FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 7 No. 3, June, 2023, pp 71 - 73
DOI: https://doi.org/10.33003/fjs-2023-0703-1823

THE EFFECT OF SOLAR RADIATION ON THE SIGNAL STRENGTH OF A.B.U. SAMARU RADIO STATION

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ABSTRACT

Solar activities including solar radiations affects not only the electron content of the ionosphere but also the various frequencies used in telecommunications. The alternating voltages of the frequency modulation (FM) in Ahamdu Bello University radio station was obtained during the period of three months from July to September 2019. The variation of all prominent peaks of the electron density begins during sunrise and sunset, where most of the peaks shows weak signal strength during the daytime i.e. at 16,000N/m^3 compared to night time and morning time at 0.00N/m^3 and 0.00N/m^3 respectively. The results showed that this station have all day signal strength, while night time show variability in signal strength. This observation may be attributed to the solar activity in the atmosphere. We calculated the critical frequency and hence find the Maximum Usable Frequency (MUF) and conclude that solar radiation factor give the minimum significant effect to radio signals.

Keywords: Solar, radiation, electromagnetic waves

INTRODUCTION

As electromagnetic waves (radio waves) signals travel, they interact with object and media in which the travel. As they do this, the radio signal can be reflected, refracted or diffracted. Their interactions cause the radio signals to change direction and to reach areas which would not be possible. If the radio signals travel in a straight line, the condition of the sun has a major impact on the ionospheric radio propagation. It affects a variety of High Frequency (HF) radio communication including two-way radio communication (Okeke at al., 2009). As the sun provides radiation that governs the state of the ionosphere and hence HF propagation, any flare or another disturbance is of great importance. Under some circumstance, this can enhance radio communication and under other circumstance, this can disrupt radio communication on the HF bands while at the same time providing some radio propagation conditions that can be used as Very high frequency (VHF) amateurs (Okeke at al., 2009). The ionosphere is the upper part of the atmosphere extended from about 50km to 2000km above sea level. The part we are interested in for electromagnetic wave transmission is the lower part of the ionosphere 500km above sea level. In the ionosphere, radiation from the sun (primarily x-rays and ultra-violet particles) bombard gas particles and cause them to be negatively charged electrons. An important parameter for electromagnetic propagation is the amount of free electrons that are present. This is called the "electron density". The higher the electron density, the more the HF radiation is bent towards surface**.** Radio wave propagation is influenced by properties of the atmosphere and subsequently earth. Electromagnetic waves can be refracted either up, away from, or down towards the surface of the earth due to the curvature of the earth and condition of the atmosphere, the ionosphere reflects transmitted very high frequency (VHF) radio waves back to earth. The strength of these radio waves depends on how much or how little the ionosphere is ionized. Ionization of the ionosphere is contributed greatly by the solar radiation activities, which can alter the strength of the signal of the radio waves (Hazmin, et. al., 2015). Ranging from 300 to 3000 MHz, UHF band was commonly used by telecommunication service (Marhamah, et. al., 2018). Different types of wave are used in these services, according to its purposes. Like Global Positioning System (GPS) and shortwave broadcast services, space wave was used to transmit data from transmitter to the receiver. Common issues arise from transmitting space wave data are the data loss. A study conducted over the Brazilian territory shows that the variation of the GPS was caused by magnetic activity in April 2000 and November 2003. The data collected differed from each other despite both periods were taken during active geomagnetic activity. During April 2000, geomagnetic index measured -300 nT which considered as an intense geomagnetic storm and cause large variation to the data. During November 2003, geomagnetic storm suppressed the GPS amplitude scintillations data. Similarly, in found that during intense scintillation (post sunset hours, late evening hours and around midnight), the GPS accuracy of position fixing deteriorates. In the same vein, in reported that both GPS links and geostationary satellite links suffered from signal fading which associated with the earth's ionosphere. The variations of carrier-to-noise ratio (CNO) of GPS signal with the corresponding position dilution of precision for satellite (Marhamah, et. al., 2018).

Solar radiation has a greater effect on the ionospheric radio propagation, especially at the period of solar maximum. It affects the operational frequency used in broadcasting stations and alters the signal strength. Therefore, this study aims at investigating the signal strength on solar radiation and is aimed at providing necessary information for weather forecasting, and to enable radio communication at Ahmadu Bello University, Nigeria to make predictions and necessary adjustments to maximize its operational frequencies.

MATERIALS AND METHODS

Sources of data and method of measurement

The data analysed in this work were obtained from the Ahmadu Bello University (Samaru) radio stations from July to August 2019 using the global positioning system (GPS). Various values of the electron density from Ahmadu Bello University (A.B.U) Samaru radio station at different periods were obtained. The value given where obtained using the global positioning system (GPS). The prerequisite input parameters used for retrieval of these data were; year (2019), month (July - August), day (1 – 31; dependent on month duration), time (local time; 8am and 10pm), coordinate (geographic), latitude (6.5 0 N), longitude (7.2 0 E), height (65, 80, 90 and 130 km). The days encompass both geomagnetic quiet and disturbed days. The procedure was wholly repeated for the 3-month period under investigation and the output was given as a function of one user-selected independent variable. The critical frequency which is defined as the highest magnitude of frequency above which the waves penetrate the ionosphere was computed using Equation 1.

$$F_c = 9\sqrt{N_{max}} \quad (1)$$

Where N_{max} is maximum electron density per m^3 and f_c is in Hz.

The maximum usable frequency was also calculated and as a rule of thumb this is usually three times the critical frequency and is given by Equation 2

$$\mathrm{M.U.F} = \frac{F_c}{\sin i} \quad (2)$$

$$\mathrm{M.U.F} = \frac{F_c}{\sqrt{1-(\frac{R}{R+h})^3}}$$

Where i angle of incidence, R= Earth's radius, h = Height of the ionosphere

RESULTS AND DISCUSSION

Both the day and night time values of the monthly electron density for the three-month period at different heights were analysed using excel tools. From the analysis, the monthly variations and altitude dependence of ionospheric electron density was made. The effects of solar activities on the electron density in the ionosphere around the study area were ascertained. Plots of monthly electron density variation in Ahmadu Bello University, Zaria radio station versus time are seen in Figures 1.

Figure 1 depicts an almost constant density of electron throughout the period under study at a height of 80 km. At 90 km, electron density peaked at a value of 16000N/m^3 at 12hrs and gradually decreased to 0. The concentration of electron density becomes quite remarkable at a height of 130 km, with distinct monthly variation throughout the solar cycle. This result agrees with that obtained by Tereshchenko et al. (2002). These variations of electron density with height and time are attributed to various reactions and processes taking place in the ionosphere (Okeke et al., 2009). This feature is inferred to be caused by the absence of the sun's ionizing radiations, hence reduction of solar control. The minimal ionization observed could be due to cosmic ray particles from extragalactic activities. The enhanced electron density with increasing solar activity and time variation as generally observed is consistent with studies (Bremer et al., 1976; Danilov, 2007, 2008) and is attributed to significant enhancement of absorption during high solar activities. As shown in Figure 1, higher concentrations of electron density were recorded at 16000N/m^3 at peak times considered in this study. The plot for monthly variations at A.B.U radio station features electron density exhibiting a three-month cycle with two maxima in July and September respectively. This agrees with the results obtained by Bailey et al. (2000), where maxima occur conspicuously in the daytimes than in night time. Large maxima occur persistently at noon and conversely minima at midnight as evidenced in Figures 1. At approximately 05:00 Local Time (LT), the electron density initially at about zero, progressively increases with time to a steep rise at 12:00 LT, where a maximum is reached. Subsequently, the electron density sharply declines till about 18:00 LT with a continued but almost a zero value throughout night time. Several works (Tereshchenko et al. 2002; Adeniyi, 2004; Pérez-de-Tejada 2004; Lakshmi, 1997; Gwal et al., 2004) report same zero and decreased electron density variation at post-midnight.

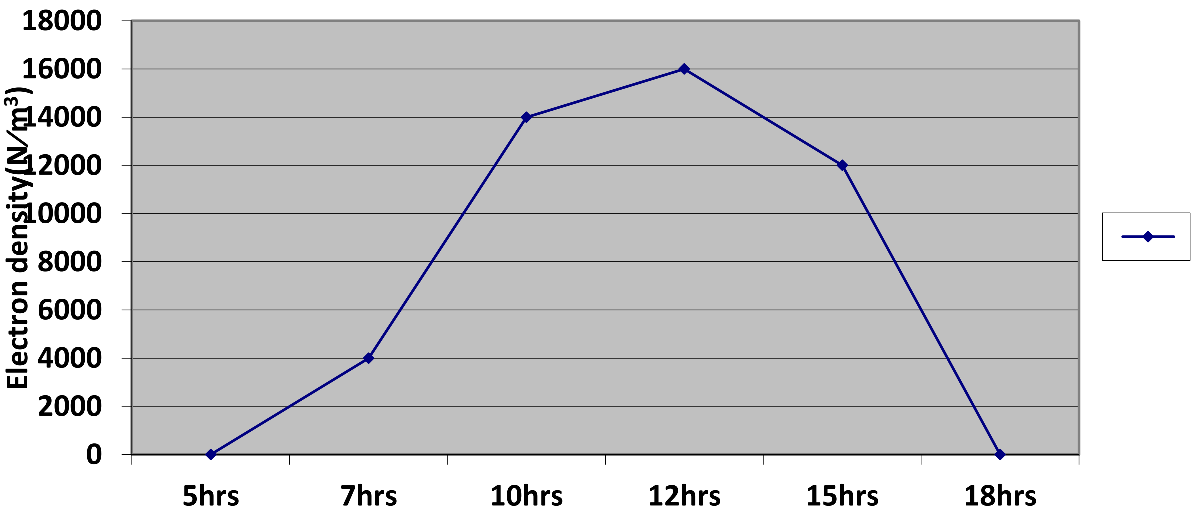

Figure 1: The graph of electron density (N/m^3) against time (hours) shows typical variation of the electron density with time of the day.

CONCLUSION

From the analysis in this study, it shows that the solar radiation has a significant effect on the signal strength of ABU- Radio Station Samaru. The operational frequencies are slightly affected by the effect of both coronal mass ejection (CMEs) and solar flares which causes major changes in the ionospheric radio propagation, after disrupting them for hours. Solar radiation usually correlates with the numbers of free electron ionized in the ionospheric level. These free electrons have great influence on the radio wave especially one that passes through the ionosphere; sky wave and space wave. This study examined the effect of solar radiation on radio signal which has identify solar radiation as the most parameters that has a significant effect on a radio signal and

Electron density. In contrast, low frequency (LF) transmissions were absorbed by the ionosphere during the daytime. Communication engineers are advised to be alert with these possible effects that will attenuate the propagation of radio wave, especially for GPS and satellite application that used UHF and L band as their propagation medium.
The result of the study also reveals that the electron density variations at lower atmosphere at A.B.U radio station are primarily controlled by solar radiation at different seasons and altitudes. In general, very high values of electron density were recorded at noon, while very low values were recorded at night or early morning hours. The highest values were observed during the months of July and September confirming results of Tereshchenko et al. (2002). This could be attributed to solar intensity variations. Since the refractive index of the ionosphere is dependent on both frequency and ionospheric electron density, probably, the effects of radiation are greater at low frequency. We ascertained from this study that during the months of July, August and September operating frequency of radio signals should be increased for avoidance of risk of information loss.

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