.

![Fig. 1: Basic instrument set-up for measurement](a) Digital CATV signal strength meter (Spectrum 46 – 870 MHz) (b) Automatic weather station (c) Digital non-contact infrared meter and (d) Receiving station

3. Results and Discussion

The signal strength of the four television stations measured from 5.00 am to 9.00 pm daily for nine months (April 2019 to Dec 2019) along with some atmospheric parameters have been averaged as presented in Table 1. Figure 2 shows the average monthly signal strengths of the four television stations from April 2019 to December 2019. The result shows a monthly variation in the signal strength of the four stations as well as the atmospheric parameters of the study area in the period under study. The maximum signal strength of the four television stations was recorded in the month of July while the minimum occurred in November for AIT, December for NTA, September for Channel television and December for ETV.

Table 1: Average monthly values of the measured parameters from April 2019 to Dec 2019
The result also showed that the maximum and minimum values of the temperature were recorded in April and August (37.63°C and 26.07°C), Atmospheric Pressure in August and April (975.69 hPa and 967.21 hPa), Relative humidity in August and December (80.60% and 31.54%), Wind speed in October and May (0.89 m/s and 0.72 m/s) and the noise temperature in April and August (33.14°C and 24.98°C) respectively.

The signal strength of AIT from the month of April decreased slightly till May and started rising until it reached the peak in August and started decreasing to the minimum value in November and started increasing in December again (Fig. 2.). Similar trends were observed with ETV as well as NTA and Channels television, but the variations in signal strengths of NTA and channels TV were not as sharp or high as that of AIT and ETV. The four stations also attained the minimum values at different months; November for AIT, December for NTA, September for Channels television and December for ETV with all occurring towards the end of the year.

We also observed a diurnal variation in the signal strengths of the four stations as well as the measured atmospheric parameters (Table 2 and Fig. 3). It was shown that the signal strengths of the four stations were higher in the morning period such that they all sloped downward from left to right from morning to noon and later started increasing again toward the evening hour. In other words, the signal strength values were higher in the morning period (5.00 am to 11.30) and lower in the afternoon period (12.00 pm to 4.30 pm) and higher in the evening period (5.00 pm to 9.00 pm) as presented in Fig. 3. This might be due to the changes in the temperature and humidity in the atmosphere.

| Parameters/Month        | April | May  | Jun  | Jul  | Aug  | Sep  | Oct  | Nov  | Dec  |
|-------------------------|-------|------|------|------|------|------|------|------|------|
| AIT Signal strength     | 37.63 | 36.08| 37.12| 38.33| 37.69| 36.02| 33.93| 32.27| 32.46|
| (dBµv)                  |       |      |      |      |      |      |      |      |      |
| NTAS Signal strength    | 28.67 | 28.50| 28.29| 29.28| 27.89| 28.54| 27.73| 27.77| 27.33|
| (dBµv)                  |       |      |      |      |      |      |      |      |      |
| Channels TV Signal      | 27.52 | 27.71| 28.01| 29.31| 27.64| 27.45| 27.52| 27.75| 27.83|
| strength (dBµv)         |       |      |      |      |      |      |      |      |      |
| ETV Signal strength     | 26.64 | 26.47| 27.73| 31.18| 36.37| 33.42| 33.59| 31.92| 32.80|
| (dBµv)                  |       |      |      |      |      |      |      |      |      |
| Temp (°C)               | 33.49 | 31.33| 29.18| 28.46| 26.07| 27.93| 27.07| 30.49| 30.25|
| Pressure (hPa)          | 967.21| 968.57|969.23| 972.26| 975.69| 975.32| 973.19| 972.76| 972.82|
| RH (%)                  | 55.51 | 62.19| 68.95| 72.68| 80.60| 74.82| 75.95| 59.46| 31.54|
| Wind Speed (m/s)        | 0.76  | 0.72 | 0.81 | 0.73 | 0.83 | 0.82 | 0.89 | 0.88 | 0.87 |
| Noise Temperature°C     | 33.14 | 31.79| 31.94| 28.64| 24.98| 26.51| 25.77| 28.36| 27.45|

**Fig. 2:** Average monthly signal strengths of the four television stations from April 2019 to Dec 2019
Table 2: Average hourly measured parameters from April 2019 to Dec 2019

| Time  | AIT (dBμV) | NTA (dBμV) | Chan (dBμV) | ETV (dBμV) | Temp (°C) | Pres (hPa) | RH (%) | Wind (m/s) | Noise Temp. (°C) |
|-------|------------|------------|-------------|------------|-----------|------------|--------|------------|------------------|
| 5.00 am | 36.74      | 28.48      | 27.79       | 31.67      | 24.11     | 965.76     | 83.44  | 0.46       | 25.05            |
| 5.30 am | 36.59      | 28.39      | 27.75       | 31.71      | 23.85     | 972.38     | 84.25  | 0.40       | 24.88            |
| 6.00 pm | 36.73      | 28.32      | 27.96       | 31.65      | 27.52     | 972.95     | 84.40  | 0.50       | 24.77            |
| 6.30 pm | 36.78      | 28.34      | 28.02       | 31.76      | 23.93     | 973.23     | 84.29  | 0.42       | 24.89            |
| 7.00 pm | 36.53      | 28.20      | 27.82       | 31.61      | 24.47     | 973.19     | 82.75  | 0.47       | 25.07            |
| 7.30 pm | 36.61      | 28.08      | 27.74       | 31.54      | 25.96     | 973.83     | 80.39  | 0.48       | 25.44            |
| 8.00 pm | 36.37      | 27.85      | 27.69       | 31.36      | 25.80     | 974.00     | 77.65  | 0.54       | 25.88            |
| 8.30 pm | 36.12      | 28.02      | 27.72       | 31.33      | 26.49     | 974.34     | 74.46  | 0.56       | 26.21            |
| 9.00 pm | 36.06      | 28.07      | 27.71       | 31.34      | 27.35     | 974.15     | 71.32  | 0.61       | 26.75            |
| 9.30 pm | 35.85      | 27.94      | 27.48       | 31.21      | 28.12     | 973.79     | 71.13  | 0.68       | 27.29            |
| 10.00 pm | 35.33     | 27.84      | 27.55       | 31.10      | 28.84     | 974.82     | 65.75  | 0.75       | 27.84            |
| 10.30 pm | 35.29      | 27.67      | 27.52       | 31.10      | 29.48     | 974.45     | 63.62  | 0.88       | 28.37            |
| 11.00 pm | 35.26      | 27.75      | 27.62       | 31.03      | 30.01     | 973.86     | 61.72  | 0.91       | 28.87            |
| 11.30 pm | 35.44      | 27.73      | 27.97       | 31.00      | 30.43     | 973.28     | 59.88  | 0.91       | 29.25            |
| 12.00 pm | 35.09      | 27.67      | 27.36       | 30.87      | 30.95     | 973.30     | 58.35  | 0.97       | 29.68            |
| 12.30 pm | 34.99      | 27.81      | 27.54       | 30.55      | 31.38     | 970.11     | 56.70  | 1.00       | 30.18            |
| 1.00 pm | 34.82      | 27.84      | 27.53       | 30.73      | 31.76     | 969.76     | 55.77  | 1.10       | 30.50            |
| 1.30 pm | 34.70      | 27.78      | 27.52       | 30.63      | 32.16     | 969.55     | 54.44  | 1.06       | 30.95            |
| 2.00 pm | 34.90      | 27.81      | 27.68       | 30.63      | 32.43     | 972.67     | 53.59  | 1.16       | 31.26            |
| 2.30 pm | 35.10      | 27.90      | 27.69       | 30.71      | 32.79     | 972.43     | 52.36  | 1.11       | 31.59            |
| 3.00 pm | 35.05      | 27.91      | 27.84       | 30.78      | 33.08     | 971.25     | 51.83  | 1.09       | 31.82            |
| 3.30 pm | 34.87      | 28.07      | 27.78       | 30.75      | 33.10     | 971.96     | 51.92  | 1.09       | 31.85            |
| 4.00 pm | 35.14      | 28.12      | 27.65       | 30.74      | 33.11     | 971.69     | 51.85  | 1.04       | 31.94            |
| 4.30 pm | 35.41      | 28.21      | 27.75       | 30.78      | 32.43     | 971.69     | 52.66  | 1.03       | 31.20            |
The variation in the signal strengths as shown in the result was a result of some variations in the atmospheric parameters. From the correlation analysis between the signal strengths and each of the measured atmospheric parameters, it was revealed that the temperatures (atmospheric and noise), wind speed and relative humidity are the major and consistent parameters affecting the signal strength. The results show that increase in atmospheric temperature and noise temperature leads to decrease in signal strength and vice versa, which is inverse proportion; whereas decrease in relative humidity leads to decrease in signal strength and vice versa, which is direct proportion. Also, a decrease in wind speed leads to increase in signal strength which is an inverse proportion, but the relationship between the signal strengths with atmospheric pressure is not uniform for all as it is directly proportional with the signal strengths of AIT and ETV but inversely with that of NTA and Channels Television (Table 3). This analysis is necessary for digitalization of video and audio signal as the case may be.

**Table 3:** Correlation values between the signal strength and the atmospheric parameters
The effect of atmospheric pressure was not consistent as it was inversely related with signal strengths of NTA and Channels TV, but directly proportional with the signal strengths of AIT and ETV. The reduction in signal strength when the temperature is high might be as a result of increase in resistance of the “medium”, though free space, which in the real sense is not actually free, where the signal travels [9]. It can also be explained from the aspect of kinetic theory of matters, thus increase in temperature of the atmosphere resulted to rapid random movement of the particles in the atmosphere and in the process, the larger particles colliding with the signal resulted in absorption, refraction, scattering and multipath effects which in the end will attenuate the signal received [11]. The wind also carries dust particles including the larger ones in the atmosphere, and these particles if larger than the wavelength of the transmitted signal will attenuate it through refraction, absorption and/or scattering. The effect of the temperature and wind speed were reduced by relative humidity as moisture will reduce the temperature as well as the amount of particles carried by wind speed because the amount of free particles in the atmosphere for the wind to carry will be less, thus the signal strength will be higher [10]. This result is in accordance with the result of the work by [3], in his work on the Cross River State Broadcasting Corporation Television on frequency, 519.25 MHz, where it was found out that radio signal strength is inversely proportional to atmospheric temperature, with a correlation coefficient of -0.93. It is also in conformity with the result of the work of[6], based on the work done in Malaysia on some frequencies in which the coefficient of correlation between signal strength and temperature change at frequency 945 MHz was -0.085.

4. Conclusion

The impact of some atmospheric parameters (atmospheric temperature, pressure, relative humidity, wind speed) on the signal strength of three National television stations (AIT, NTA and Channels TV) and one international TV station (ETV) in Karshi area Abuja, have been carried out. It can be concluded that there were variations in the signal strengths of the four stations hourly and monthly, with maximum signal strength for all the stations occurring in the month of July, and their minimum values occurred towards the end of the year though in various months. It can also be concluded that digital terrestrial television signal strength is higher in the morning and evening periods but lower in the afternoon period with atmospheric temperature, noise temperature and wind speed inversely proportional to the signal strength while the relative humidity is directly proportional to the signal strength, but the effect of pressure is not consistent or uniform with the four stations. The result of this work will help the Nigeria Broadcasting Commission to improve on the quality of signal transmission of DTB in other states of the federation that digital switch over will take place later. It will also assist communication systems designers for channel optimization and designing of communication equipment. Satellite link designer, satellite and mobile communication experts as well as radio propagation experts will find these results useful. However, more years of measurement are needed to model the atmospheric parameters and noise temperature with the signal strength.

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