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Atmospheric Humidity and Its Implication on UHF Signal over Gusau, North West, Nigeria

By

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ABSTRACT

Studies have shown that the variability of radio refractivity is largely driven by atmospheric Humidity and consequently the radio wave propagation in the lower atmosphere. In this study, the effect of atmospheric humidity variation on radio signal at Ultra High Frequency (UHF) was studied using four months (May, June, August and September 2017) meteorological data collected using Davis automatic weathr station and UHF signal strength data measured simultaneously at the premises of Federal University, Gusau *(6^0 78' N, 12^0 13' E).* The result indicates that there is a strong relation between the humidity variation and UHF signal strength. Regression analaysis of the two parameters gave a correlation of 0.418, 0.532, 0.728 and 0.639 for May, June, August and September Respectively. The results show that in addition to other meteorological factors not considered, relative humidity variation has strong effect on the signal strength.

INTRODUCTION

Increased dependence on mobile network for communication in our day to day life makes the reduction in the quality of analog transmissions and an increase in the error rate of digital transmissions. Previous studies such as (1, 2,) established that atmospheric humidity affects the refractive index of air and hence, the transmitted signal.

Recent studies on the effect of atmospheric humidity on signal strength established a relationship between the two parameters. The controversy has always been the nature of the relationship. While some studies record positive correlation, other records shows a negative correlation. The contradictory results may depend on the location of the research. (3, 4, 5 and 6).

The effect of atmospheric humidity on UHF signal strength in Gusau, Northwestern Nigeria, is investigated in this study to determine extent of degredation of UHF signals as relative humidity varies.

RELEVANT THORY

Relative Humidity

Humidity is the content of water vapour in the atmosphere which is measured as a vapour density or a vapour pressure. The relative humidity, H of the air, is expressed as a percentage. When the relative humidity of the air reaches 100%, air is said to be saturated. At this stage, water vapour turns into liquid state and condenses in the form of fine droplets. This phenomenon occurs as in rain, fogs, clouds, etc. (7). The factors influencing the specific humidity in the Planetary Boundary Layer (PBL) are as follows:

- Type of surface, its temperature, and availability of moisture for evaporation and/or transpiration.

- The rate of evapotranspiration or condensation at the surface and the variation of water vapour

- The depth of the PBL through which water vapour is mixed.

Radio Wave Propagation

Radio propagation is the behavior of radio waves when they are transmitted, or propagated from one point on the Earth to another, or into various parts of the atmosphere. Like light waves, radio waves are affected by the phenomena of; reflection, refraction, diffraction, absorption, polarization and scattering.

The Electromagnetic Spectrum

The range of all types of electromagnetic radiation is termed as the electromagnetic spectrum. The classification in term of their frequencies is given below;

VLF – Very Low Frequencies 3-30 KHz

LF – Low Frequencies 30-300 KHz

MF – Medium Frequencies 300 3000 KHz.

HF – High Frequencies 3MHz – 30 MHz

VHF – Very High Frequencies 30 MHz – 300 MHz

UHF – Ultra High Frequencies 300 MHz – 3 GHz

SHF – Super High Frequencies 3 GHz – 30 GHz

EHF – Extra High Frequencies 30 GHz – 300 GHz

Generally, when dealing with signals from Transmission to reception takes three forms (Line of Site, Ground wave and Sky wave), but for VHF and UHF propagation LOS is very useful.

INSTRUMENTATION

The Instrument used for the measurements of atmospheric parameters and UHF signal strength

(UV) sensor. Temperature, pressure and humidity sensors are mounted in a passive radiation shield to minimize the impact of solar radiation on the sensor readings. The data from the ISS then transmit to the console via radio signal and stored in the data logger. The console is connected to a computer, through which the stored data are collected. The UHF measuring device was designed and constructed by the research group using our available networks, the device has two modules, the external and internal. The external module received the UHF signal strength from the networks and transmits to the internal module. The internal module is connected to a computer, through which the stored data are collected.

METHODOLOGY

Surface values of relative humidity as well as UHF signal strength used for this study were extracted from the measurements made using Davis Vantage pro2 automatic weather station and UHF signal strength measuring device located at the ground surface of Federal University, Gusau *(6^0 $78'$ N, 12^O $13'$ E)* North West, Nigeria. The weather stations have thirty minute integration time while the UHF signal strength measuring device has five minute integration time.

Data collected for the month of June, August and September 2017 for both weather parameters and signal strength were averaged over each hour to give twenty four data points representing diurnal variations for each day and average was taken over the month to give a 24 data point for the month. The data were used to compute the correlation between weather parameters and signal strength and determined the impact of Relative humidity on UHF signal strength.

RESULT AND DISCUSSION

Fig. 1 depicts the graph of the variation of signal strength with relative humidity for the month of decreasing to the end of the day. The pattern of variation sems to be synchronous with Sunrise and Sunset. The signal strength increases as sSun rises and decreases as Sun sets.

The correlation for the month of June between the Signal Strength and Relative Humidity is 0.532 as shown in Figure 3. This result also agreed with the earlier result obtained for the Month of May. The diurnal variation of the signal strength for the month of June as shown in Figure 4 also sychronized with the Sunrise and Sunset. This can be attributed to diurnal variation of relative humidity. The relative humidity is expected to be low in the day when the temperature is high. This result shows that signal strength is affected by relative humidity.

Figure 5 shows the relationship between signal strength and and relative humidity for the month of August. The correlation coefficient obtained for the month is 0.728. This agreed with earlier months studied. The strenght of the correlation for this month is stronger than the previous months and this is attributed to the month of August been the peak of rainy season in the study area. The diurnal variation for the month of August as depiceted in Figure 6 follow the same pattern as the two previous months studied.

The month of September also experienced high rainfall comparable to August in the study area and the correlation between the signal strength and relative humidity was found to be 0.639(Figure 7). This agreed with the previous months studied. The diurnal variation of signal strength for September as shown also follow the pattern of the previous months studied.

The results from this study as presented in Figure 1 to Figure 8 shows that relative humidity has effect on signal stength. The signal quality is better in the night than the day. This is attributed to higher humidity during the night. The high humidity makes the atmosphere denser which probably makes the radio signal to move faster. This result agree with previous studies (Adewumi, 2013 and Amajama, 2016).

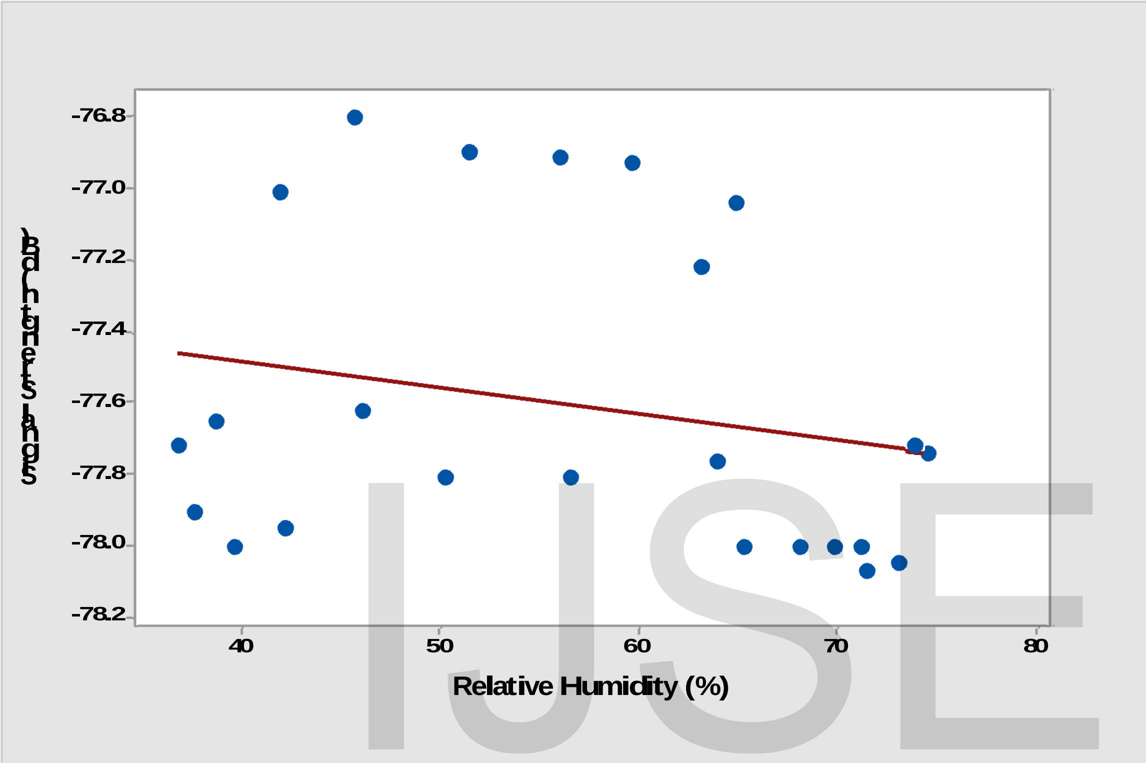


Figure 1: Variation of Signal Strength with Relative Humidity for The Month of May

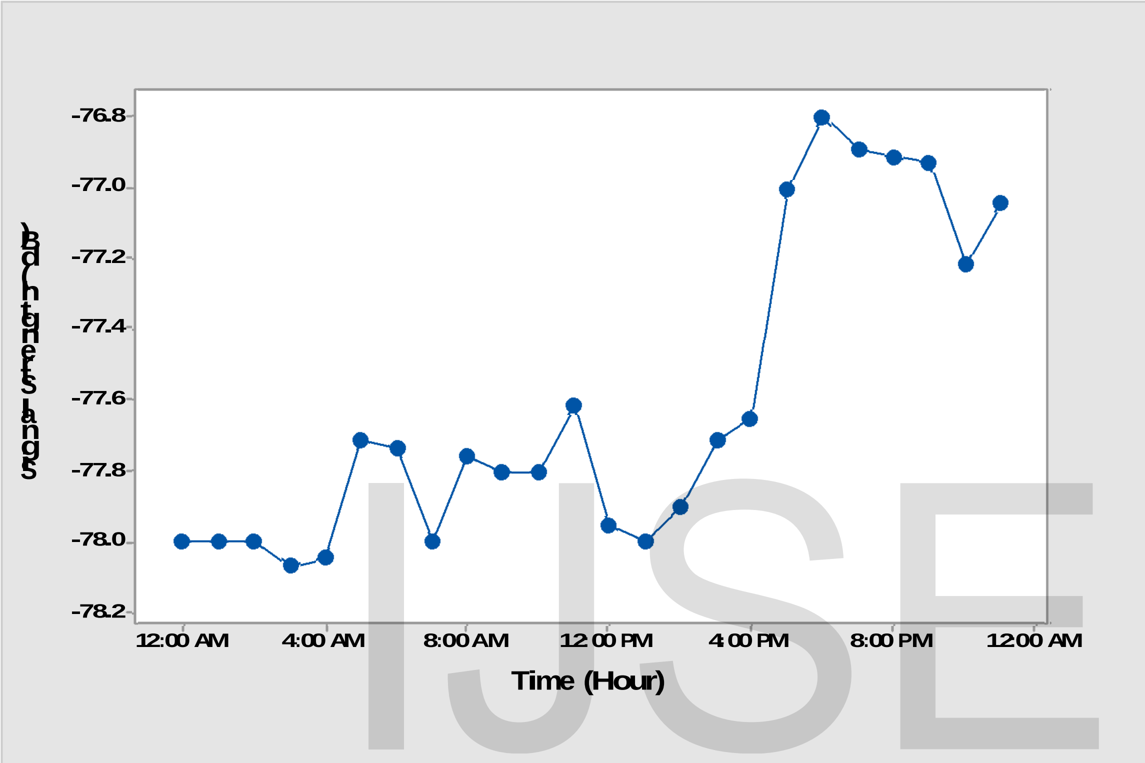
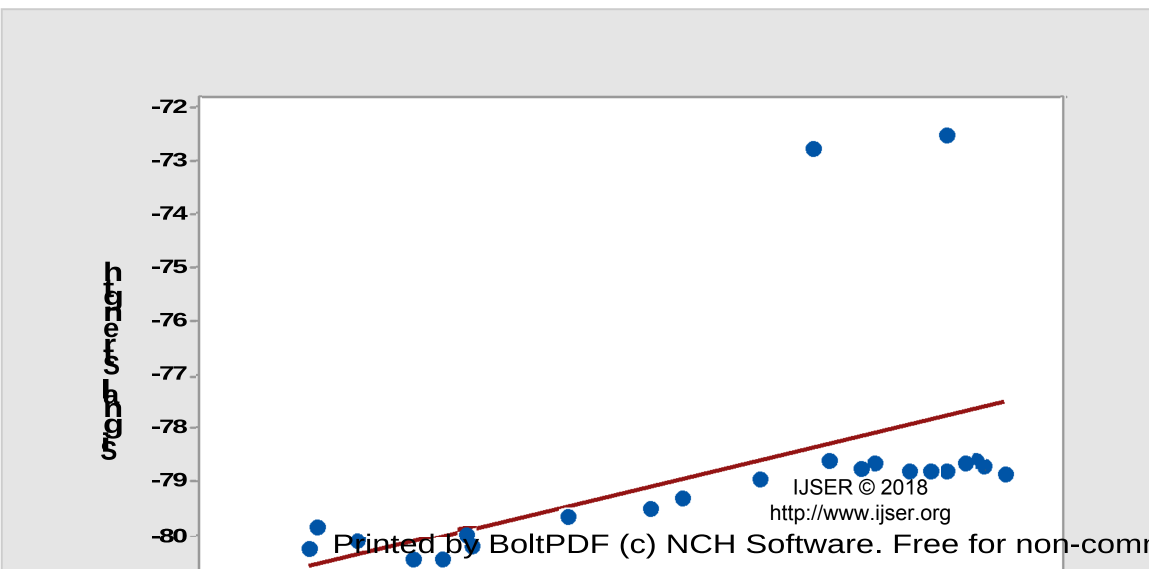


Figure 2: Diurnal Variation of Signal Strength for The Month of May



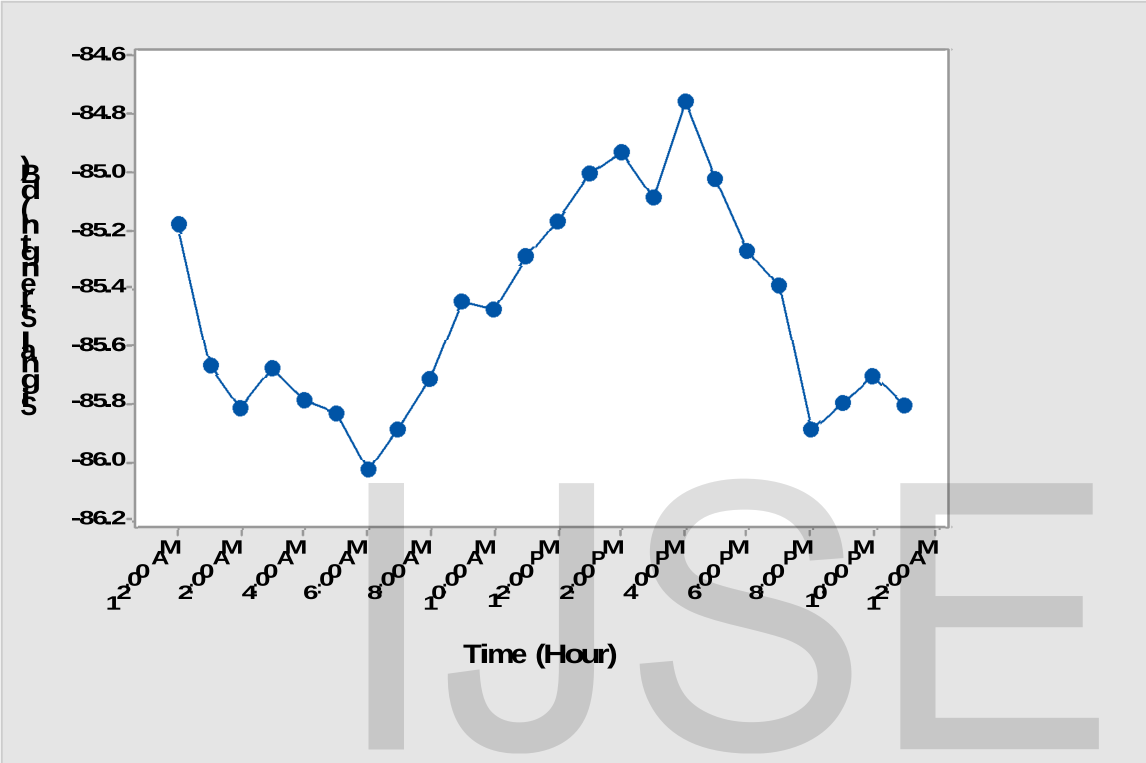
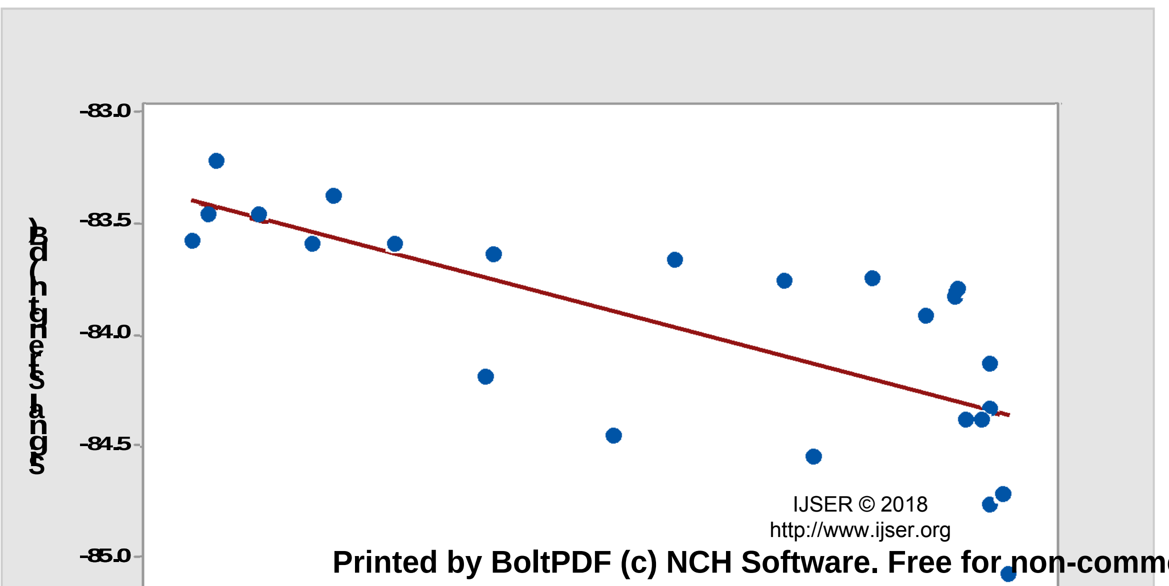


Figure 4: Diurnal Variation of Signal Strength for June



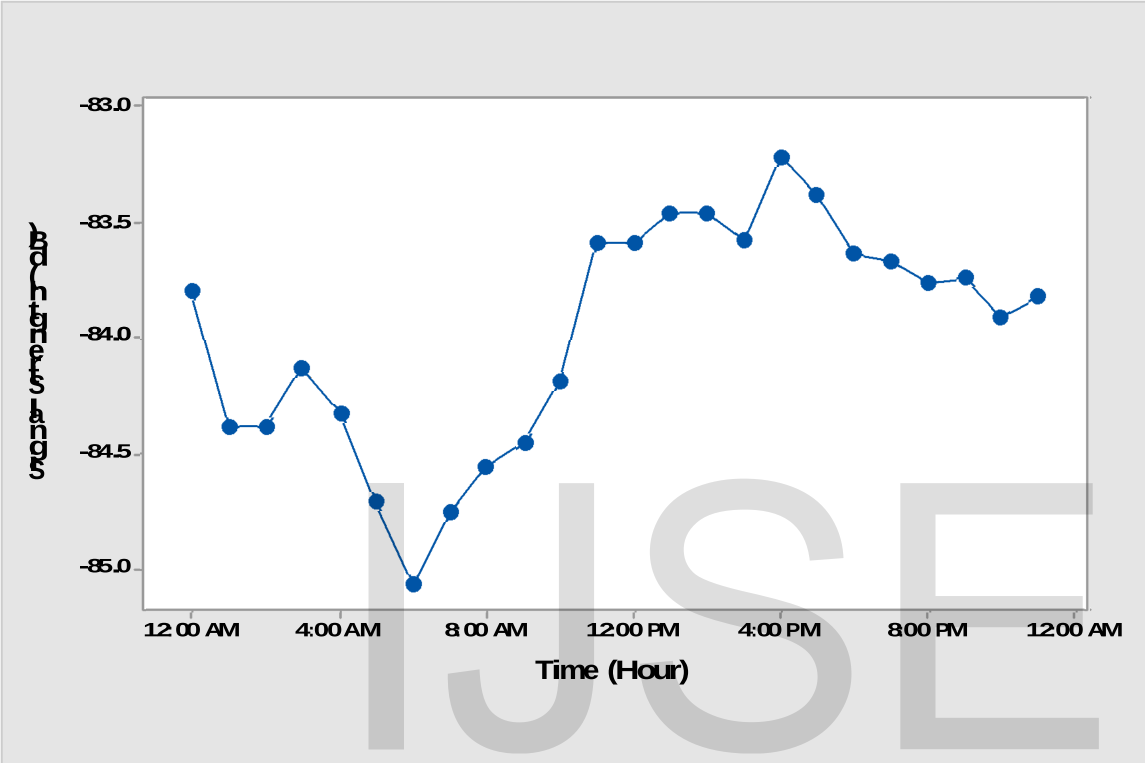
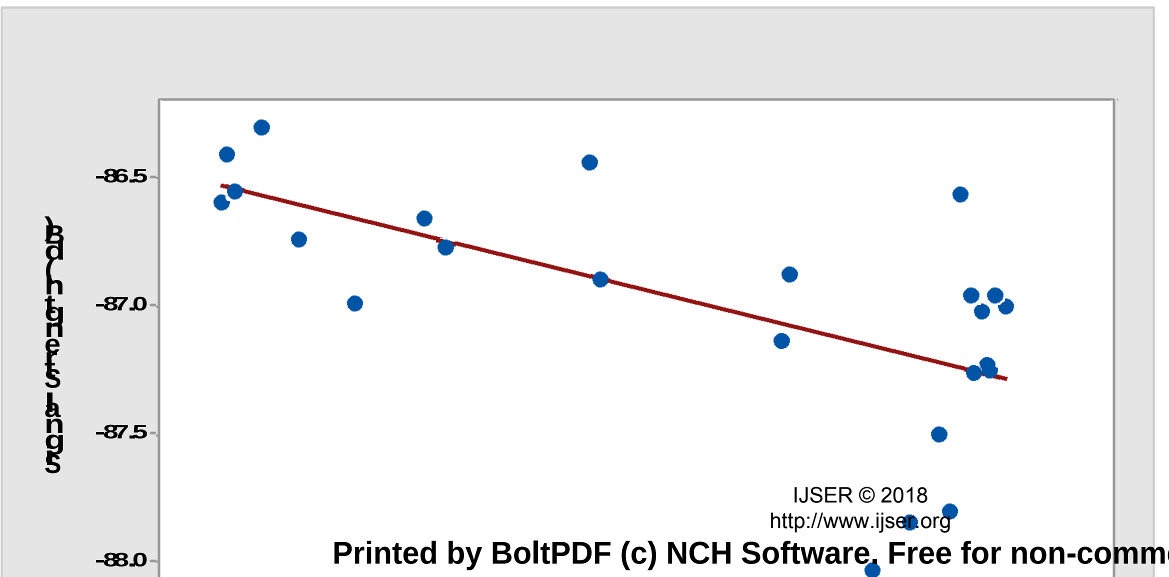


Figure 6: Diurnal variation of Relative Humidity in August



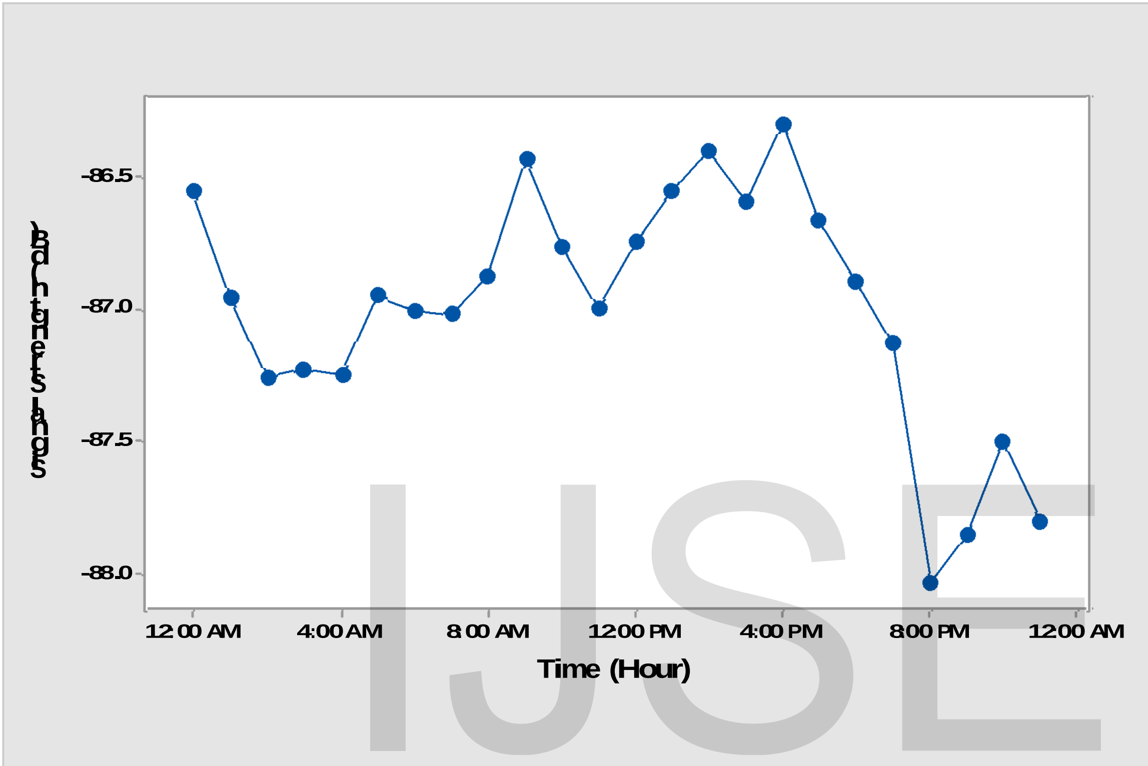


Figure 8: Diurnal Variation of Signal Strenght for September

CONCLUSION

Measurement of atmospheric humidity simultaneously with UHF signal strength were made on the premises of Federal University, Gusau, North-West, Nigeria with the objective of examining the impact of atmospheric humidity on UHF signal strength in the lower atmosphere. The following summations were made from the observation.

- Signal strength and Relative humidity strongly correlate.
- There is an appreciable impact of Relative humidity on the transmitted signal.
- Other meteorological parameter and environmental factors may affect the signal strength.
- Future work will include a follow up analysis using a large number of measurement and

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Acknolegedement

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