



## Solar Radiation and its Effect on Signal Reception of Direct –to-Home Satellite System in some selected towns of Nasarawa State, Nigeria

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### ABSTRACT

This research work examines the effects of variation in solar radiation on signal reception of Direct-to-Home (DTH) satellite on Ku-Band in some selected towns in Nasarawa State, Nigeria. Data used were obtained through experimental approach of recording both solar radiation and the quality of signal received from DTH at 12.517GHz at regular interval of one hour covering two climatic conditions (Rainy and Dry seasons) in 2017. The data obtained from field was used and daily and monthly averages were evaluated. The result showed a consistence in the amount of solar radiation within the three towns (Akwanga, Keffi and Lafia) under study largely to the fact they lie within same coordinates. All the towns experience high value solar radiation in the month of March shortly before the rainy season sets in and in its lowest in August when the rainy season is at its peak. The result showed that, the state has average values of 22.7MJm<sup>2</sup> and 15.4 MJ/m<sup>2</sup> as high and low values respectively in the months of March and August respectively. The averaged value for the whole states showed a weak negative correlation coefficient value of -0.398 and R<sup>2</sup> value of 0.011 when fitted into linear regression between solar radiation and the quality of signal reception within the study area.

**Keywords:** Solar radiation, Direct-to home, Signals reception, Akwanga, Keffi and Lafia

### INTRODUCTION

Direct-to-home (DTH) satellite service which refers to the satellite television (TV) systems in which the subscribers or end users receive signal directly from the geostationary satellite orbit (GEO) dedicated for such purposes. These signals are broadcast in digital format at microwave frequencies (Elbert, 2008). The service providers make use of satellite link to transmit their signal to the entire world through space known as atmosphere consists of a mixture of ideal gases with molecular nitrogen and oxygen as predominant in volume, while carbon-dioxide, water vapour and ozone as minor constituents play crucial roles, is the thin layers of gases, commonly referred to as air that surround the earth and retained by the earth's gravity; seals the planet and protects us from the vacuum and electromagnetic radiations given off by the sun (David, 2010).

Radio wave propagation is influenced by the properties of the earth and the atmosphere. The curvature of the earth and the condition of the atmosphere can refract electromagnetic waves

either up, away from, or down toward the earth's surface (Adediji, 2014). The ionosphere reflects transmitted radio frequency waves back to Earth. The strength of these radio waves depends on how much or how little the ionosphere is ionized. Solar radiation contributes to ionization of the atmosphere, which can alter the strength of the transmitted or received radio waves (Merola, 2006). Radio frequency bands defined by International Telecommunications Union (ITU) together with their mode of propagation and primary uses are shown in Table 1.

Solar radiations and other solar activities affect the total electron content of the ionosphere and also affect various radio frequencies used in telecommunications (Ezekoye, 2007).

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In this paper we present a trigonometrically fitted method based on two-step explicit third

and fourth order Improved Runge-Kutta method derived by Rabiei *et al.* (2013).

Table 1: Radio Frequencies together their Primary Propagation Characteristics and their Uses

S/N	Name	Frequency Range	Primary Mode of Propagation	Primary Uses
1	Extremely Low Frequency (ELF)	3 kHz	Earth and the ionosphere. Wave guide penetrates sea water	Land to sub-marine Communications.
2	Very Low Frequency (VLF)	3 – 30 kHz	Between ground and lower ionosphere. It is a ground wave and uses wave guide also	Navigation, communication, standard frequency, and time
3	Low Frequency (LF)	30 – 300 kHz	Wave guide, ground wave	Maritime and broadcasting.
4	Medium Frequency (MF)	300 – 3000 kHz	E region of the ionosphere reflection (might). Ground wave	Maritime, aeronautical, international distress, and Maritime/land mobile.
5	High Frequency (HF)	3 – 30 MHz	Reflection from E and F region of the ionosphere.	Maritime and aeronautical fixed services and Broadcasting.
6	Very High Frequency (VHF)	30 – 300 MHz	Line of sight, scatter from ionosphere. Reflection by active satellites	Television, frequency modulated broadcasting , public safety, and aeronautical
7	Ultra High Frequency (UHF)	300 – 3000 MHz	Line of sight (affected by ionosphere irregularities). Active satellites	Space communications, TV, radar, broadcasting, and navigation (fixed mobile)
8	Super High Frequency (SHF)	3000 – 30000 MHz	Line of sight (troposphere affected by ionosphere irregularities).	Space communication, TV, radar, broadcasting, and navigation (fixed mobile)

Source: (Leo, 1994

The effect of the solar radiation and particles that stream out from Sun would be quite deadly for inhabitants of Earth. Earth’s atmosphere, which block out the X rays and most of the ultraviolet radiation. When X-ray or ultraviolet photons encounter the atmosphere they hit molecules and absorbed, causing the molecules to become ionized; photons are reemitted but at much longer (and less biologically destructive) wavelengths.

Solar radiations affect the total electron content of the ionosphere that may disturb the radio-frequencies used in telecommunications. It may state with full confidence that the increase in the

critical frequencies of the F2 layer from the values observed in the morning hours to the afternoon maximum frequencies, is due to ultraviolet (UV) radiation from the Sun. During an ionospheric storm, some radio frequencies are absorbed and others are reflected, leading to rapidly fluctuating signals and unexpected propagation paths.

**METHODOLOGY**

The equipment used for this work includes: Light meter (LX101A) for recording the intensity of solar light radiation from which the solar irradiance was evaluated shown in figure 1 and a complete set of direct-to home satellite

kit (Antenna, signal Decoder and Scopes) shown in figure 2 and 3 for the observation of the signal responses as a result of variation in solar radiation.



Figure 1: LX 101A Light Meter



Figure 2: Parabolic Antenna



Figure 3 TV setup for observation

The experimental approach was adopted in which both solar radiation and signal reception pattern were recorded and regular interval of one hour for whole year. The work deployed experimental as well as statistical methods in the analysis. The data used were obtained from field and Nigeria Meteorology Agency (NiMet).

Nasarawa state is located in the North central region of Nigeria as shown in figure 4 with three major towns of Keffi, Akwanga and Lafia whose coordinates are as shown in table 2 choosing as the study area.

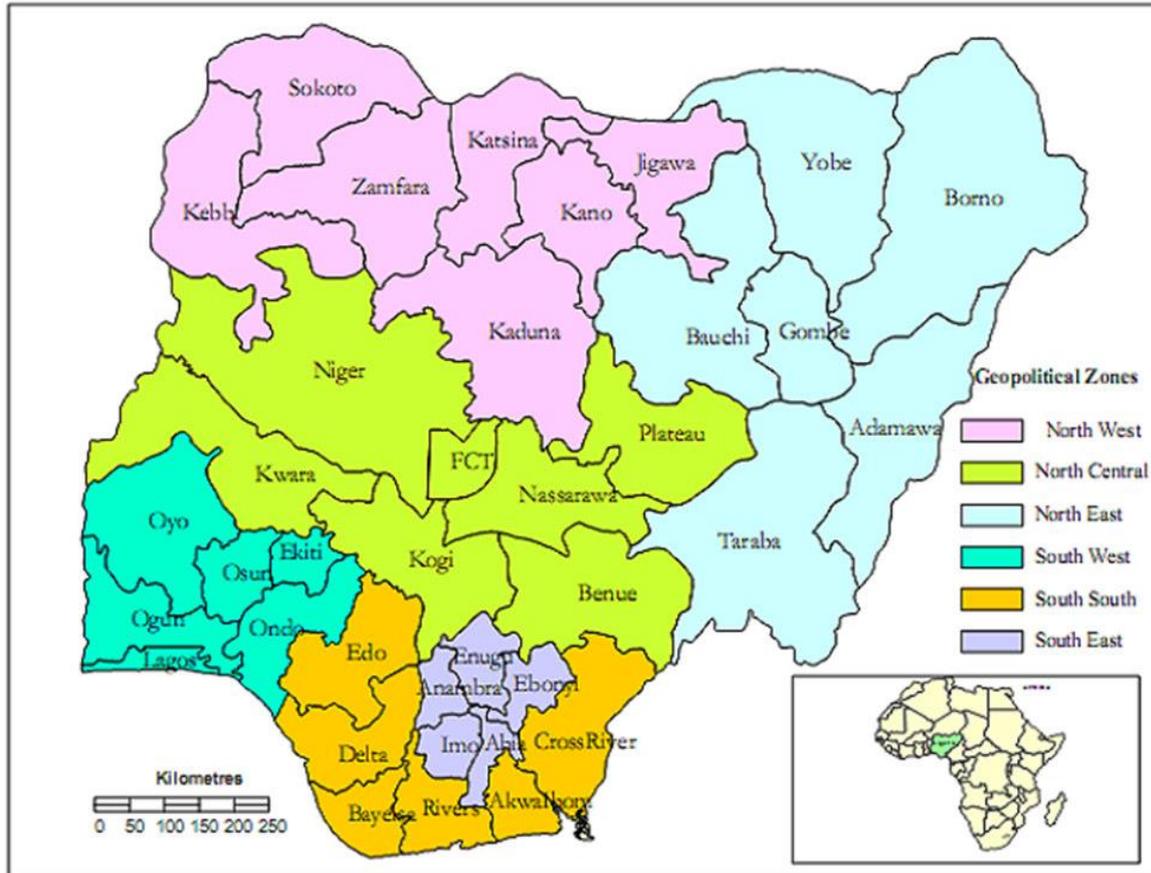


Figure 4: Map of Nigeria showing the six geo-political zones (NASDRA, 2013)

Table 2: Towns and Coordinates of the study area in Nasarawa State

TOWN	LOCATION	ALTITUDE (m)
Akwanga	8.917°N / 8.367°E	359
Keffi	8.843°N / 7.871°E	338
Lafia	8.492°N / 8.517°E	290

(Nimet, 2015).

solar radiation and signal quality over the study area are as shown in Figure 5 and 6 respectively, while, Figure 7 shows the hourly daily record of the variations recorded between 31<sup>st</sup> May, 2017 and 3<sup>rd</sup> June, 2017, while Figure 8 shows the average monthly record for the variation experienced and Figure 9 depicts the overall average value for the state. Figure 10 shows the correlation between the averaged values of the solar radiation and the signal quality

**RESULTS**

The results obtained were as depicted in the figures listed. The average monthly values of

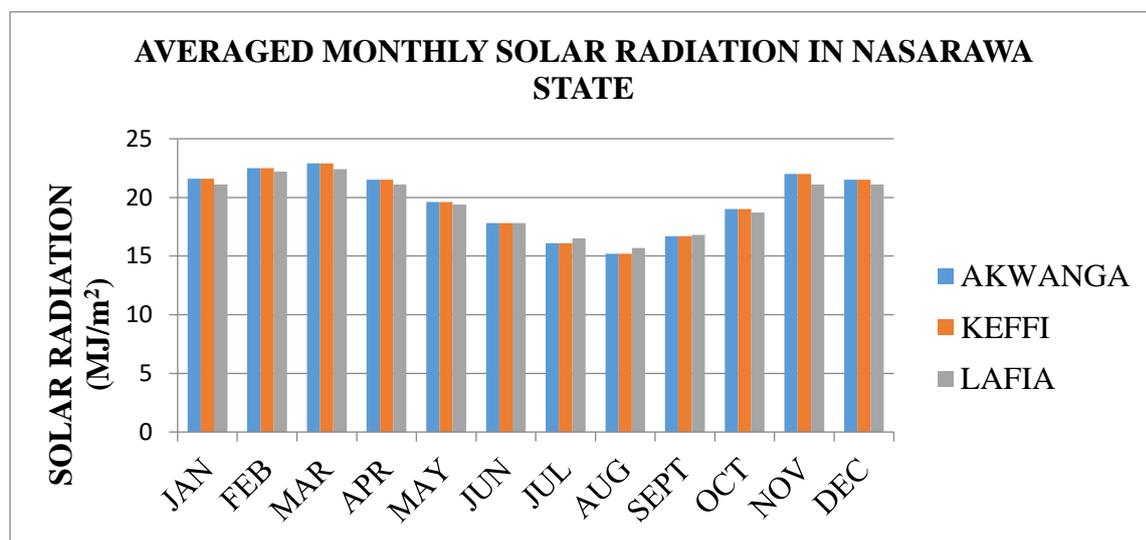


Figure 5: Average monthly variation in the solar radiation of the study area

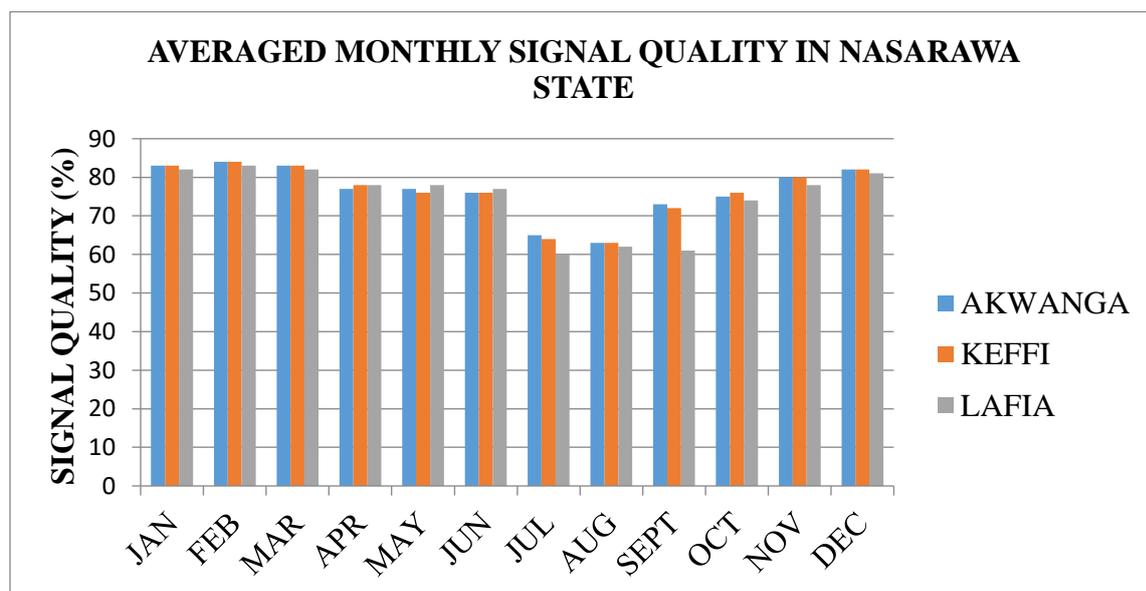


Figure 6: Average monthly variation in the signal quality of the study area

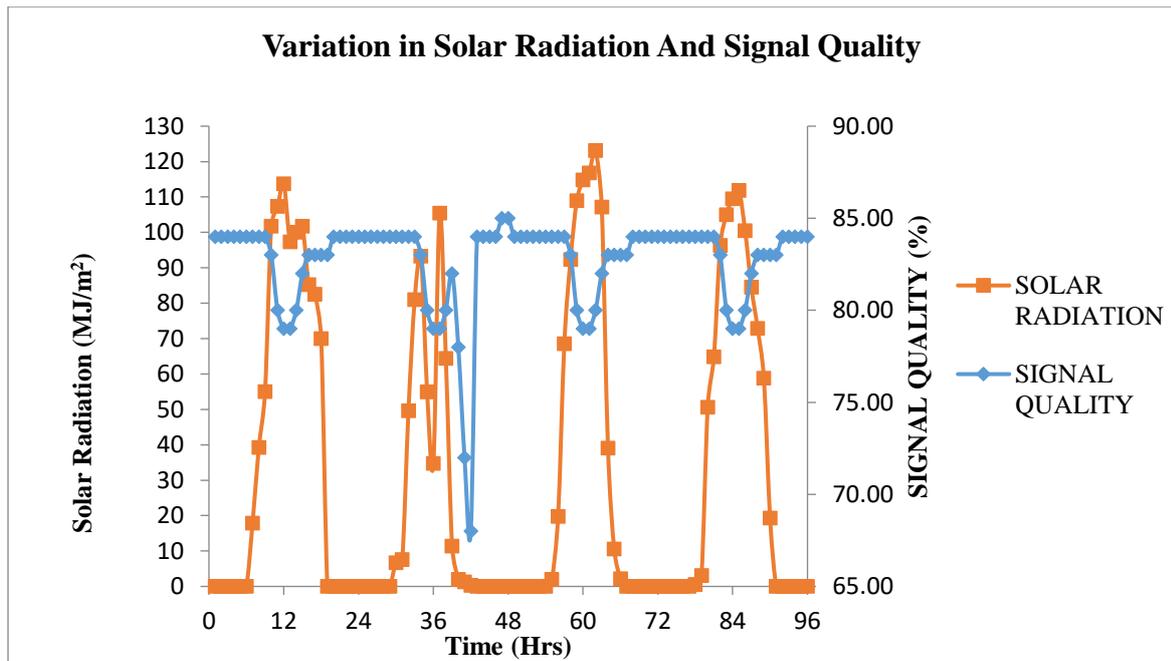


Figure 7: Hourly daily record of the variations recorded between 31<sup>st</sup> May, 2017 and 3<sup>rd</sup> June, 2017

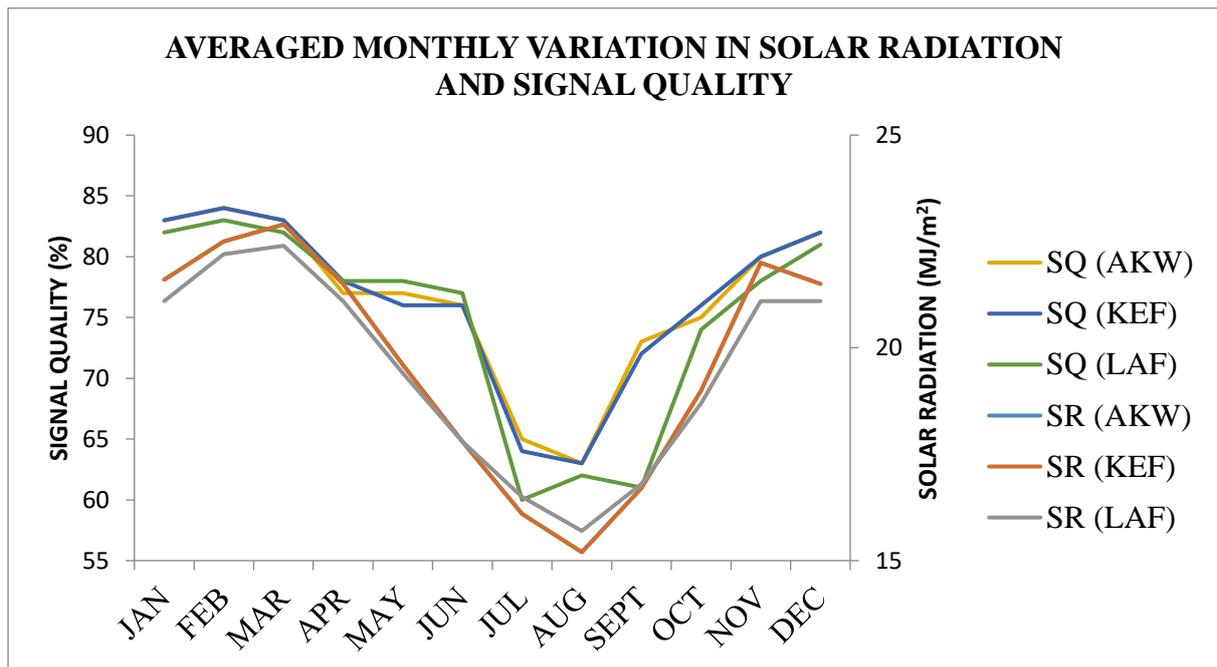


Figure 8: Average monthly variation in solar radiation and the signal quality in of the study area

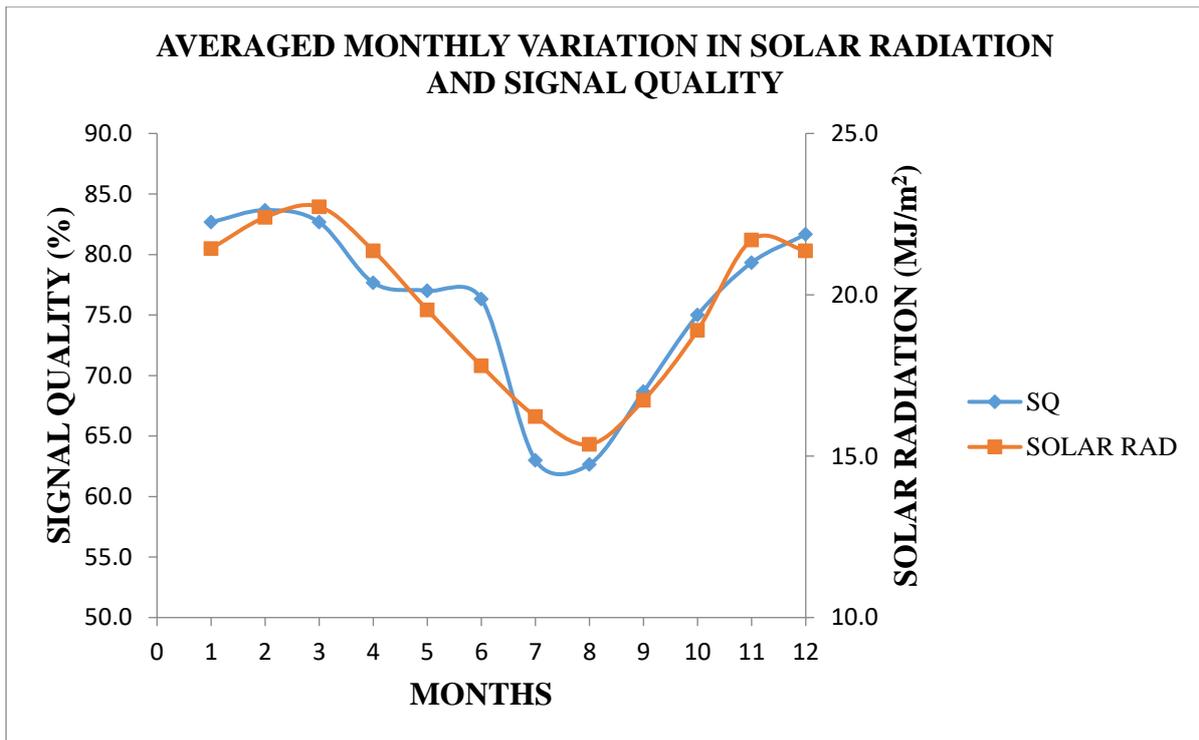


Figure 9: Average monthly variation in solar radiation and the signal quality in the State

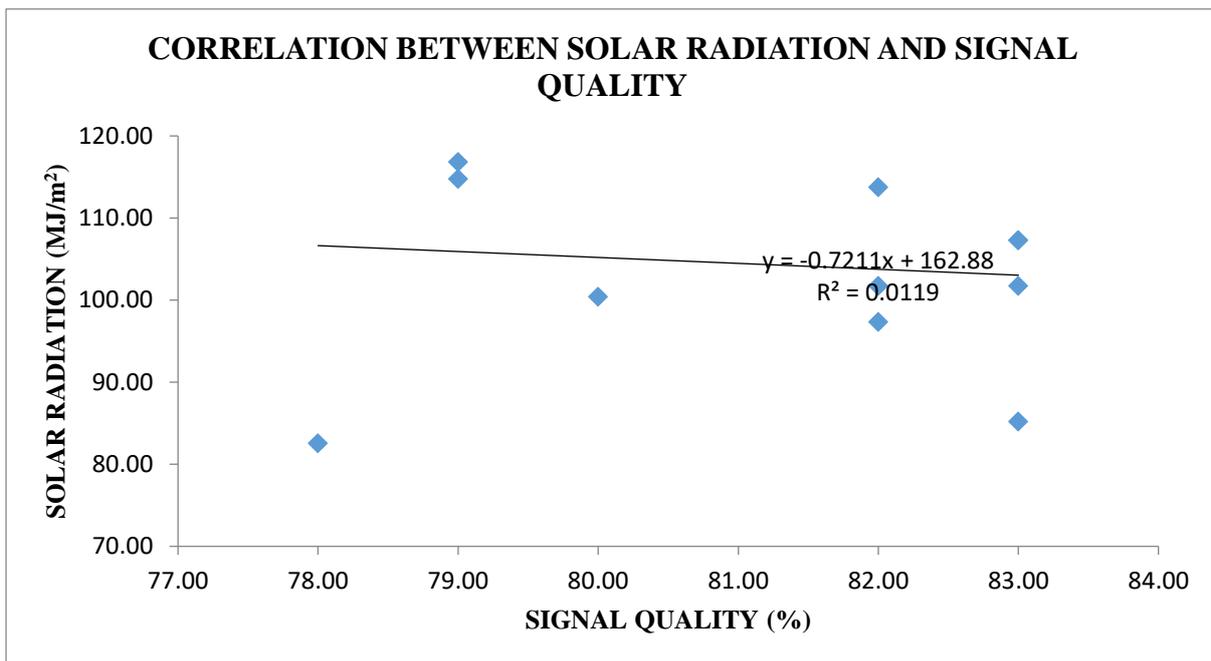


Figure 10: Correlation between the averaged values of the solar radiation and the signal quality

**DISCUSSION**

Figure 7 indicates that solar radiation rises gradually and reach its peak between 12noon and 3pm daily during which the quality of signal received reduces or drops and rises again

as the intensity of solar radiation reduces till sunset when the maximum receivable signal quality is reached and maintained at nights. The trend observed shows that a variation in the

intensity of solar radiation results into a variation in quality of signal received, though there exist some abnormalities seen intermittently, this is not as a result of variation in solar radiation that resulted into such sharp drop in the quality of signal received but could be attributed to other factor(s) not under consideration as a variable e.g. cloud, rainfall, wind direction and speed.

The data obtained and averaged shows that the amounts of solar radiations are lowered during the rainy season, this is as a result of cloud formation preceding the rainfall, while the amount got higher during the dry months. This assertion is evident in Figure 5. Figure 10 indicates that there exists a linear regression with  $R^2$  value of 0.011 when fitted into a linear line of best of fit of relation  $y = -0.721x + 162.8$  with Solar Radiation and signal quality as independent and dependent variables respectively. The correlation between the two parameters has a negative correlation coefficient of -0.398 and by implication means a weak correlation.

### Conclusion

The trend of the results obtained shows that as solar radiation increase in daytime, the quality of Ku-band signal received decreases. Considerable reduction in the quality of signal reception within the study area. The correlation between solar radiation and the signal quality shows linear correlations, with  $R^2$  values of 0.011 for solar radiation when correlated with signal quality. This value is likely going to increase as time passes by, due rising activities on earth through pollution leading to gradual depletion of the Ozone layer through global warming, the likelihood of the solar radiation under study to also rise is there and hence, what is not too significant now could be in near future, most especially in tropical region like the area under study. Conclusively, the result obtained and analyzed shows that variation in solar radiation has 1.1% effect on the signal reception. This effect on the signal reception thus summed up into the proposition that, the quality of signal received is inversely proportional to the variations in solar radiation.

### REFERENCES

- Adediji, A. T., Mandeep, J. S. and Ismail, M. (2014). Meteorological Characterization of Effective Earth Radius Factor ( $k$ -Factor) Wireless Radio Link Over Akure, Nigeria. *Metrology Society of India* 29 (2): 131-141.
- David, G. A. (2010). An Introduction to Atmospheric Physics, 2<sup>nd</sup> edition, Cambridge University Press, Edinburgh, UK, Pp 1- 2.
- Elbert, B. R. (2008). Introduction to Satellite Communication, 3<sup>rd</sup> Edition, Artech House, Boston London.
- Ezekoye, B. A. & Obodo R. M. (2007). The effects of solar radiations on Telecommunications, *the Pacific Journal of Science and Technology (PJST)*, 8(1): 109 – 117.
- Leo, F. M. (1994). Radio Amateur Guide to the Ionosphere, Krieger Publishing, London.
- Merola, L. (2006). A Study of the Effects of Sunrise and Sunset on the Ionosphere as Observed by VLF Wave Behavior (online). <http://solarcenter.stanford.edu/SID/StudentWork/LeandraMerola.pdf> (21 April 2015).