INSTITUTE OF RESEARCH ADVANCES

IRA-International Journal of Technology & Engineering
ISSN 2455-4480 Vol. 03 Issue 01 (April, 2016)
Paper DOI: https://dx.doi.org/10.21013/jte.v3.n1.p4

Optical Attenuation & Atmospheric Visibility of Free Space Optics

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ABSTRACT

The study was conducted at University of Gujrat during 2015 with an objective to explore the effects of dust on Free Space Optics (FSO) communication. Growing pollution and dust gales motivated studies we presented in this paper. In this paper analysis of the influence of dust on free space optics communication is presented. We focused our studies on Lahore as it is polluted city of Punjab and made a comparison with dust effects in Rahimyar Khan Region. Dense dust consists of large dust particles that raise from Earths sphere and whose atmospheric intensification values are high enough to affect FSO communication links. Dust storm research is based on visibility data. In order to test visibility data, we made calculations of atmospheric conditions for different dust conditions. Visibility of wave is calculated using weather spark. As it

is related with the optical attenuation, so we also calculated optical attenuation of dust particles due to influence of dust particles and compared it with that of Rahimyar Khan.

Keywords: Visibility, Attenuation, Concentration of Dust, Atmospheric Conditions

Introduction

FSO is a line of sight technology that uses laser to provide optical bandwidth connections or FSO is an optical telecommunication technique that propagates light in free space to wirelessly transmit data for telecommunication and computer hookups.[1] FSO broadcasting has many advantages when compared with free space radio based systems. These include large bandwidth, being license free, fast deployment, having low power consumption, enhanced security and insensitivity to interference, and having compact dimensions. In free-space optics, light propagates through atmosphere channel. The atmosphere is considered as challenging dynamic channel for electromagnetic wave propagation. Since atmospheric channel, through which light propagates is not ideal, it effects the optical carrier wave due to interaction with the atmosphere which are highly effected by various environmental factors like fog, smoke, haze, rain, dust depending upon atmospheric conditions. [2] Various studies have been performed on the investigation of environmental influence on FSO links whose performance depends on weather conditions of specific location before its installation. Due to relatively small size of atmospheric particles such as dust and smoke compared to THz wavelength, there should be minimal THz attenuation due to airborne particles. [3] Among all the effects, although dust does not affect the intensity of FSO adversely but increasing pollution and dust storms values are high enough to affect FSO communication links.

AjaybeerKaur and Dr. M L. Singh compared the effect of Fog and Snow by introducing three models and compared their specific attenuation and visibility for different models of wavelengths and concluded that, in case of Fog, for less visibility attenuation affects more. Increasing visibility specific attenuation decreases. In case of snow, increasing visibility specific attenuation decreases.[4] Khaleel S. Altowij,

AbdulsalamAlkholidi and HabibHamam evaluated the effect of clear atmospheric turbulence on the quality of free space optics in Yemen. They focused on the scintillation on the performance of FSO. It was concludedthat performance of FSO system is good during the worst condition. To improve transmission frequency wave length 1550nm and increased distance between transmitter and receiver must be used. [5] M. Latif, K. Ullah, R.D. Khan , R. Walli and E. Leitbeg presented their research on the optical attenuation from measured visibility data in Islamabad, Pakistan using three models to estimate optical attenuation from visibility and concluded that Fog attenuation occurs mostly during the months of November to February in Islamabad every year and presented maximum attenuation during campaign of four years. [6]

Simulation & Results

Visibility data collected from 30 th May 2015 to 4 th June 2015 (6 days) for both the cities with the time difference of two hours was observed and the total duration for visibility data was calculated as:

$$\textbf{(6*24*60) minutes=8640 minutes}$$

The visibility data collected for two cities, Lahore and Rahimyar Khan was used to calculate the concentration of dust particles by using the relationship given by CHEPIL and WOODRUFF in 1957 at height 6 feet above the surface of ground.

$$\mathbf{C=56/\ (V)^{1.25}[mg/m^3]}$$

Where "V" is the visibility in meters and "C" is the concentration of the dust particles in mg/m^3.

Similarly visibility can be calculated if concentration of dust particles is known.

$$\mathbf{V=\ (56/C)^{1.25}[m]}$$

Then, to calculate the attenuation caused by these dust particles, we used the CCIR formula in 1990, given by:

$$\mathbf{A=17/V \quad [dB/km]}$$

Where "A" is the attenuation in dB/km and "V" is the visibility in meters

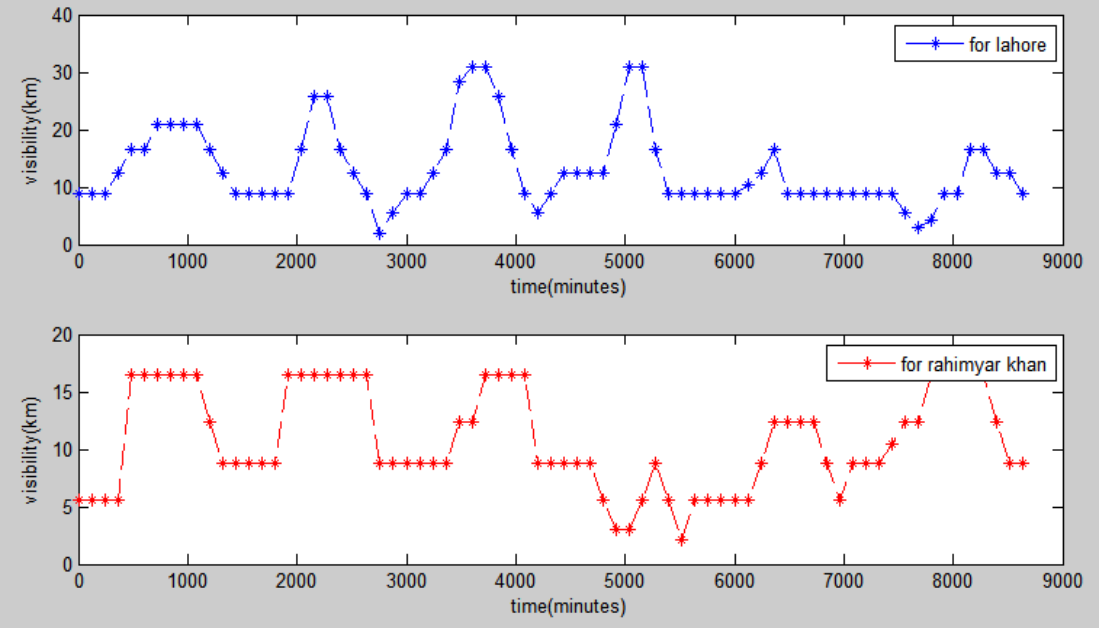
From all the above expressions, it can be observed that the visibility and attenuation are in inverse relationship. Similarly the visibility and concentration are also in

inverse relationship so if visibility decreases both attenuation and concentration of dust particles increases and vice versa and dust particles and attenuation are in direct relationship i.e. increasing one, other also increases.

We can compare the results calculated above.

Comparison of Visibility of two cities

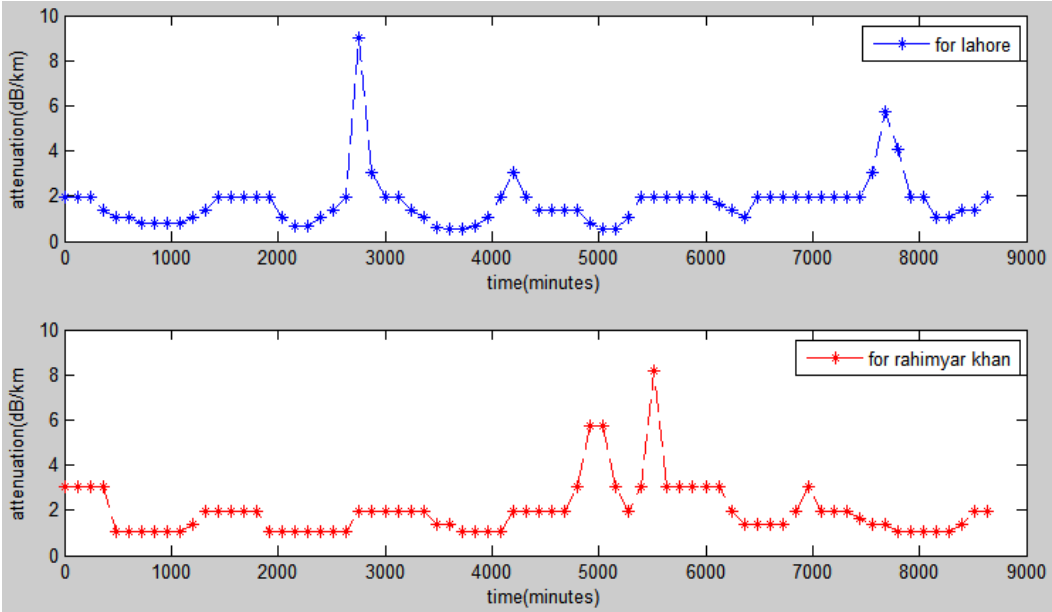
The following graph shows visibility in km on vertical axes and time in minute on horizontal axes for both the cities and we observed that visibility is low in



RahimyarKhan.

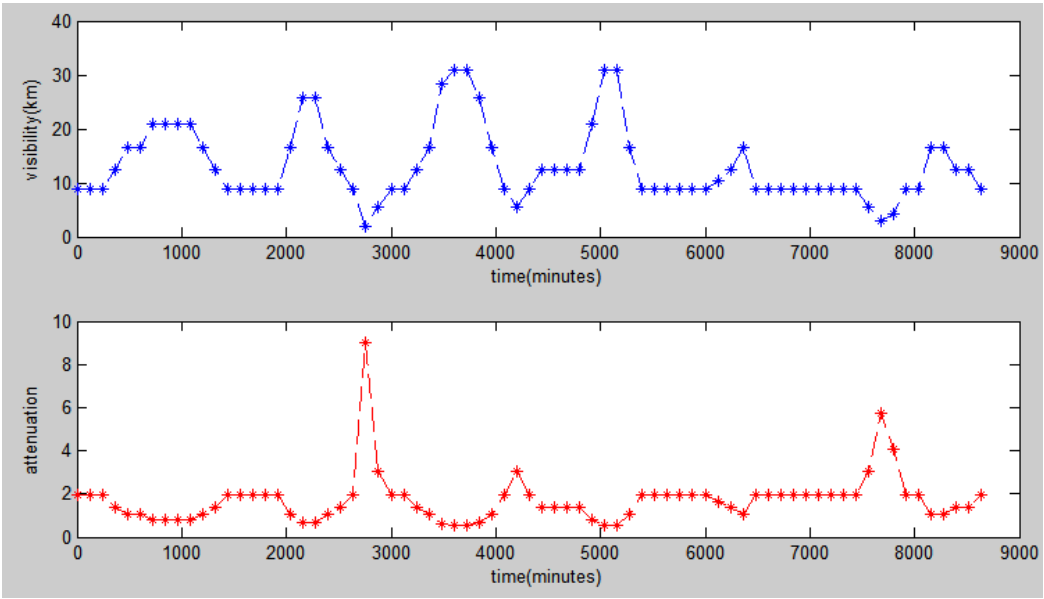
Comparison of Attenuation for both cities

The following graph shows attenuation in dB/km on vertical axes and time in minute on horizontal axes for both the cities and we observed that attenuation is high in Rahimyar Khan as compared to Lahore.



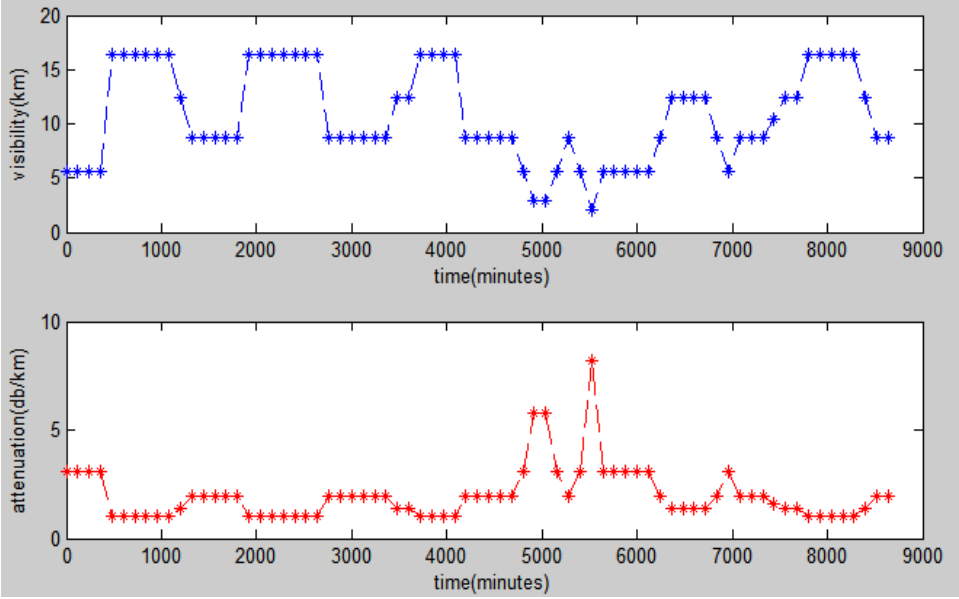
Comparison between Attenuation & Visibility for Lahore

From this graph, we can clearly observe that the visibility and attenuation are inversely proportional to each other because at the peak value of attenuation we have minimum value of visibility.



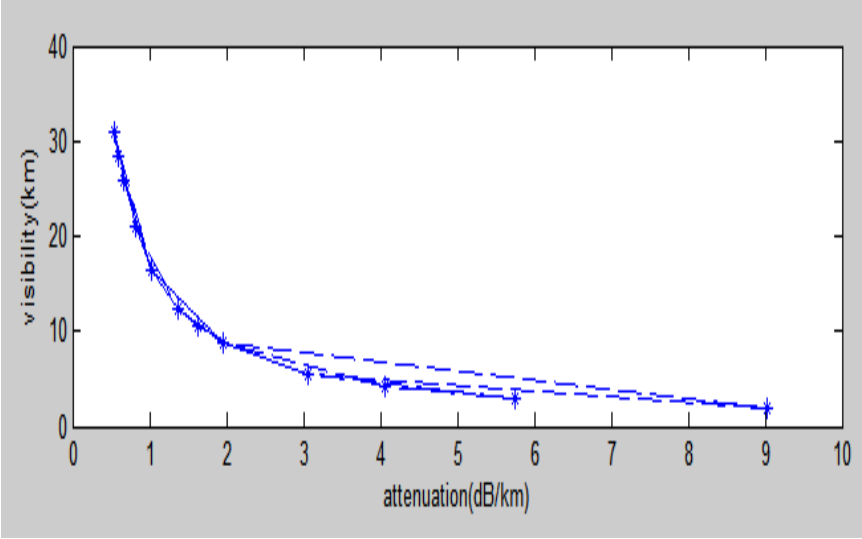
Comparison between Attenuation & Visibility for Rahimyar Khan

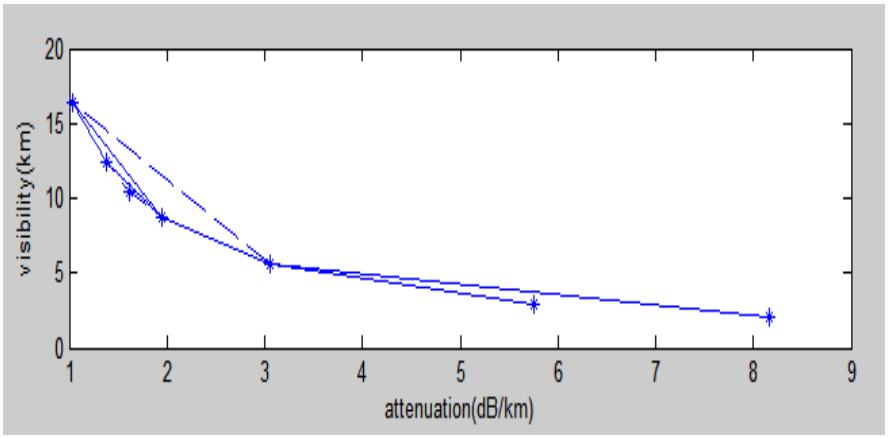
These graphs show measured time series of visibility and attenuation for Rahimyar Khan.

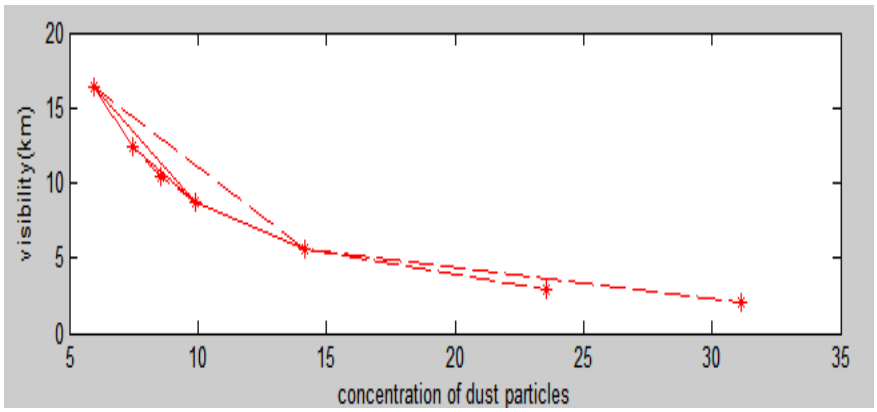


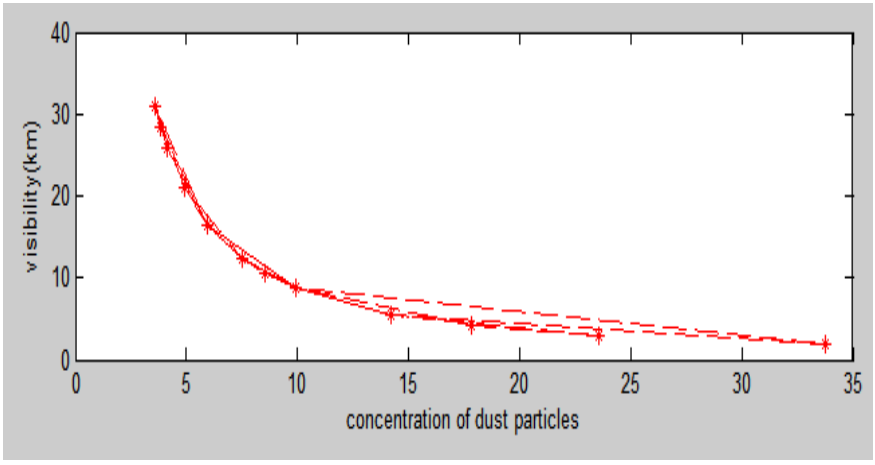
Comparison between Attenuation & Visibility for both cities

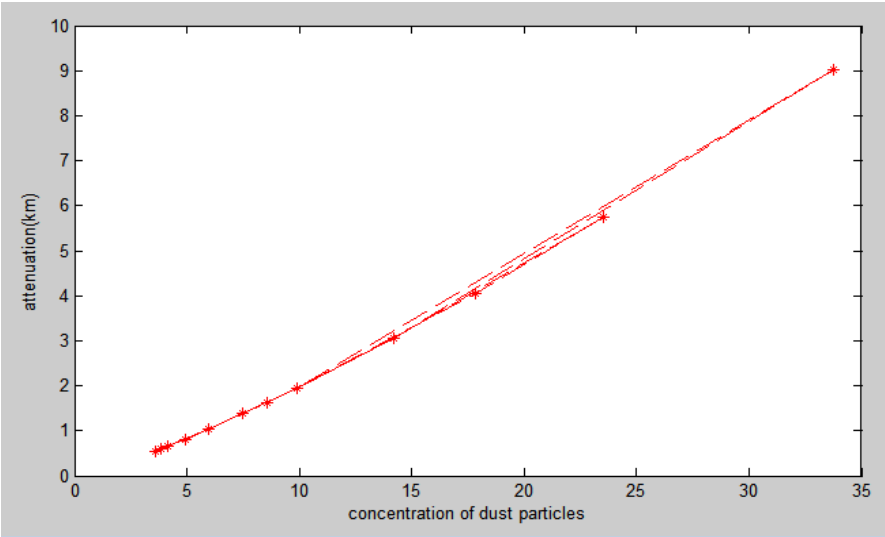
As stated previously, as attenuation increases visibility decreases. The graphs verified the results we stated.




visibility(km)
attenuation(dB/km)
0
5
10
15
20
1
2
3
4
5
6
7
8
9


visibility(km)
concentration of dust particles
0
5
10
15
20
5
10
15
20
25
30
35


visibility(km)
concentration of dust particles
0
10
20
30
40
0
5
10
15
20
25
30
35



- Visibility data is taken from http://www.weatherspark.com/\

"Average Values"

Average value for attenuation in Lahore	**1.9762**
Average value for attenuation in Rahimyar Khan	1.7174

It can be observed in the simulation results that the relationship b/w visibility & attenuation and the relationship between visibility and concentration of dust particles is inverse and that for attenuation and concentration of dust particles is direct.

CONCLUSIONS

In this paper, measurement of visibility and attenuation has been described. Relationship between attenuation and visibility for both the cities and their comparison with concentration of dust particles has also been evaluated. We observed that dust particles cause considerable attenuation in Rahimyar Khan Region than that of Lahore as concentration of dust is more in this region. Estimated statistics also showed that increasing dust concentration causes attenuation and decreases visibility. This indicates that, by choosing appropriate budget, margin and

distance links, FSO links can be installed with higher reliability and availability in Lahore.

ACKNOWLEDGEMENT

We would like to thank several individuals who were extremely instrumental in allowing us to complete this task. We are indebted to Engr. Ajmal Hussain for encouraging us to start this project and Engr. Shahid Iqbal, who helped us togather information by providing books and telling different sources from where we can increase our knowledge regarding our topic. He also helped us to gather numerous examples and illustrations that I have used throughout. We thank him for his time and intellectual investment in our work. His couching and feedback certainly helped us in improving our performance.

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