



## LIGHTNING STROKE FATALITIES: A QUANTITATIVE REVIEW

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### ABSTRACT

This paper explains the number of deaths in different countries of the world. Based on the exhaustive review of lightning stroke, the fatalities and injuries have been reported during the last two decades. Lightning is an everlasting problem and during rainy seasons normally it takes place all over the world. Lightning affects the human life as it hits the people while working outside, jogging and taking refreshment. Likewise it affects the economy as it hits buildings, power lines and research premises. The present paper highlights the number of fatalities in numerous countries of the world. This paper aims to take the preventive measures against lightning in mentioned countries. As lightning effect human life as well as the industry, the quantitative review of this article will help the contractor, consultant, research institutes, governmental and non-governmental organization to plan perfectly for the betterment of individual and improvement of the economy of countries all over the world.

**Keywords:** lightning, upward leader, side flashes, induces voltage.

### INTRODUCTION

This paper elaborates the quantitative review of lightning fatalities in different parts of the world in order to make sure the protection of human as well as different industrial places. The purpose of this paper is to provide protection against lightning particularly in the mentioned countries.

Physically the manifestation of lightning is ancient but its understanding is relatively new. The real initiative about this phenomenon was taken when the electric transmission line had to be protected from the effect of lightning. Fundamentally lightning is the combination of very large electric discharge and sparks which have a long distance from 3 to 50 kilometers. The degree of hazards depends on situation. To minimize the chances, to be hit by the lightning stroke any one should be far away from the tall object or someone should be inside the well-protected buildings (E. Kuffel, 2000).

For the last decade it is obvious that the effect of lightning on human life and on the industrial level is increased abruptly. From the effect of direct and indirect lightning human life could be effect inside the houses or outside in open fields (R.L.Holle, 2010). S.Commitee analyze that lightning stroke formation takes place in two steps. The first step is the ionization of the air which surrounds the Centre of the charge and produces the step leaders. The step leaders propagate the charge from cloud into the air. The magnitude of the current related with the step leader is small (100 A) as compare to the final stroke (S. Committee, 1996). The direction of the step leaders is random from 10 to 80 meters in length with velocity of 0.05 % of light or 150,000 m/s. The second step is the return stroke which is extremely bright streamer which takes place from earth to upward follow the same path of the down ward step leaders as main line. The return stroke has a maiden value of 2400 A which proceeding in upward direction to neutralize the charge center. The velocity of the return stroke is 10% or  $30 \times 10^6$  of the velocity of charge (Anderson, 1987).

### Lightning could be divided into 4 types. Intra-cloud

**(IC):** This is type of discharge is not harmful for the human life as well as for industrial and other power sectors. Around 50% of flashes consist of IC discharges. IC consists of positive and negative ions inside the clouds and its discharging time is 0.5 s.

**Cloud-to-cloud:** This kind of discharge takes place when two opposite charges collide with each other. This collision occurs within the cloud or with the cloud which is nearby.

**Cloud-to-air:** Sometime the discharges take place very slowly with 10m/s with making a long slow motion of the lightning channels in the sky. It looks like "rocket lightning".

**Cloud to Ground (CG).** This is one of the most dangerous lightning discharges which can increase the voltage on the earth surface also can damage the property and the electric equipment. Its induce field effect is also harmful for human and other property (Donald, 2001)

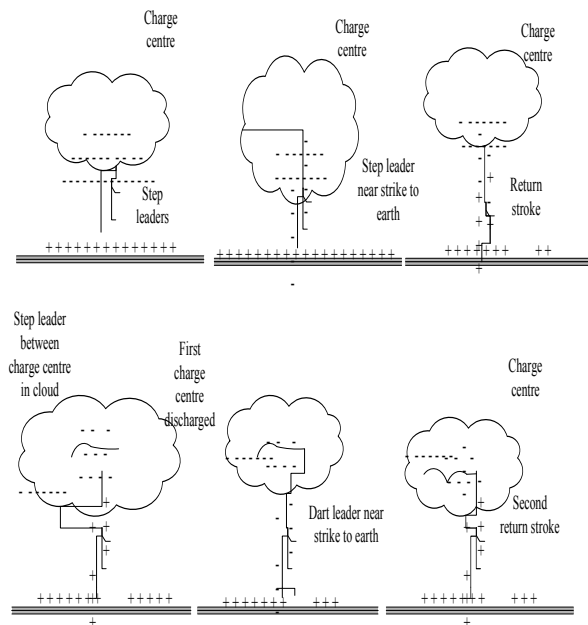
### SUMMARY OF LIGHTNING STRIKES MECHANISMS

(Donald, 2001) mentioned that the limit of the cloud having stroke is 3 to 50 Km in length. A shadow could be seen on the earth of the cloud having charge which takes the negative charge to the surface of the earth. As the earth surface has the positive charge electric field takes place between the opposite charges. Earth surface has a charge of  $5 \times 10^5$  C. When the strength of the earth surface field varies from 1.5-2 kV/m then those object which have sharp points and small radius get discharge and a result thunder storm takes place.

(IEE guide, 1996) elaborates that different theories have been carried out about the formation of charge center, the separation of charge within the cloud and as a result of this the formation of lightning stroke. One of these theories explains the charge separation to the existence of both positive and negative ions in the air and the existence of normal electric field towards the earth. The large drops of water are polarized in the electric field.



The upper surface has negative charge and the lower part has positive charge. Due to gravity the water drops comes down the positive sides attract the negative sides (ions). While the upper side remains without any such action. As a result all the charge becomes negative and those charges which were random and were neutrally charge become separated. As a result of all this process the upper portion become positively charged while the lower portion becomes negatively charged. According to the other theory the interaction of ascending wind current in the leading head of a cloud breaks up the water droplet causing the droplet to be positive charge and the air to be negative charge. The positively charged water droplet cannot move down ward through the ascending wind current at the head of the cloud. Accordingly the small portion of cloud becomes positively charge while the remaining large portion becomes negatively charged. Similarly a theory also suggests that there are portion of subzero temperature within the cloud which ice crystal are produced which is essential factor in the explanation of charge Center within the cloud. Figure-1 shows the charge distribution with various discharges (Donald, 2001).



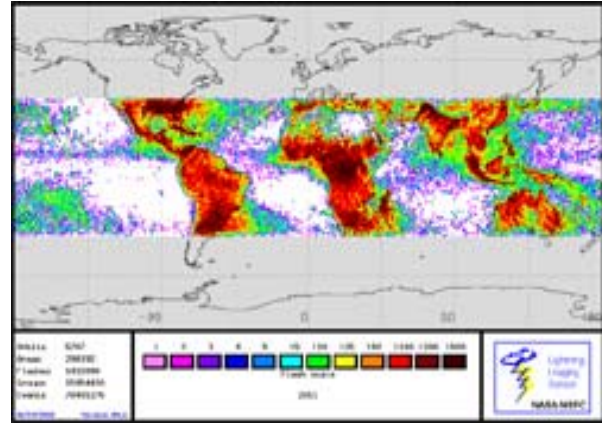
**Figure-1.** Lightning mechanism (Donald, 2001).

### LIGHTNING FLASH DENSITY IN DIFFERENT PARTS OF THE WORLD

According to (E. Gourbière et.al, 1997) lightning stroke affects those areas which are situated on equator or nearby the equator. Such places receive more sun rays which produce much more upward updraft. In this way the air having moisture and cold fronts are formed which leads it into the lightning flashes.

(O.Pinto Jr *et al.*, 2007) observed the comparison between low and high latitude. According to this observation the current of the negative flashes increasing downward to the 30 degree and after that almost remains

the same to the equator surface. Figure-2 shows the number of flashover density in different parts of the world. The blackish color shows the intensity of ground flash density.



**Figure-2.** World's isokeraunic map.  
(<http://thunder.nsstc.nasa.gov>. Access on 04 April 2015).

### LIGHTNING INCIDENTS IN MALAYSIA

(M.Z.A.Ab Kadir *et al.*, 2012) explained that Malaysia is known as the Crown of Lightning in the World and it is situated on the equator, therefore it has a very high lightning intensity. About 70% of power outages in Malaysia are due to lightning. It affects different sectors like Power, Telecommunication and other sectors. Therefore every year a huge amount of RM 250 million is spent to solve these kinds of problems. Due to lightning, many injuries and deaths occur because people involve in indoor or outdoor activities like fishing, agriculture and recreation in such place which are not protected from the effect of lightning.

As Malaysia is a tropical country therefore more than 150 days are thunderstorm days. Figure-3 shows the number of thunder storm days in Malaysia. (Metrological-department, 2015).



**Figure-3.** Number of thunderstorm days in Malaysia  
(Metrological Department of Malaysia Access on 04 April, 2015).



(N.A.Ahmand *et al.*, 2010) carried out statistical analysis from 2000-2013 in Malaysia which indicates the number of deaths in different part of the country in different time

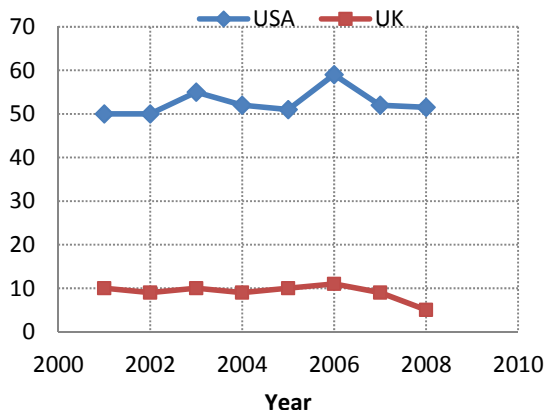
of the year which is shown in Table-1. Moreover among these, the number of male deaths is more than female.

**Table-1.** Number of deaths in Malaysia 2004-2013 ((N.A.Ahmand *et al.*, 2010).

Year	Month												Total
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
2004					7								7
2006				6	2						3	1	12
2007	3										1		4
2008	1			2	1	1					2		7
2009					11					4		2	17
2010				4	2			2	1				9
2011	1	1	1			3	2	12	5	1	3	1	29
2012	6												6

#### LIGHTNING INCIDENTS IN USA AND UK

(US fire administration,2009) reported that in USA the residential fire is about 25% of all fire this includes in 70% of deaths and injuries while the economic loss is 56% due to these fires. Department for communities and local government U K analyze that in USA residential fire due to lightning is about 1.5% to 2% which cost \$100 million loss annually. The residential fires due to lightning in USA is about five to ten times more than the other countries of the world e.g. UK as shown in Figure-4 (National Statistics, 2010).

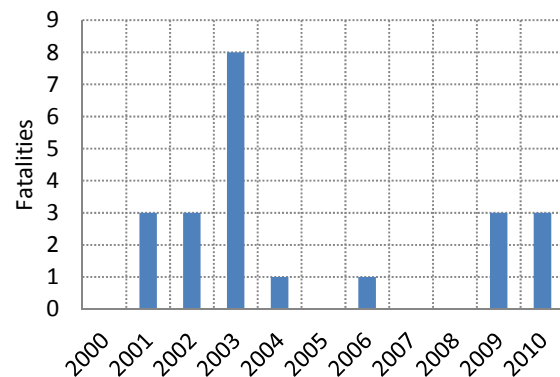


**Figure-4.** Annual numbers of lightning fires in the USA and UK per million residences (2001-2008) (National Statistics, 2010).

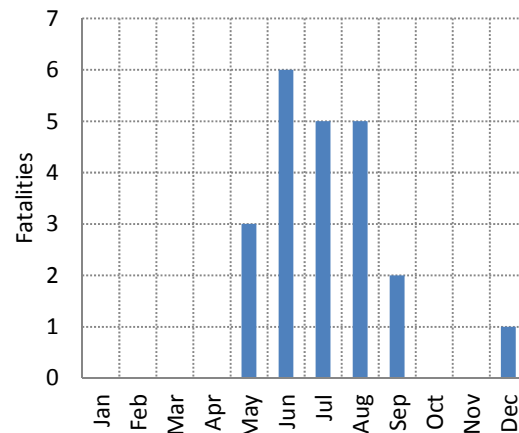
#### LIGHTNING ACTIVITIES IN GREECE

(Peppas *et al.*, 2012) calculated the statistical analysis of death and injuries in Greece during 2000-2010 as illustrated in Figure-5. During the mentioned time period 22 people have been killed due to the lightning stroke. The same study also demonstrated the number of deaths per month which is shown in Figure-6. From the

graph, it is obvious that death rate is more in monsoon season due to lightning strike.



**Figure-5.** Number of deaths per year in Greece (Peppas, 2012).



**Figure-6.** Numbers of deaths per month in Greece (Peppas, *et al* 2012).



### LIGHTNING FATALITIES IN SWAZILAND

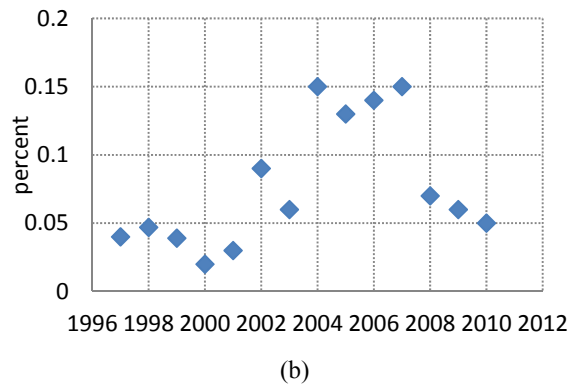
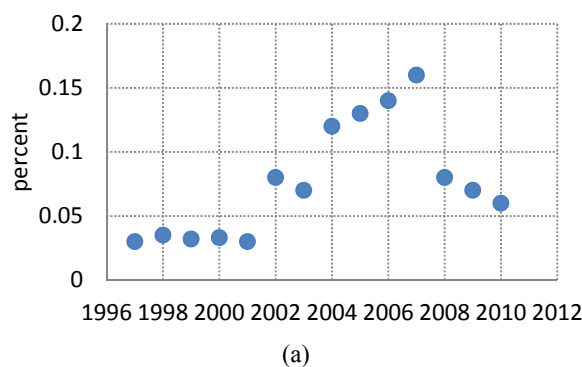
(Dlamini, 2009) has calculated the number of deaths in Swaziland during 2000-2007. The entire country is situated in between South Africa and Mozambique. During the given time of the analysis 113.9 victims were reported which is 14.24 per million in one year during the moon soon in different time of the year though out the country. Table-2 shows the number of casualties during 2000-2007.

**Table-2.** Number of casualties in Swaziland during.

Year	Fatalities per million
2000	3.1
2001	9.7
2002	8.2
2003	24.4
2004	18.1
2005	16.9
2006	17.8
2007	15.7
Average	14.24

### LIGHTNING DAMAGES IN CHINA

(Zhang, 2012) has find out that the thunderstorm activities in China continue throughout the year. While the peak months are June- August. Similarly the minimum injuries and deaths have been recorded in the months of November to February. Figure-7(a) shows the number of deaths in percentage from 1997 to 2010 in different parts of the country while Figure-7(b) depicts the number of injuries for the same period.



**Figure-7.** (a) Fatalities and (b) Injuries due to lightning stroke in China 1997-2010 (YijunZhang, 2012).

### LIGHTNING IN BANGLADESH AND SRI LANKA

(Chandima Gomes *et al.*, 2006) investigated the number of deaths and injuries in Sri Lanka and Bangladesh in 2003. Both of the countries are located at west and east of India respectively. In Sri Lanka, the lightning incidents could be noticed in March-April and October- November during moon soon. During the mentioned period, the numbers of flashes are 80-120. In Sri Lanka, during the year 2003, 49 people have been killed, while another 18 were injured. Similarly in Bangladesh, the lightning is in much number during March to June and October to November during the monsoon. In Bangladesh, during the thunderstorm 133 people were killed and 137 were injured. These people are killed due to direct or side flashes. One of the victims in Bangladesh due to lightning stroke is shown in Figure-8.



**Figure-8.** A victim injured in Bangladesh due to direct or side flash of thunderstorm.

### DISCUSSIONS

Lightning is a natural occurring phenomenon having a very high voltage and current. It takes place due to the interaction between positive and negative ion sometime within the cloud or from the loud to the earth. Lightning stroke affects almost every country of the world. Developed, as well as developing countries are affected





during the rainy seasons. China, America and other developed countries of the Europe face economical as well as human losses every year. Naturally those countries which are situated on equator are caused more. Some countries like Malaysia, Indonesia, Singapore and Thailand are one the equator also called the tropical countries. Lightning in these countries occurs regularly and every year a number of fatalities and injuries take place. South Asian countries also have a lot of flashover during the monsoon.

As the lightning is a permanent issue for the whole world there for the governmental and non-governmental organization should as well as the research institute should come forward to solve this problem. The temporary public shelters and the building with low height can be considered as the initialization point. Moreover, the building geometrical structures should be studied in future to protect them from direct and indirect lightning stroke.

## CONCLUSIONS

A quantitative data of the human casualties has been carried out in this paper. It is obvious that normally the individual and infrastructure get affected due to lightning stroke in rainy season. Accordingly best protection scheme from lightning stroke must be provided everywhere in the world. The houses, hospital industries, telecom and power sectors should be designed and constructed in such a way which is well equipped with lightning protection capability. The investigated data shows the number of casualties in different countries of the world which provide awareness about lightning protection of human life and shelters.

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