Journal of Academic and Applied Studies (JAAS)
Vol. 2(1) Jan 2012, pp. 1-7
Available online @ www.academians.org
ISSN1925-931X

ASSESSMENT OF AREAS THAT ARE PRONE TO THUNDERSTORM ACTIVITIES IN THE NORTHEAST ZONE OF NIGERIA

G. A. Adegboyega and K. O. Odeyemi

Department of Electrical and Electronic Engineering,

The Federal University of Technology, PMB 704, Akure, Nigeria

Abstract

Lightning and thunderstorm are the most significant cause of interferences in the transmission and electrical power distribution systems. All terrestrial based electrical systems; telecommunication exchanges stations, global system for mobile communications (GSM) base stations as well as tall structures are prone to disruptive forces of lightning strikes. The intent of this study is to look at the available data for the development of a map on the thunderstorm day and flash density and to determine the area that are prone to high/low risk of thunderstorm/lightning in the northeast zone of Nigeria. This was done in order to give insight into the risks associated with the thunderstorm on electrical equipment in relation to the locations in the region. The data information for more than twenty years about this region was collected from the Nigeria Meteorological Service (NMS) for the analysis of the thunderstorm day level.

Keywords: Thunderstorm Day (T_d), Ground Flash Density (F_D), Keraunic Levels, Nigeria Meteorological Service (NMS)

I. Introduction

Lightning is an electric discharge in the form of a spark or flash originating in a charged cloud. Majority of communication systems failure may be attributed to thunderstorm/lightning activities. Komarek (1965) stated that the lightning channel of a discharge to ground or between clouds is highly ionized and carries a time-varying current which can be considered as an aerial emitting over a wide spectrum of frequencies. Thus, this constitutes a powerful source of noise which interfaces with communication and broadcasting systems. Telecommunications network has always been exposed to potentially hazardous environment been caused by lightning activities. Gallaghar and Pearmain (1983) confirmed that the danger of lightning strokes to transmission networks is related to the degree of thunderstorm activity. Lightning is the most feared naturally occurring phenomenon because of its amazingly destructive force. Cummins et al (1998) stated that lightning is a significant cause of interruptions or damage in almost every electrical or electronic system that was exposed to thunderstorms.

The occurrence of thunderstorm is a measure of the risk to electrical and communication installations due to lightning flashes. In arriving at the processed thunderstorm day data for all the major cities, the definition of thunderstorm day is a day that the sound of thunder is heard and no matter the number of occurrence only one is recorded for day, Kuffel and Zaendl (1988).

The lightning ground flash density F_D is defined as the number of cloud-to-ground flashes in km^{-2} yr^{-1} is an important meteorological data that is used in calculating the risk of lightning strikes to a structure or system. It is evident that the number of strokes contracting a tower or ground wire along the span can only depend on the number of thunderstorm days, in a year called the keraunic level or also called Isokeraunic level. Abidin and Ibrahim (2003) stated that a more accurate method of determine the lightning ground flash density is by the use of Lightning Detection Systems (LDS). They confirmed that the two different technologies currently available are the Magnetic Direction Finding (MDF) and Time-of-Arrival (TOA) system. In this paper, thunderstorm day level data collected from the Nigerian Meteorological Agency (NMA) was employed and we were able to develop a keraunic level map on thunderstorm day and lightning flash density levels for several key locations in the Northeast Zone of Nigeria.

The keraunic level is defined as the number of days in the year on which thunder is heard. It does not even distinguish between whether lightning was heard only once during the day or whether there was a long thunderstorm. Fortunately, it has been found by experience that the keraunic level is linearly related to the number of flashes per unit area per year. In fact it happens to be about twice the number of flashes/km^2/year. By assuming this relationship to hold good throughout the world, it is now possible to obtain the frequency of occurrence of lightning in any given region quite easily.

Because of the destructive capacity of lightning, it has become the standard practice to establish the vulnerability of an area to thunderstorm activities. One of the widely use parameters in the risk factor assessment of any structure, in a given area to lightning strike, is the density of lightning flashes to ground of that area. By far the simplest and widely recommended method involves the use of historical isokeraunic data of the area via an established empirical relationship to obtain the corresponding most probable flash density to ground of the area. Another important parameter needed to assess the severity of direct lightning strike is the magnitude of the associated transient current which can only be accessed through field measurement in the area under consideration. However, the prohibitive cost of the equipment needed usually for close such field measurement in most developing environments.

Thus, flash density can be obtained from thunderstorm day using (ERA Report, 1988):

$$F_D = 0.0267948 \times T_D^{1.2781} \qquad (1)$$

Where

F_D is the flash density; and

T_D is the thunderstorm days.

II. Methods

The NMS has been monitoring and recording the thunderstorm days T_d in the northeast zone of the Nigeria for over twenty years, where the weather stations have been making these observations on a 24 hours basis. The reason for data acquisition on thunderstorm activities from meteorological departments is to determine the frequency of occurrence of thunderstorm-days and areas that are prone to high risk of thunderstorm/lightning. Lightning flash detector or flash counter was not installed in this zone to obtain the thunderstorm-day at present when these data were collected and table 1 below shows the data obtained from NMS.

Table 1

ANNUAL THUNDERSTORM DAY FOR THE PERIOD OF 1988 TO 2008

Major town/cities	Average T_d	Standard deviation	Minimum T_d	Maximum T_d
Bauchi	67	18	60	125
Yola	88	28	38	141
Potiskum	46	5	37	60
Maiduguri	50	3	43	55
Nguru	44	5	36	54
Wukari	77	11	63	95
Gombe	69	12	55	90
Jos	131	10	116	157
Mubi	62	10	56	88
Jalingo	60	9	54	85
Biu	50	8	45	67
Damaturu	40	6	38	56

III. Results and Analysis

In order to determine the lightning flash density for various locations, the equation (1) was used to compute lightning density per km^2 per year from thunderstorm days as shown in Table 2.

Table 2

ISOKERAUNIC LEVELS AND LIGHTNING FLASH DENSITIES

Major Town/Cities	Thunderstorm Days	Lightning Density per km^2 per year
Bauchi	125	12.92
Yola	141	15.07
Potiskum	60	4.06
Maiduguri	55	5.78
Nguru	54	3.97
Wukari	95	10.01
Gombe	90	9.5
Jos	157	17.29
Mubi	88	8.25
Jalingo	85	7.89
Biu	67	5.82
Damaturu	56	4.63

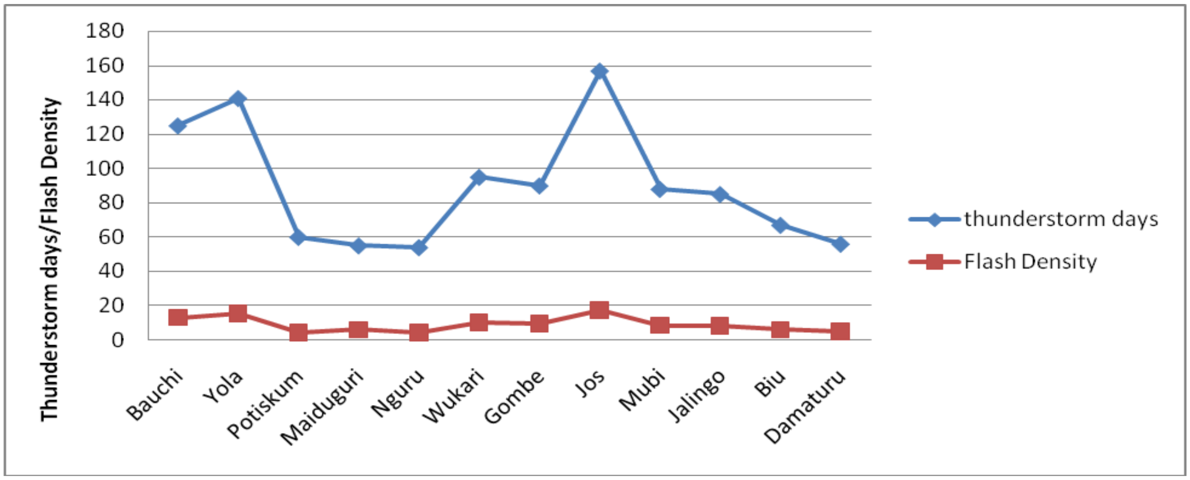
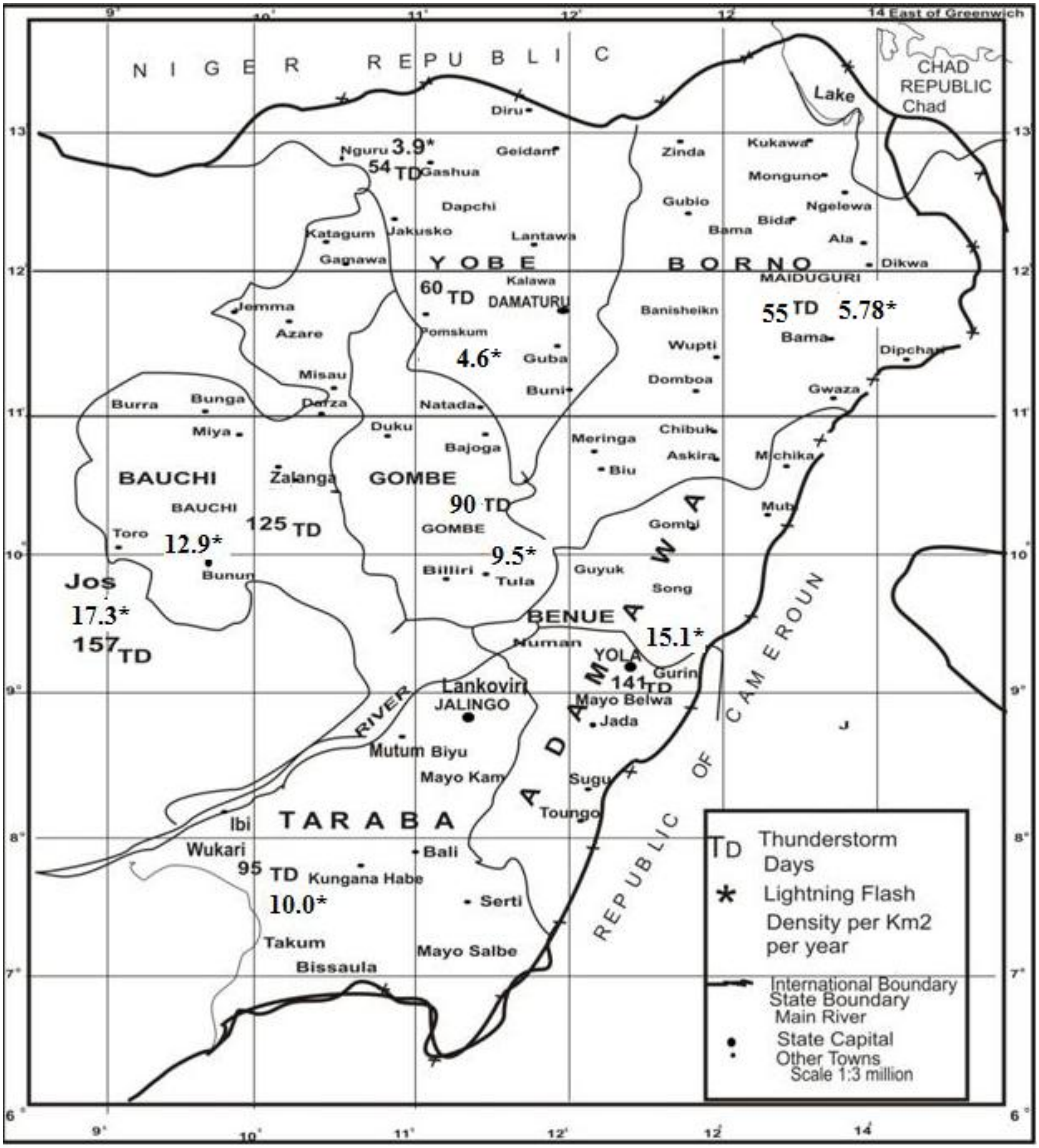


Figure 1: Relationship between Thunderstorm days and Lightning Flash Density

It can be deduced from the figure 1 and table 2 that the lightning flash density is proportional to thunderstorm days; this implies that the area with high thunderstorm days also has high flash density vice versa. Jos area has high F_D of 17.29 km^2 per year with T_d of 157 which shows that the area is prone to high risk of thunderstorm/lightning, this required that all electrical and communication equipment installed in this area should be well protected from lightning strike. On the other hand, Nguru area has low F_D of 4.06 km^2 per year with 54 T_d and this indicates that electrical and communication equipment in this environment are not really liable to thunderstorm/lightning strike.

The map showing the T_d in the selected locations is as shown in figure 2. This map would enable the reader to estimate the T_d and F_D values for various locations in the northeast zone of Nigeria. In case of locations that are not within major cities mentioned in table 1, then approximate values can be determined by taking the T_d and F_D values of the nearest location by interpolating the values between two known adjacent locations.



IV. Conclusion

Reliable information on the ground flash density is required to estimate the risk of lightning strike. A more accurate method of determining the F_D is by the use of a lightning detection system (LDS). However, using data collected on thunderstorm days the ground flash density was obtained for the northeast zone of Nigeria. On the basis of the computed lightning flash densities, a realistic thunderstorm day/lightning flash density map was then developed for the northeast zone of Nigeria. The map offered initial meaningful insights on the potentially prone area to high risk of lightning activities and their impacts on communications and electrical supply infrastructures.

The results indicated that there is high incidence of thunderstorms activity in Jos area which decreased to minimum in Nguru area. In view of the high occurrence of thunderstorms in Jos area and others, electrical and communication equipment and installations should be well grounded. In addition, thunderstorm flash detector and lightning arresters should be installed for monitoring and protection against lightning strikes.

References

Abidin, H.Z and Ibrahim, R., (2003), "Thunderstorm Day and Ground Flash Density in Malaysia", National Power and Energy Conference Proceedings, Bangi, Malaysia.

Cummins, K.L., Krider, E.P and Malone, M.D. (1998), "The U.S National Lightning Detection Network and Applications of Cloud-to-Ground Lightning Data by Electric Power Utilities", IEEE Transactions on Electromagnetic Compatibility, Vol. 40, No. 4, pp.465-480

Electrical Research Association (ERA), (1988), Great Britain report No 87-0328 Lightning Protection Seminar Proceedings, Technology.

Gallagher, T.J and Pearmain, A.J, (1983), "High Voltage: Measurement, Testing and Design", John Willey and Sons.

Komarek,H, (1965), "Lightning Flash Counter as Aid to Measurement of Radio Noise from Thunderstorms", Electronics Letters, Vol.2, NO.7.

Kuffel, E. and Zaengl, W.S, (1988), "High Voltage Engineering Fundamentals", Pergamon Press