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Analysis of the propagation different wavelengths (632.8, 785, and 1330 nm) in Free Space Laser Link at Babylon City

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Abstract

Attenuation due to Aerosols, It restricts the distance of free space optical communication systems (FSO) and limits the availability for line -sight terrestrial link. This work is focused on the effect of Aerosols on the FSO link. The attenuations was studied in the Babylon city in the aerosols phenomena for three selected wavelengths (632.8, 785, and 1330 nm) for horizontal transmitting range (10 m-3 km).The results show the system availability as a function of the range, and indicate that FSO systems can be deployed with reliability in Babylon city of Iraq.

Key words: Attenuation, Propagation, Atmospheric Transmittance, FSO.

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الخلاصة

توهين الهباء الجوي يحدد مسافة أنظمة الاتصالات البصرية بالفضاء الحر ويحدد خط البصر للوصلة الارضية. هذا العمل مركز على تأثير الهباءالجوي على الاشارة البصرية لأنظمة الأتصالات البصرية بالفضاء الحر بمحافظة بابل بأستخدام ثلاث أطوال موجية مختاره لأشعة الليزر (632,8، 785 ، 1330 نانومتر) لمدى ارسال أفقي (من 10 أمتار الى 3 كيلومتر). بينت النتائج توهين الهباء الجوي كداله للزمن وتشير أن أنظمة الأتصال البصري في الفضاء الحر يمكن أن تعمل بالثقه في العراق محافظة بابل .

1. Introduction

The atmospheric attenuation of laser power in the atmosphere is described by Beer's Lambert law [1]

$$\tau(R) = \frac{P_r}{P_t} = e^{-\mu R} \qquad (1)$$

where: $\tau(R)$ - transmittance at range *R*, P_r - laser power at *R* , P_t - laser power at the source,*R* - propagation range , μ - Attenuation or total extinction coefficient (per unit length) [1-3].The attenuation coefficient has contributions from the absorption and scattering of laser photons by different aerosols and gaseous molecule in the atmosphere [4]. The attenuation coefficient is made up of four parts [4]:

$$\mu = \alpha_g + \alpha_p + \gamma_g + \gamma_p \qquad (2)$$

where: α_g - molecular absorption coefficient, α_p - aerosol absorption coefficient, γ_g - molecular or Rayleigh scattering coefficient, and γ_P - aerosol or Mie scattering coefficient.This relationship applies to both visible and IR wavelengths, in this expression, the factor $e^{-\mu R}$ represent the transmittance. The total atmospheric transmittance can be factored as the product of the absorption and scattering transmissivites.

$$\tau(R) = \tau(\alpha)\tau(s) \qquad (3)$$

where: τ_α- the absorption transmittance, τ_s - the scattering transmittance [5].The attenuation from dust and atmospheric aerosols are resulting from Mie scattering particles, which depend on the volume of the atmospheric aerosols, and the effects of absorption electromagnetic will be relatively small comparing with

Mie scattering, therefore, the scattering coefficient can be computed form the visibility distance and wavelength of the incident beam. The range of visibility is related with concentration of dust as [6]:

$$V = 7080 \times C^{-0.8} \quad (4)$$

Where V - visibility distance , C- concentration of dusts (change with altitude)Therefore, there is a direct relation between concentrations of dust and scattering coefficient due to atmospheric aerosol [7]:

$$\tau_S = \exp\left[\left(\frac{-3.91}{7080 \times C^{-0.8}}\right)\left(\frac{\lambda}{0.55}\right)^{-q} \times R\right] \quad (5)$$

where τ_S - transmittance resulting from scattering , λ - the wavelength, q - positive constant proposed computed (the size distribution of the scattering particles) , q =1.6 for high visibility (V > 50 km), q = 1.3 for average visibility (6km < V < 50 km), q = 0.585 V⅓ , = 0.16 V + 0.34 for low visibility (V< 6km), q = V - 0.5 for low visibility (0.5 km < V < 1km) , and q = 0 for low visibility (V < 0.5 km) [8].

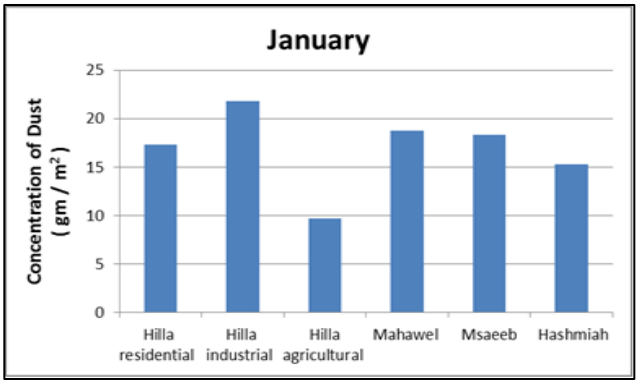
2.Experimental Data

In present work a concentration of dusts chronicle down with six selected region in Babylon city of first half of 2011, The geography region selecting were taken from the meteorological atmospheric stations in Hilla city as listed regions in Tables (1).

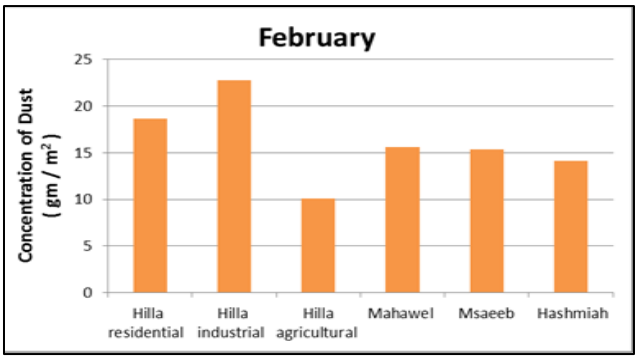
Table (1): The Town and Geography Coordinates selecting for Babylon City

The Town	Geography Coordinates
The Hilla residential center	E0444454 , N3591932
The Hilla industrial center	E0445720 , N3589771
The Hilla agricultural center	E0444432 , N3599379
The Mahawel residential center	E0444054 , N3614145
The Msaeeb residential center	E0434689 , N3626167
The Hashmiah residential center	E0467704 , N3581664

The Figure (1a, 1b, 1c, 1d, 1e, and 1f) shown the direct relation between concentration of dust and scattering coefficient of atmospheric aerosol in Babylon city at different regions and months.



(a)



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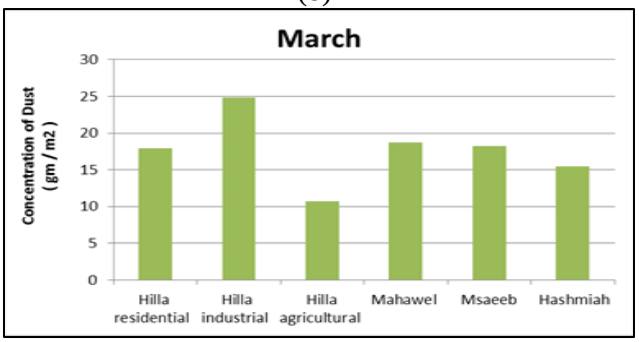

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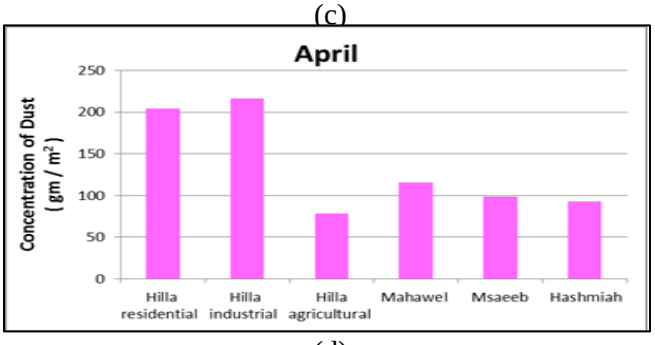

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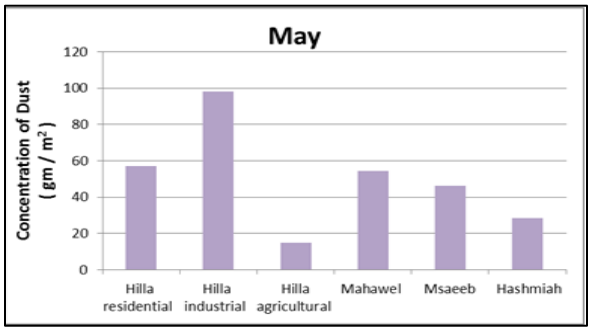

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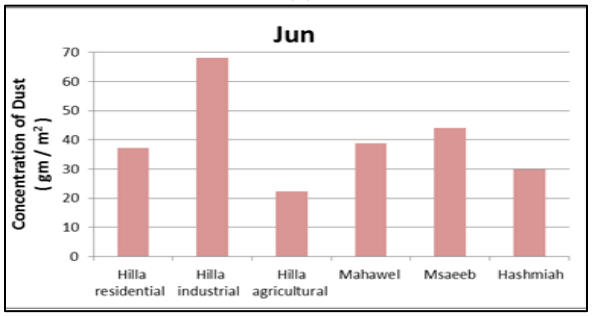


(f)

Figure (1): The Result eteorologicalAtmospheric Stations Registry for Dust Concentration in Babylon City for the Six Selected Region

3. Results and Discussion

Depending on meteorological data we can calculation atmospheric transmittance, calculation attenuation due to dust on beam propagation in Babylon city for the three wavelengths used. Figure (2) shows variation of the visibility distance as a function of the concentration of dust is calculated from equation (4). It is seen that the visibility distance decreases because the concentrations of particles in the size are increased, which reduces the visibility distance.

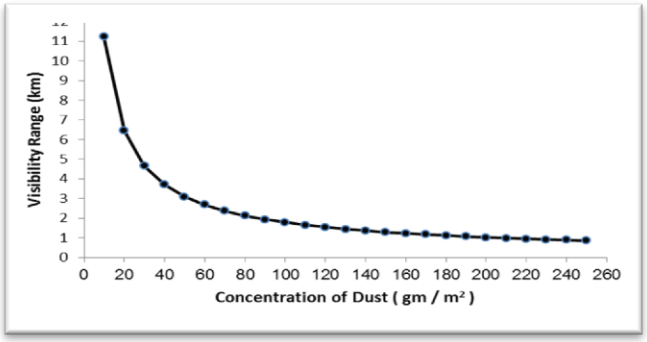
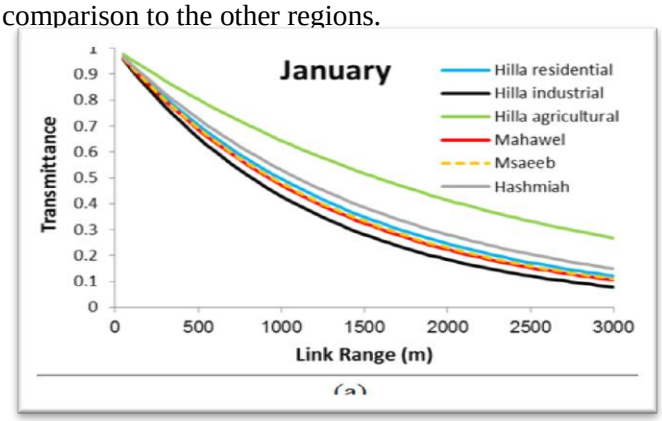
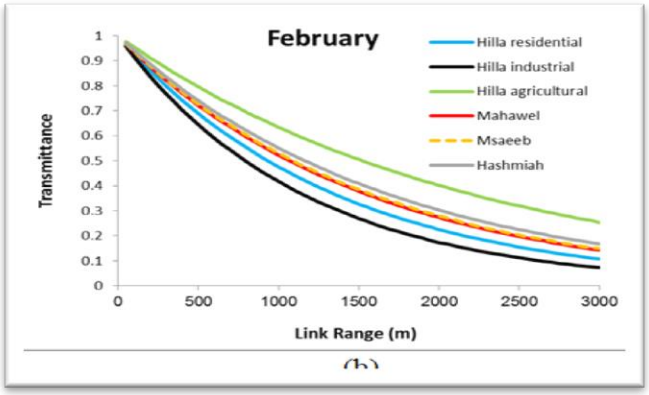


Figure (2): Variations of Visibility Range as Functions of Dust Concentration

The transmitted power for six selection region in Babylon city at wavelength (632.8) nm, were calculated for this case and the results were as shown in Figures (3a ,3b,3c,3d,3e, and 3f).The maximum total transmittance values for this period in Hilla agricultural region about 0.3 at 3Km rang at winter period and the minimum transmitted power in Hilla industrial about fewer 0.1 at 3 km range at summery period. The maximum total transmittance values for this period in Hilla residential, Al-Mahawel, Al- Msaeeb, and Al-Hashmiah regions about 0.15, 0.13, 0.14, and 0.2 at 3Km rang on arrangement.Figures (3), (4), and (5) represent variations of the atmospheric transmittance with range of 10 m to 3 km, is calculated depending on international visibility code weather conditions with some data of standard visibility distance. The attenuation-visibility curve is calculated for laser light from equation (5), for wavelength of (632.8, 785, and 1330) nm, for the sixth state selected region in Babylon city, as from the Figures (3), (4), and (5) it is obvious that the transmittance is fewest when dust concentration increases, and that the Hilla industrial region has more operative attenuation to the effect of dust than further regions because their higher concentration of dusts in comparison to the other regions.





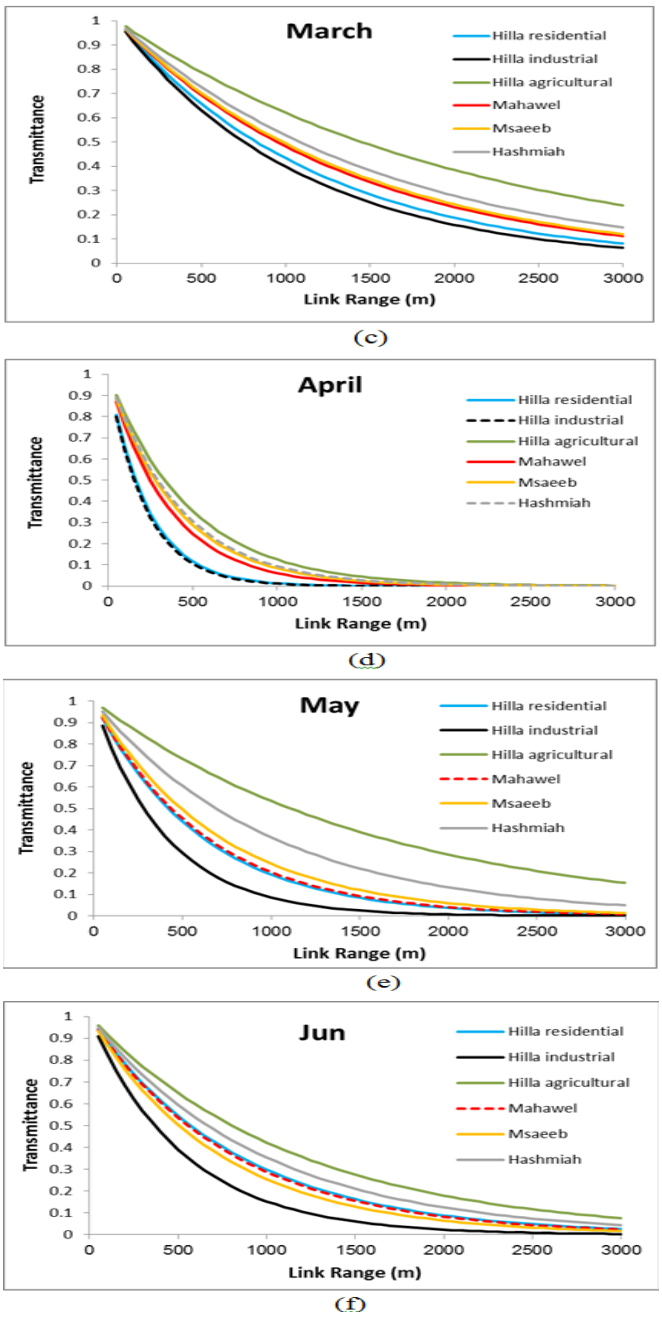
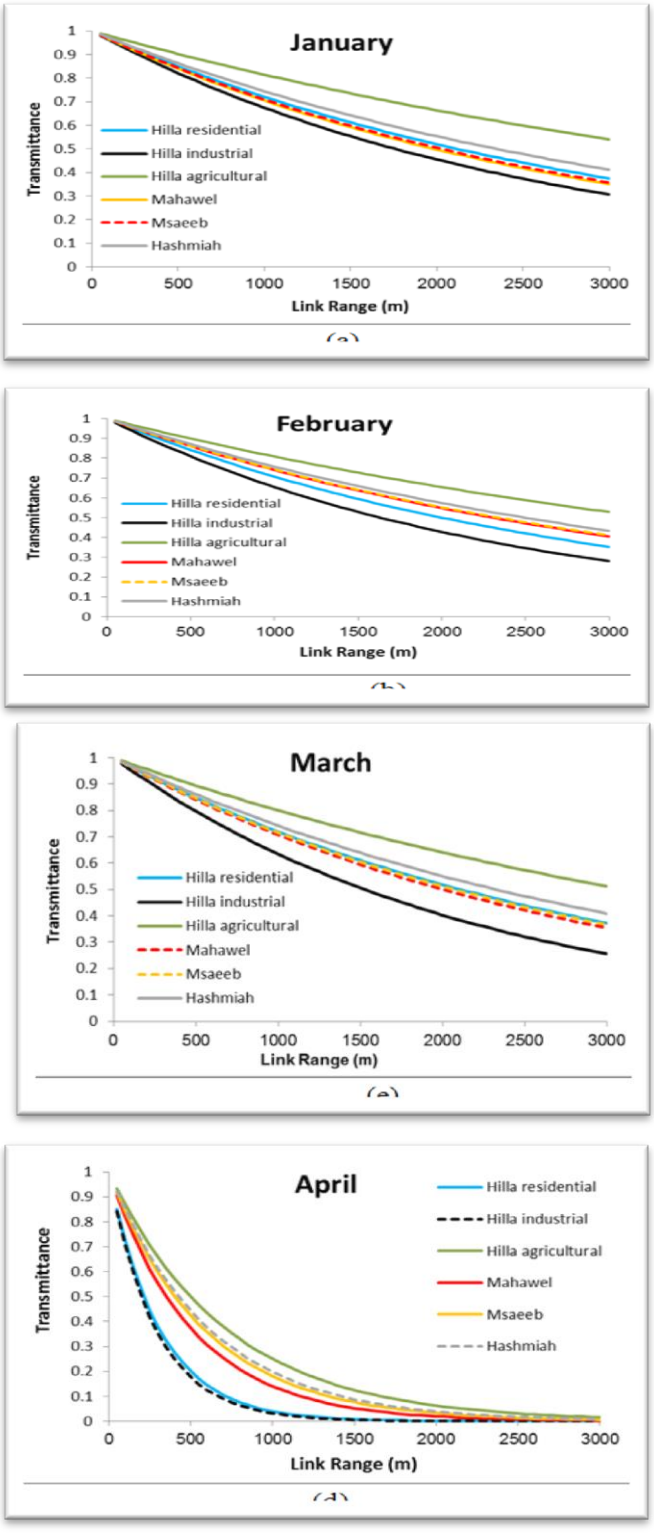
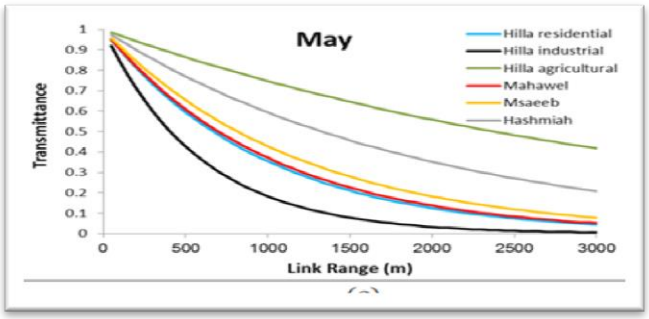


Figure (3): Variations of Transmittance for Wavelength (632.8 nm) as Functions of Dust Concentration, for the Six Selected Region, for Path Length of 3 km

The transmitted power for six selected regions in Babylon city at wavelength (785) nm, were calculated for this case and the results were as shown in figures (4a, 4b, 4c, 4d, 4e, and 4f).The maximum transmittance values for this period in Hilla agricultural region about 0.6 at 3Km rang at winter period and the minimum transmitted power in Hilla industrial about fewer 0.1 at 3 km range at summery period. The maximum total transmittance values for this period in Hilla residential, Al-Mahawel, Al- Msaeeb, and Al- Hashmiah regions about 0.4, 0.38, 0.37, and 0.45 at 3Km rang on arrangement.





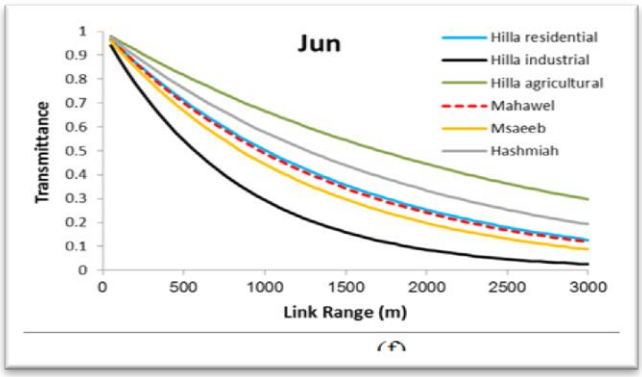
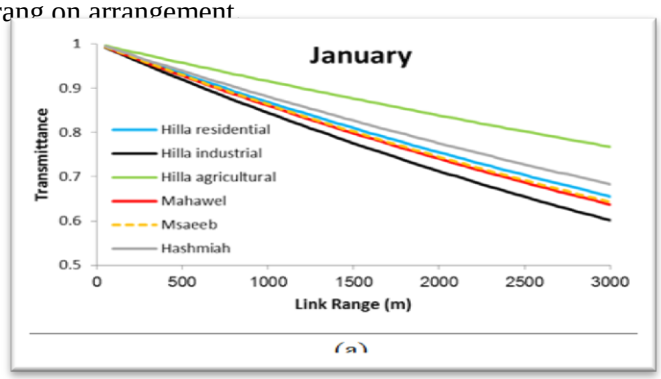
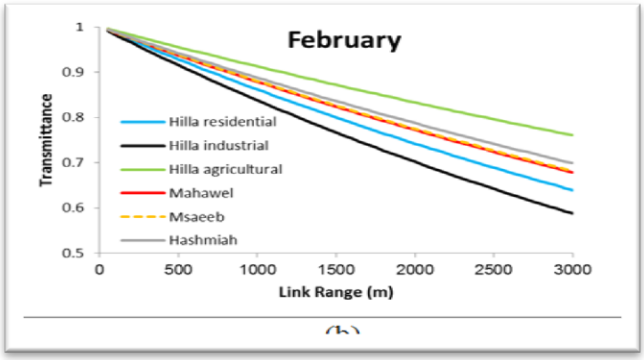
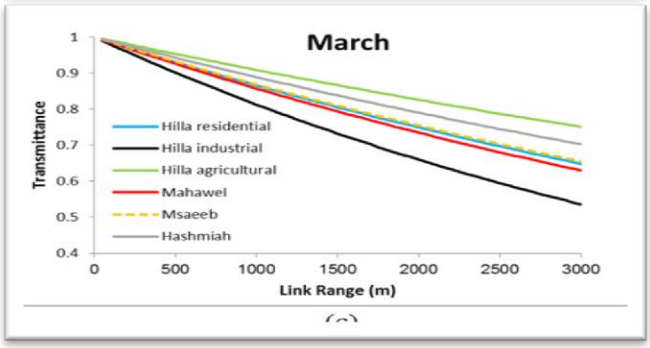


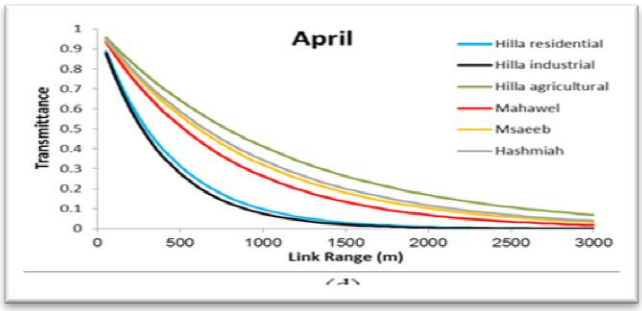
Figure (4): Variations of Transmittance for avelength (785 nm) as Functions of Dust Concentration, for the Six Selected Region, for Path Length of 3 km

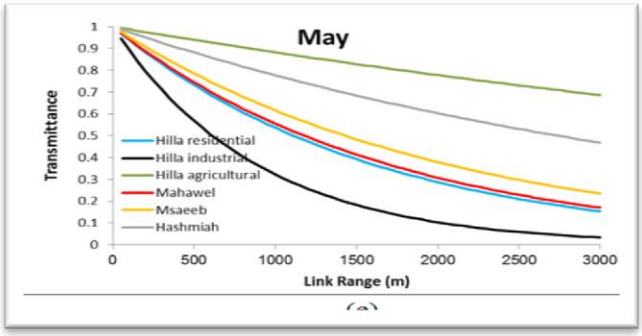
The transmitted power for the sixth state selected regions in Babylon city at wavelength (1330) nm, were calculated for this case and the results were as shown in figure (5a, 5b, 5c, 5d, 5e, and 5f).The maximum transmittance value for this period in Hilla agricultural region about 0.8 at 3Km rang at winter period and the minimum transmitted power in Hilla industrial about fewer 0.1 at 3 km range at summer period. The maximum total transmittance values for this period in Hilla residential, Al-Mahawel, Al- Msaeeb, and Al-Hashmiah regions about 0.7, 0.67, 0.68, and 0.8 at 3Km rang on arrangement











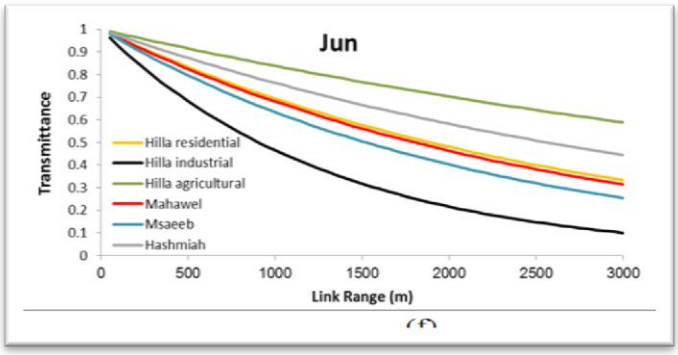


Figure (5): Variations of Transmittance for velength (1330 nm) as Functions of Dust Concentration, for the Six Selected Region, for Path Length of 3 km

From there Figures, we can see that the wavelength of 1330 nm is more capability to penetrate dust effect in the path length than the other two wavelengths (785, 632.8 nm) because their higher wavelength in comparison to the other wavelength, and wavelength of 785 nm is more capable to overcome the effect of dust than the wavelength of 632.8 nm. It is found out that the residential regions are Al- Hilla city, Al-Mahawel city, Al-Msaeeb city, and Al-Hashmiah city of dissimilar transmittance rate, in comparison to the other regions are Hilla industrial and Hilla agricultural for disparities transmittance rate of all the months. In Iraq the effect of aerosols is approximately high effect because of there climate area in Iraq are semi desert area (desert climate).

4. Conclusions

1- The best use of laser beam propagation in agricultural regions.

2- Laser beam of wavelength (1330 nm) is more suitable to overcome some of the atmospheric effects has more than wavelengths of (785 nm, and 632.8 nm) as used in laser communication.

3- The best use of laser beam propagation is through clear weather especially in winter period, because of the decrease in temperature and the absence of any turbid phenomenon which reduces the visibility range to less than 10 km. scattering of laser beam is constant in clear weather.

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