Investigation Of The Influence Of Atmospheric Temperature And Relative Humidity On Fm Radio Signal Strength: A Case Study Of We Fm Abuja.

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Abstract: The work concentrates on the determination of the relationship between the signal strength of the WE FM, radio station, Abuja with respect to temperature and relative humidity. The WE FM radio station based in Abuja, Nigeria operates at the frequency of 106.3 MHz. The research was carried out, during cloudy and uncloudy days, with the use of CATV signal level meter, Hygrometer and thermometer to measure the signal strength, the temperature and relative humidity respectively. The results show that signal strength reduces as the atmospheric temperature increases, but the signal strength increases with the increase in relative humidity. The calculated correlation coefficients of the temperature and signal strength for the two days are -0.42369and -0.51878 while relative humidity and signal strength correlation coefficients are 0.29 and 0.39. These results further affirm that signal strength directly varies with relatively humidity and inversely varies with the ambient temperature. It was also found that the effect of these parameters on the signal strength of the FM station radio is higher during cloudy or rainy day than on clear or sunny day.

Keywords: Atmosphere, Communication link, Correlation, Humidity, Signal strength, Frequency, Temperature.

1.0 Introduction

It is well known that modulation is the transmission of communication signal by varying of one or more properties of the carrier signal. Some types of modulations are amplitude modulation (AM), which occurs when amplitude of the signal is varied, frequency modulation (FM), and phase modulation (PM). Frequency modulation, which occurs as the frequency of the signal varies, is the transmission of communication by varying the frequency of the signal while the amplitude remains constant.

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A radio frequency is part of Electromagnetic spectrum with long wavelengths and low frequencies of all the electromagnetic spectrum. Some examples of radio frequencies are Low Frequency (LF), Ultra Low Frequency (ULF), Very Low Frequency (VLF), Medium Frequency (MF), High Frequency (HF), Very high frequency (VHF), Ultra High Frequency (UHF) and Super High Frequency (SHF). It is also well known that temperature is the degree or extent of coldness or hotness of a body, object or particles, and it measures the average kinetic energy of particles. This implies that the average kinetic energy of particle, i.e. radio signal in this is affected by its temperature or temperature of the environment through which it is being propagated. Relative humidity is the amount of moisture in the air or atmosphere. As the amount of moisture in the air at a particular location varies from time to time, so also its values in different locations on the earth varies even at the same. Thus, the relative humidity in two different locations at the same moment can be different, and this is also applicable to temperature as well. According to Amajama (2015)), the condition of the atmosphere has significant effect on signal and can cause loss of signal. He further reported that the major atmospheric elements that constitute the weather are the atmospheric temperature, pressure, humidity and wind speed and direction. Therefore, finding how each or some of these components affect the radio signal strength is very paramount and thus, this work is considering temperature and relative humidity in the first instance. In addition to building and vegetation, other factor that affects radio wave propagation is the weather (rain, wind, temperature, and water content of the atmosphere) and these can combine in different ways to affect radio wave propagation to a point that some combination may cause radio signals to be heard far away beyond its ordinary range or resulting in attenuation that can make the signal not to be heard even over a normally satisfactory path (Michael, 2013). Some related works have been carried out but very little in Nigeria. Roshidah *et al., (*2016) conducted a similar research in Malaysia using weather station (Vantage Pro 2, USA) and Spectrum analyser for frequencies 945 MHz, 383 MHz, 1800 MHz and 2160 MHz. Spectrum analyser was used to measure the radio signal while the weather station was used to measure the temperature. It was found out by them that there was a relationship between radio signals and the change of temperature, and that the correlation coefficient between radio signal and temperature for 945 MHz, was -0.085, for 383 MHz was 0.249, for 1800 MHz was 0.268 and for 2160 MHz was 0.134. Amajama (2016) worked on radio signal strengths of Cross River State Broadcasting Co-operation Television (CRBC-TV on the frequency of 519.25 MHz (UHF) using Cable TV analyzer and weather instruments. Cable TV analyzer was used to measure the radio frequency signal strength while the weather instrument were used to measure temperature, atmospheric pressure, relative humidity and wind speed and direction. He observed from his results that if other measured metrological components including wind speed and direction were observed constant, radio signal strength is inversely proportional to atmospheric temperature, with the correlation coefficient of -0.93. These works and some others reviewed in the course of the work have not considered in the frequency modulation band 88 – 108 MHz specifically, and as well significant works in this area have not been done in Abuja. This makes the present work necessary as it will show how FM radio signal strength is affected by temperature and relative humidity, the major aim of this research.

2.0. The Measurement Location

The experimental setup was done in a residence in Karshi, a satellite community in Abuja Municipal Area council, Federal Capital Territory, Abuja. The location of the measurement or experiment is along the boundary of federal capital territory and Nasarawa state, and is on latitude 8.83^{0}N and longitude 7.56 ^{0}E. It has some hills and a very few trees with short grasses. WE FM radio station is located in Maitama, Abuja Municipal Area council. The station is located on latitude 9.10 ^{0}N and longitude 7.44^{0}E. It is in the heart of Abuja city. The radio station transmits on the frequency, 106.3 MHz.

3.0 Materials and method

3.1 Materials

The materials used for the work are Community Access Television (CATV) signal meter, digital Hygrometer/thermometer, Microsoft excel software package. The CATV signal level meter is S110 model and operates on a 9v DC inbuilt battery. The digital Hygrometer/thermometer has temperature measurement range of -10^{0}c to +50^{0}c, and relative humidity measurement range of +10% to + 99%. The equipment also has the accuracy of +/- 1^{0}c (1.8F) and +/-5%. It operates on a 1.5v DC battery

3.2 Methods

A coaxial cable was connected to a Yagi Uda antenna and it was mounted on a vertical pole at about 12m tall. The other end of the cable was attached to a connector which was then connected to the CATV meter through its connector. The device was then put on by pressing the on/off button. The desired frequency (106.3MHz) was inputted into the device, and when "OK" was pressed, it will start to display the signal strength though varying from time to time. The digital Hygrometer/thermometer puts itself on automatically when the battery was inserted in its position. The antenna was made to face the direction of higher signal as displayed on the meter screen, and it was left at the fixed position and direction throughout the study period. At each point of the readings, the highest and stable value of the signal strength was taken on the CATV signal meter and the temperature and relative humidity were also read from the Hygrometer/thermometer simultaneously with the signal strength. The processes were carried out from 5am to 9pm at one hour interval on 29th September and 7am to 7pm on 30th September, 2017. The data was represented graphically and in tabular forms, while correlation analysis was used to assess the relationship between the signal strength and temperature, and between the signal strength and relative humidity. The analysis was done in excel worksheet.

4.0 Results and discussions

Table 1 shows the measured temperature, relative humidity and radio frequency signal strength on 29th September, 2017, between 5 am and 9 pm (17 hours), on a clear sky day, while Figure 1 shows the graphical representations of Signal strength, Temperature & Relative Humidity, and Figures 2 and 3 show Signal strength &Temperature, and Signal strength & Relative Humidity respectively.

Table 1: *Measured Signal strength, Temperature & Relative Humidity on 29th September, 2017, between 5am and 9pm*

Time	Temp (0c)	RH(%)	Signal Strength (dBuV)
5	27.6	74	43.9
6	28.0	73	44.6
7	26.8	78	44.5
8	27.1	73	42.9
9	27.6	74	42.7
10	27.8	73	42.8
11	29.2	68	43.5
12	29.1	69	42.4
13	29.9	70	41.8
14	30.1	68	43.6
15	30.5	67	43.5
16	30.8	68	43.0
17	30.6	73	42.6
18	30.3	66	42.5
19	30.0	65	42.4
20	29.9	70	42.2
21	29.6	72	40.7

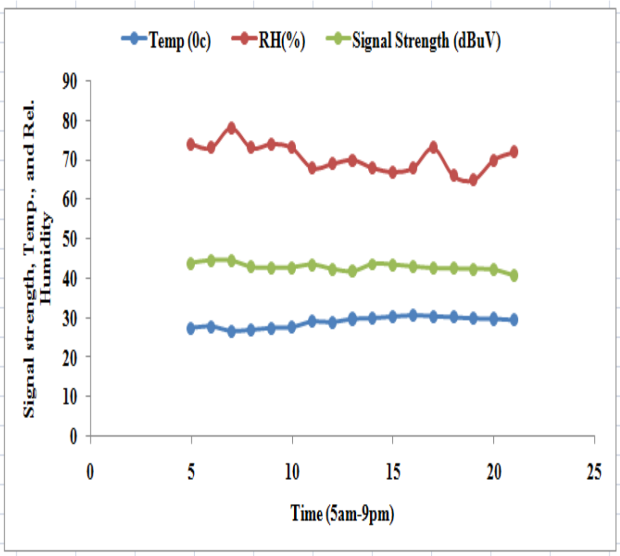

Figure1: *Graph of signal strength, Temperature & Relative humidity and time*

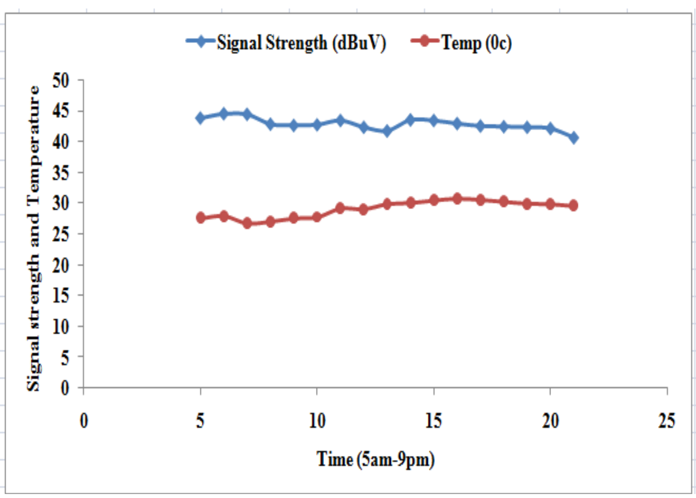

Figure2: *Graph of signal strength& Temperature and Time*

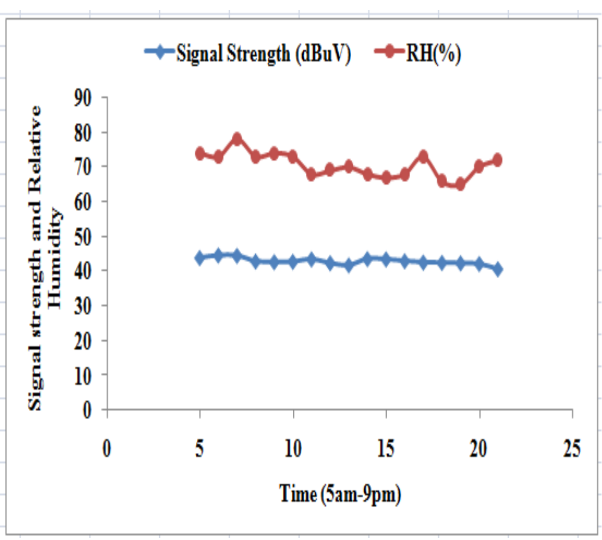

Figure3: *Graph of signal strength & Relative humidity and Time*

From the results in figures 2 and 3, it can be observed that there was a relationship between the radio frequency signal strength and the temperature as well as relative humidity. In order words, temperature and relative humidity affect Signal strength. From the Table 1, it can be seen that the signal strength increases with increase in temperature at some points and decreases with temperature at some other points but it was obviously found out that the measured signal strength generally increases with decrease in temperature and vice versa. This scenario was also experienced in the case of relative humidity, but it was found that the measured signal strength increases with increase in relative humidity. This observation is also collaborated by the correlation analysis between the signal strength and the temperature and relative humidity accordingly. The coefficient of correlation between the signal strength and temperature is -0.42369, while that between the signal strength and relative humidity is 0.29. This shows that both have effects on signal strength but temperature has more effect than relative humidity at this frequency (106.3 MHz).Table 2 shows the measured temperature, relative humidity and radio frequency signal strength on 30th September, 2017, between 7am and 7pm (13 hours), a cloudy day (after a rainy night).

Table 2: *Measured signal strength and Temperature andRelative Humidity on 30th September, 2017, between 7am and 7pm*

Time	Temp (0c)	RH(%)	Signal Strength (dBuV)
7	26.7	77	40.5
8	27.0	74	39.6
9	26.9	73	37.5
10	27.2	73	37.0
11	27.7	74	35.4
12	28.0	74	35.7
13	28.5	73	32.5
14	29.0	68	35.3
15	29.4	68	35.4
16	29.6	67	36.0
17	29.2	69	34.6
18	29.3	69	37.0
19	29.4	69	38.1

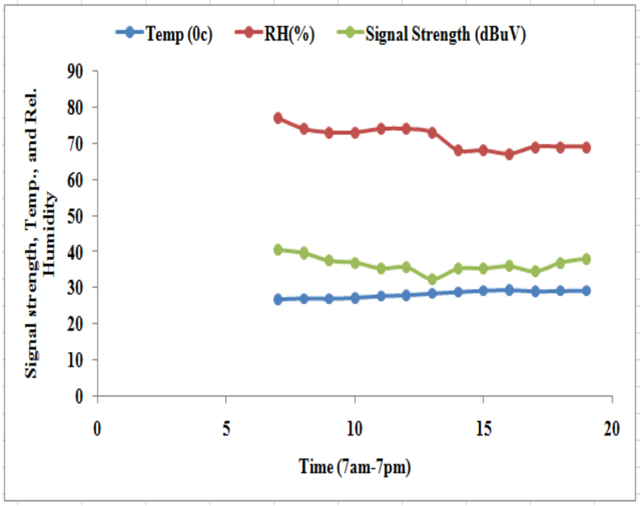

Figure 4: *Graph of signal strength, Temperature & Relative humidity and Time*

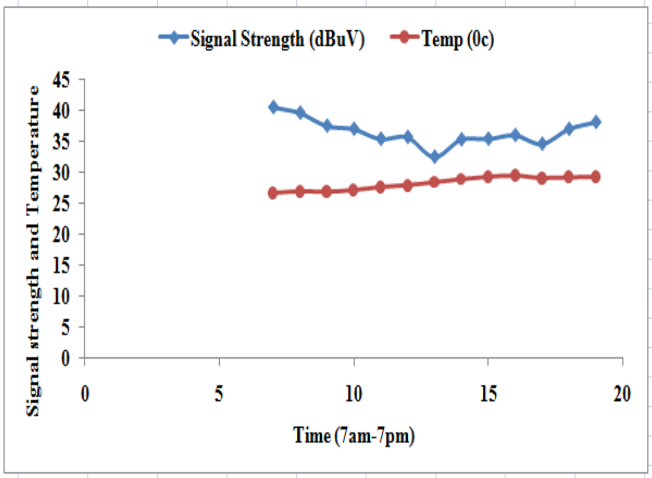

Figure 5: *Graph of signal strength & Temperature and Time*

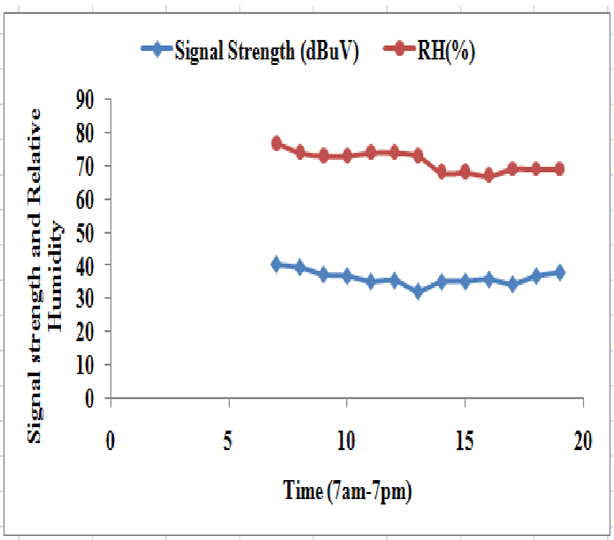

Figure 6: *Graph of signal strength & Relative humidity and Time*

Figures 4 - 6 show the graphical representations of Signal strength, Temperature & Relative Humidity, Signal strength and Temperature, and Signal strength and Relative Humidity respectively. The results show that the signal strength, temperature and relative humidity are related even though their relationship at some points was inversely proportional, while at some points directly proportional. The correlation coefficient between the signal strength and temperature is -0.51878 (r = -0.51878), while that between the signal strength and relative humidity is 0.39. This also shows that both have effects on signal strength but temperature has more effect than relative humidity at this frequency (106.3 MHz). The higher effect on the second day when compared to the first day can be said that the effects of the two parameters are high on cloudy or light shower days than on sunny or clear sky days. However, in both cases, increase in temperature results in decrease in signal strength and vice versa, while increase in relative humidity leads to increase in signal strength and vice versa. This is in conformity with the result of Joseph Amajama**,** in his work on the Cross River State Broadcasting Co-operation Television on frequency, 519.25 MHz **(**Joseph**, 2016)**. It was observed by him that radio signal strength is inversely proportional to atmospheric temperature, with correlation coefficient of -0.93 (r = -0.93). It is also in line with the result of Roshidah, *et al.,* 2016, in 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 (r = -0.085).

5.0 Conclusion

The relationship between the frequency modulation (FM) signal strength measured by digital CATV signal meter, temperature and relative humidity measured by digital Hygrometer/thermometer on both clear sky and cloudy days have been analysed using graphical relationship and correlation analysis. It was observed that radio frequency signal strength is affected by temperature and relative humidity. It can be concluded from the correlation coefficients on both days that radio frequency signal strength is inversely proportional to the atmospheric temperature and directly proportional to relative humidity. It can also be concluded that the effect of relative humidity and temperature is higher on cloudy days than on clear sky days. These results will be important to satellite or radio communication link designers, designers of antenna as well as mobile communication personnel.

6.0 Recommendations

This work considered only temperature and relative humidity effect on radio frequency signal strength, there is need to assess the relationship between radio signal and other atmospheric elements like atmospheric pressure and wind speed in future works. In addition, this work was done on FM frequency (106.3 MHz), the relationship of radio signal strength at other frequency band with temperature and relative humidity should be assessed in future work in this area.

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