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The Lethal Frequencies of Thunderstorm Sounds and Energies: A Mini Review

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Abstract

Attention of people is focused on the rain rather than the damage that can be caused by lightning. However, median lethal dose of electric current has been reported to be very low. In view of this, literatures were assessed for determination of the frequency of sound, power and energy that originated from lethal thunderstorm. Frequency of about <4-260Hz and above, and energy of 5 x 103 - 10^{10} J from 1 stroke can kill human being, animal or damage objects severely. But generally, the range of frequency, power, current, voltage and energy from thunderstorm and lightning that can kill vary according to location, time and distance.

Keywords: Biomaterials; Metals; Titanium; Stainless steel; CoCr alloys

Introduction

Lightning in animals may cause burns, scratched hairs on the legs, shoulders, heart fibrillation and death that may implicate vets [1]. Thunder storms could be 15 miles in diameter and lasts for 30 minutes [2]. Lightning detection and location are very important for protection against hazard. The vast amount of energy from bombarded energetic solar and galactic cosmic ray particles creates ions that conduct below 50km with effect up to 3km above earth is very important [3]. Thunder lightning discharge requires determination of peak power energy for efficient conversion of electrical energy to acoustic energy [4]. Acoustic imaging helps in identification and quantification of thunder sources as a function of lightning current [5]. Thunder is a consequence of shock wave that originates from rapid expansion of air by hot lightning channel. Its perception depends on distance [6]. The wide disparities on energy dissipations in relation to acoustic energy [7] may be responsible for the inability to determine the lethal frequency of thunderstorm lightning electric current. The exact cause of lightning remains uncertain, but the charges are due to precipitation and air current [8].

The Frequency and Energy of Lethal Thunder Stroke

The total acoustic energy that originated from thunder spectrum was calculated using E (total acoustic energy) = P(t) πR^2 (t) dt. Where P is the total power flow and R is the acoustic distance of the flash, c $(t-t_o)$ [9]. Energy spectrum (Q) generated by thunder is 0.5–2 with frequencies range from <4 to 125Hz. At the low frequency of <10Hz wind noise could mask the thunder sign. The peak power flux ranges from 0.4 to 0.003 erg cm^{-2} Sec^{-1} Hz^{-1} where as the average total power flux ranges from 0.17 to 19.3ergs cm^{-2} sec^{-1}. The range of average rms pressure value is 2.2 to 24 dynes cm^{-2}. Intra-cloud thunder spectrums with power (28Hz) showed acoustic energy of $1.9x10^{18}$ ergs and cloud-to-ground spectrum at 50Hz exhibited acoustic energy of 6.3x1018 [4]. Several return strokes that varied in amplitude and rise time is greater than 1KA with frequency higher than 1kHz [5]. The best correlation coefficient between dI/dt (KA/μs) and 1KA is $2.61^{1.34}$ to $2.01^{1.28}$. The ground resistance of earthing system is 0.15-9Ω. But the energy per unit of lightning is $E = {}^{1}\!/_{\Pi} R_o^{\,2} x P^{1/2} dt$ Whereas Ro is the initial channel of radius, P is the plasma resistivity and t dispatch [10]. Energy can be reduced to E=Po πR2 if a few centimeters initial radius is neglected with regard to relaxation radius (several meters) [11].

The maximum frequency according to Dawson et al. [12]

$f_{max} = 0.63\ C_0\sqrt{\frac{P_0}{E}}$ The energy volume $(E_{vol}) = 0.015P_{max}$ whereas P_{max} is expressed in Pascal with unit (mJ/m^3 or J/m^3). E_{vol} = 1.23-1.26 $I_{max}^{1.64}$ [11], a voltage of 10^9V at height of 2km produced 10^{10} joules per flash [13]. But $1x10^7$J per stroke and $5x10^3 J/m^3$ at height of 2km from ground level had been reported [14]. Also $f_m = (0.63) \left(C_0\sqrt{\frac{P_0}{E}}\right)^{1/2}$ whereas Po and Co are the ambient pressure and sound respectively. Whereas the relaxation radii is $(R_o) = (3E/4\pi P_o)^{1/3}$ or $R_o = (E/\pi Po)^{1/2}$ [9]. Thunder has non-stationary data [15] as they are not amenable to many standard power spectra techniques and therefore special [9]. Thunder spectra of 10Hz to 150Hz [16] and frequency of 180 to 260 Hz had been reported

[17]. But coordinate $X=r/R_o$ where r (spherical) and Ro (cylindrical) [17] with Brode's [18] non dimensional coordinate (λ) differs from X by the constant $(4\pi/3)^{1/3}$ with a length (d) = $2.6R_o$

$$f_{min} = \frac{c}{d} = \frac{c}{2.6R_0}$$

where c is the speed of sound.

Also d = $2.6 \frac{E}{\pi P_0}^{1/2}$ with bottom f_{min} (57Hz) and top f_{min} (39Hz).

Conclusion

The incidence of lightning varies in various parts of the world [19]. The primary frequency is about 20MHz [20]. Lightning prefers to strike tall trees several times [8]. Strokes could be triggered by 9.8KA to 297.7KA/μs [11]. The return strokes extended to 2km from the cloud base to ground at 10^{10} J [13]. Early men considered lightning as weapon of their Gods despite people pay more attention to the rain rather than the danger of lightning [21-23].

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