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Calculation of Linke turbidity in atmosphere over Iraq by solar constant

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Abstract:

Using extraterrestrial radiation, global solar, solar constant,(K_R)and correction factor of sun – earth distance as input of some mathematical models, the Linke turbidity has been calculated and average sixteen placed around of Iraq by using thirty years solar radiation data covering period from (1961 – 1991). The average values (TL) were found to range from 4.27 to 4.75 the minimum value in Basrah and maximum value in Zakho.

The results obtained for all locations carried out and observed small difference for all location. The average (T_L) gradient from the north to south of Iraq.

Key word: Solar radiation, turbidity , Linke turbidity

Introduction:

Solar radiation is attenuated spectrally when passing through the earth atmosphere; solar radiation is subjected to scattering by air molecules and aerosols over the whole solar spectrum. It is also absorbed in selective spectral band by various atmospheric constituents mainly ozone, water vapor, oxygen and carbon dioxide. Both scattering and absorption processes modify considerably the spectral intensities of incoming extraterrestrial solar radiation through the whole wave bond. Attenuation of the solar radiation is strongly dependent on sky condition. In a clean and dry atmospheric condition solar radiation is attenuated by permanent atmosphere constituents of air molecules, gases, and ozone, whose contents are nearly invariables. Two additional attenuation processes which are the absorption by water vapor and scattering by aerosol particles take place in a real atmosphere [1]. A number of calculations and studies on atmospheric turbidity have been undertaken in Asia [2, 3]. In South Africa investigation Linke turbidity from the climate data at eight locations regardless of cloud cover [4]. The turbidity coefficient estimation from broadband solar radiation by three Method [5]. Linke turbidity (T_L) is an index that represents the depth of clean and dry atmosphere that would be necessary to produced attenuation of extraterrestrial radiation. The value normally varies from (1-10). The calculation of turbidity factor according to

Linke is based on Bouger- Lam Bert extinction low [1]. The aim of this work is to calculate the Linke turbidity factor (TL) for the sky of Iraq as no previous work was made.

Theory:

Linke turbidity refers the whole spectrum that is over all spectrally integrated attenuation and accounts for the presence of water vapor and aerosols in the at mo sphere. As season's change, hence extraterrestrial solar radiation (Ra) change as well [6, 7]. The Ra, for each day of the year and for different latitude can be estimated from the solar constant, the sun declination and time of year by

$$R_a = \frac{24\,(60)}{\pi} \quad Gs\, dr\, [ws \ \sin(\emptyset) + \mathrm{Cos}\,(\delta)(\mathrm{Cos}(\emptyset)\,\sin(ws) \quad \ldots\ldots\ldots\ldots 1$$

G_s= solar constant

R_a= extraterrestrial solar radiation

d_r = inverse relative distance earth-sun

w_s = sun set hour angle

ø = latitude

δ = solar declination

The amount of radiation reaching a horizontal plane is known as a solar radiation (Rs) or (global radiation)[6]. If the Rs is not measured it can be calculated with the Angstrom formula.

$$R_s = (as + bs\,\frac{n}{N})\ Ra \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

R_s= global solar radiation

$\frac{n}{N} =$ relative sunshine duration.

A_s and b_s is called regression constants.

According to Bougure – Lembert law it possible to express broad bond and global solar flux on the earth surface Rs in term of over all extinction coefficient K [5]

$$R_s = d_r\ Gs\ \exp\,[-Km] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

G_s solar constant (1367 w/m^2)

K can be expressed as combination of extinction coefficients of the processes of Rayleigh scattering Kr, gas absorption Kg, ozone absorption K_o, aerosol scattering Ka and water absorption Kw.

$$K = K_r + K_g + K_o + K_a + K_w \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

In case of clear and dry atmosphere, the extinction coefficient of clear and dry atmosphere.

K_R can be expressed as combination of three extinction coefficient of K_r, Kg and K_o [1, 5].

The value of Linke turbidity can be calculated.

$$T_L = -\frac{1}{KRm} \ \mathrm{Ln} \ \frac{Rs}{dr\ Gs} \ \ldots\ldots 5$$

Because the amount of air molecule, ozone and gaseous constituent are assumed to be in variant, the extinction coefficient of ideal clean and dry atmosphere, K_r is expressed only as a function of air mass (m)

$$K_R = 6.6296 + 1.7513m - 0.1202m^2 + 0.006m^3 - 0.00013m^4 \ \ldots\ldots\ldots 6$$

The Linke turbidity varies with air mass even when the atmospheric condition remains constant [1, 5].

Result and discussion:

The republic of Iraq is located in south- west of Asia, Iraq lies between latitude $29^o5'$ and $37^o22'$ north and between longitudes $38^o45'$ east and $48^o45'$.

The locations selected in the present study are [Appendix A].the factor K_r, R_s, dr and G_s data reported in this paper were supplied by the relevant metrological and solar radiation were mainly taken from the Republic of Iraq metrological office (RIMO). The measured values in a period from (1961- 1991) for all stations, this results obtained by using equation from (1 to 6).

R_a and R_s evaluated by equation 1 and 2 tables (1) and (2). K_r evaluated by the equation (6), the air mass (I, 1.2, 1.5, 1.7, and 2).

Using equation (5) to calculate the Linke turbidity (T_L) for all selected locations table (3). The maximum values (TL) for all location are observed in January, February November and December, while the minimum values appeared in April, May, June ,July, August and September figures (1,2,and3).

The overall averaged of (T_L) (i.e. Mean average of all stations) in Iraq depicted in figures (4). Observed the maximum value of (T_L) in Zakho, Mousul, Kirkuk, and Salaimaniya cites (northern of Iraq) but the minimum value (T_L) in the middle and south of Iraq figures (5), exhibit, that monthly values of link turbidity are almost variant slightly through a year. The monthly mean values of (TL) not very much. The link turbidity agrees with the result of other studies [1].

Conclusion:

Our study shows, it is possible to obtain the global solar radiation by means of a model that has been depended local atmospheric condition and geographical parameter (i.e. latitude). This model provides a good estimation for Linke turbidity (T_L) for all locations and we can say that the model performs well. The maximum Linke turbidity in January, February, November and December and the maximum values in April, May, June, July, August and September.

The values of the (T_L) were found vary with months and depend on global solar radiation.

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Table (1) extraterrestrial solar radiation for all selected location

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Jan.	20.98	20.66	20.55	20.16	20.10	20.10	20.05	19.76	19.45	19.34	20.89	18.87	18.02	17.66	17.51	16.90
Feb.	25.70	25.85	25.29	25.03	24.96	24.96	24.86	24.62	24.36	24.21	23.79	23.64	23.08	23.02	23.36	22.05
Mar.	31.38	31.19	31.10	30.88	30.99	30.99	30.76	30.59	30.41	30.3	29.97	29.86	29.53	29.49	29.06	28.63
Apr.	36.60	36.52	36.49	36.38	36.37	36.37	36.32	36.23	36.31	36.07	35.92	35.86	35.61	35.59	35.44	35.19
May	39.97	39.94	39.94	39.97	39.64	39.64	39.95	39.93	39.9	39.94	39.94	39.94	39.89	39.87	39.88	39.82
June	40.14	40.86	41.22	41.22	41.22	41.22	41.27	41.22	41.35	41.38	41.45	41.55	41.49	41.48	41.53	41.77
July	41.49	40.46	40.46	40.52	40.51	40.51	40.52	40.51	40.54	40.56	40.59	40.56	40.70	40.65	40.59	40.61
Aug.	37.83	37.76	36.50	37.24	37.66	37.66	37.32	37.56	37.60	37.5	37.42	37.38	37.24	37.22	37.08	36.94
Sep.	33.38	33.06	33.99	32.81	32.81	32.81	32.72	32.58	32.61	32.35	32.07	32.00	31.62	31.57	31.33	30.97
Oct.	27.31	27.08	26.96	26.70	26.70	26.70	26.55	26.34	26.33	25.97	25.58	25.44	24.89	24.81	24.48	23.95
Nov.	22.06	21.73	21.59	21.30	21.29	21.29	21.11	20.83	20.83	20.43	19.96	19.79	19.16	19.06	18.67	18.08
Dec.	19.63	20.22	19.19	18.80	18.79	18.79	18.59	18.37	18.33	17.94	17.51	17.24	16.57	16.46	16.04	15.41

Table (2) global solar radiation for all selected location

Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Jan	12.42	11.72	12.11	11.19	11.45	11.65	11.67	11.4	11.23	11.06	11.53	10.13	9.17	9.34	7.87	8.05
Feb	15.6	15.22	15	14.68	14.64	14.98	14.7	14.89	14.62	14.31	13.95	12.71	12.30	11.67	12.28	10.91
Mar	18.51	17.87	18.48	17.41	18.02	18.02	18.15	18.18	18.20	17.88	17.68	16.17	15.66	14.64	15.79	14.26
Apr	21.7	20.93	21.57	21.07	21.07	12.35	21.32	20.42	12.31	21.74	21.01	20.28	19.86	19.57	19.70	18.74
May	24.92	23.94	24.01	23.66	23.47	23.76	24.39	22.76	24.8	42.73	24.94	23.63	23.97	24.39	27.47	23.48
June	26.34	23.88	27.04	27.55	27.04	27.4	27.88	27.70	28.33	28.35	27.73	27.21	26.49	28.23	28.31	27.28
July	26.96	24.32	28.19	27.28	27.27	27.42	27.57	27.56	28.32	27.89	27.71	26.82	26.44	27.99	27.95	27.45
Aug	23.94	23.54	25.61	25.84	25.7	25.26	25.9	25.78	26.43	26.22	25.50	24.76	25	25.82	25.73	24.85
Sep	22.78	21.6	25.01	24.6	22.19	21.98	22.19	22.23	22.25	22.16	21.62	20.96	12.31	12.7	21.63	20.75
Oct	18.4	11.14	17.19	17.09	16.85	16.85	17.11	16.86	16.97	16.62	16.44	15.43	15.44	15.27	15.31	14.47
Nov	13.69	12.9	13.03	12.76	11.93	12.85	13.26	12.68	12.96	12.29	11.96	11.66	11.23	10.68	10.59	9.52
Dec	11.77	11.47	10.98	10.84	10.65	10.75	10.82	10.46	10.53	10.36	9.66	8.98	8.36	9.26	8.12	7.59

Table (3) Linke turbidity for sixteen locations in Iraq

Month	Al.basrah	Al.nasiriya	Al.samaua	Al.amara	Al.diwaniya	Al.najaf	Al.hia	kerballa	Al.rutbah	Baghdad	Haditha	khanoqin	kirkuk	Al.sula-imaniya	Al.mosul	Zakho
Jan	5.47	5.63	5.54	5.71	5.67	5.64	5.63	5.67	5.73	5.75	5.66	5.98	6.22	6.17	6.58	6.53
Feb	4.43	4.51	4.52	5.57	4.57	4.53	4.57	4.54	4.58	4.63	4.68	4.89	4.96	5.07	4.96	5.23
Mar	4.41	4.55	4.48	4.62	4.53	4.52	4.53	4.53	4.50	4.56	4.57	4.80	4.86	5.03	4.86	5.13
Apr	3.90	3.97	3.91	3.98	3.98	3.96	3.69	4.05	3.97	3.91	3.98	4.08	4.12	4.15	4.15	4.27
May	3.65	3.77	3.73	3.79	3.83	3.79	3.73	3.90	3.68	3.71	3.68	3.79	3.77	3.72	3.43	3.83
June	3.40	3.64	3.35	3.31	3.35	3.31	3.28	3.28	3.23	3.24	3.28	3.33	3.40	3.27	3.23	3.33
July	3.43	3.70	3.37	3.43	3.43	3.41	3.41	3.41	3.33	3.39	3.38	3.46	3.51	3.38	3.38	3.41
Aug	3.74	3.79	3.62	3.58	3.61	3.63	3.58	3.58	3.53	3.56	3.63	3.68	3.65	3.58	3.58	3.68
Sep	3.81	3.91	3.59	3.61	3.87	3.89	3.87	3.87	3.87	3.87	3.91	3.98	3.98	3.91	3.91	4.03
Oct	4.47	5.67	4.60	4.67	4.69	4.69	4.64	4.70	4.67	4.73	4.75	4.90	4.90	4.93	4.91	5.07
Nov	5.06	5.21	5.18	5.23	5.39	5.23	5.16	5.25	5.21	5.32	5.39	5.44	5.53	5.65	5.67	5.93
Dec	5.52	5.67	5.72	5.79	5.77	5.83	5.80	5.90	5.87	5.92	6.1	6.27	6.43	6.19	6.51	6.67
Mean	4.27	4.50	4.30	4.35	4.39	4.36	4.34	4.39	4.34	4.38	4.41	4.55	4.61	4.58	4.59	4.75
S.D	0.660	0.711	0.713	0.789	0.719	0.713	0.716	0.712	0.732	0.751	0.754	0.790	0.821	0.849	0.867	0.897

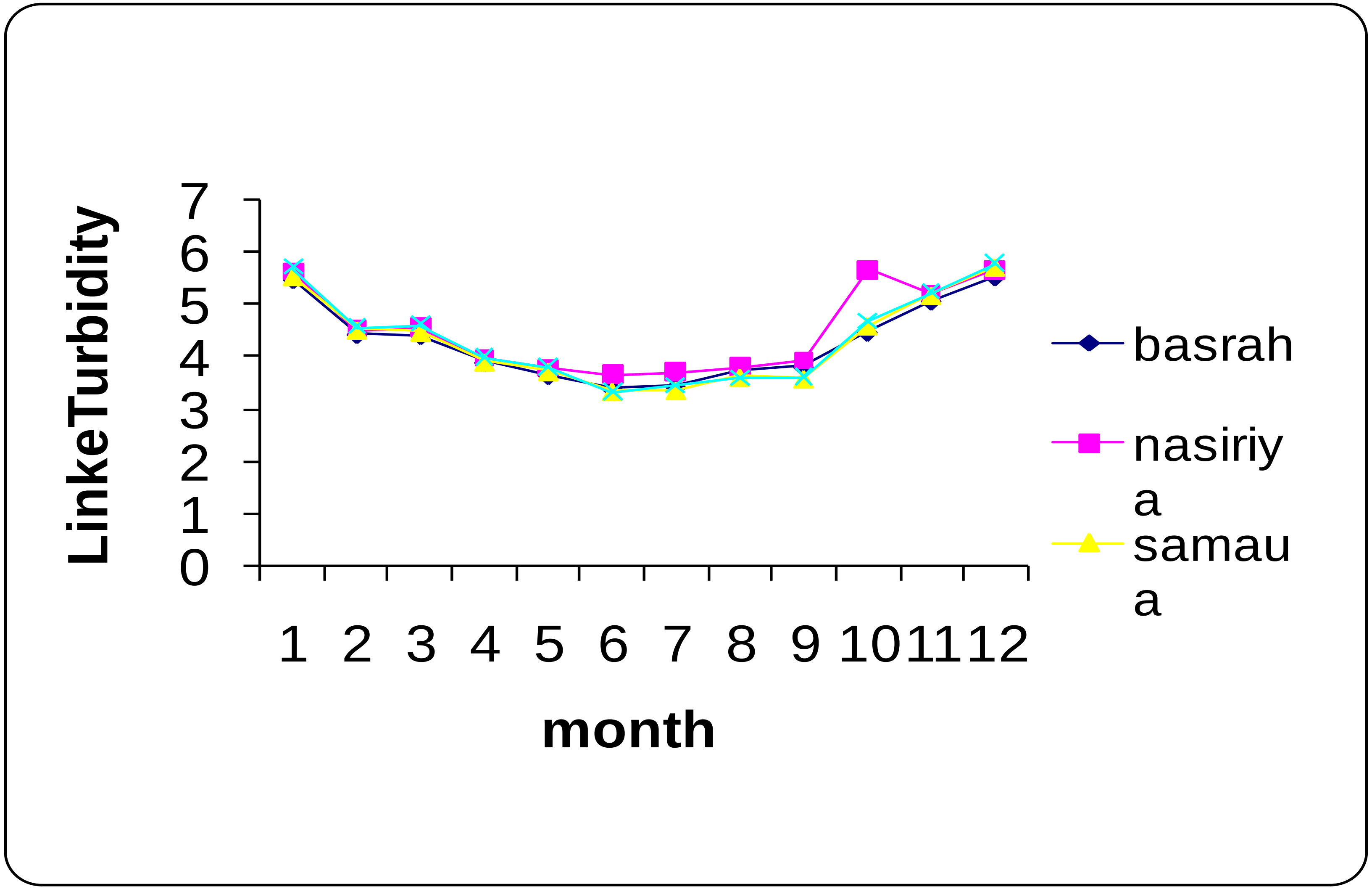


Fig (1): The variation of Linke turbidity against number of months for (South of Iraq)

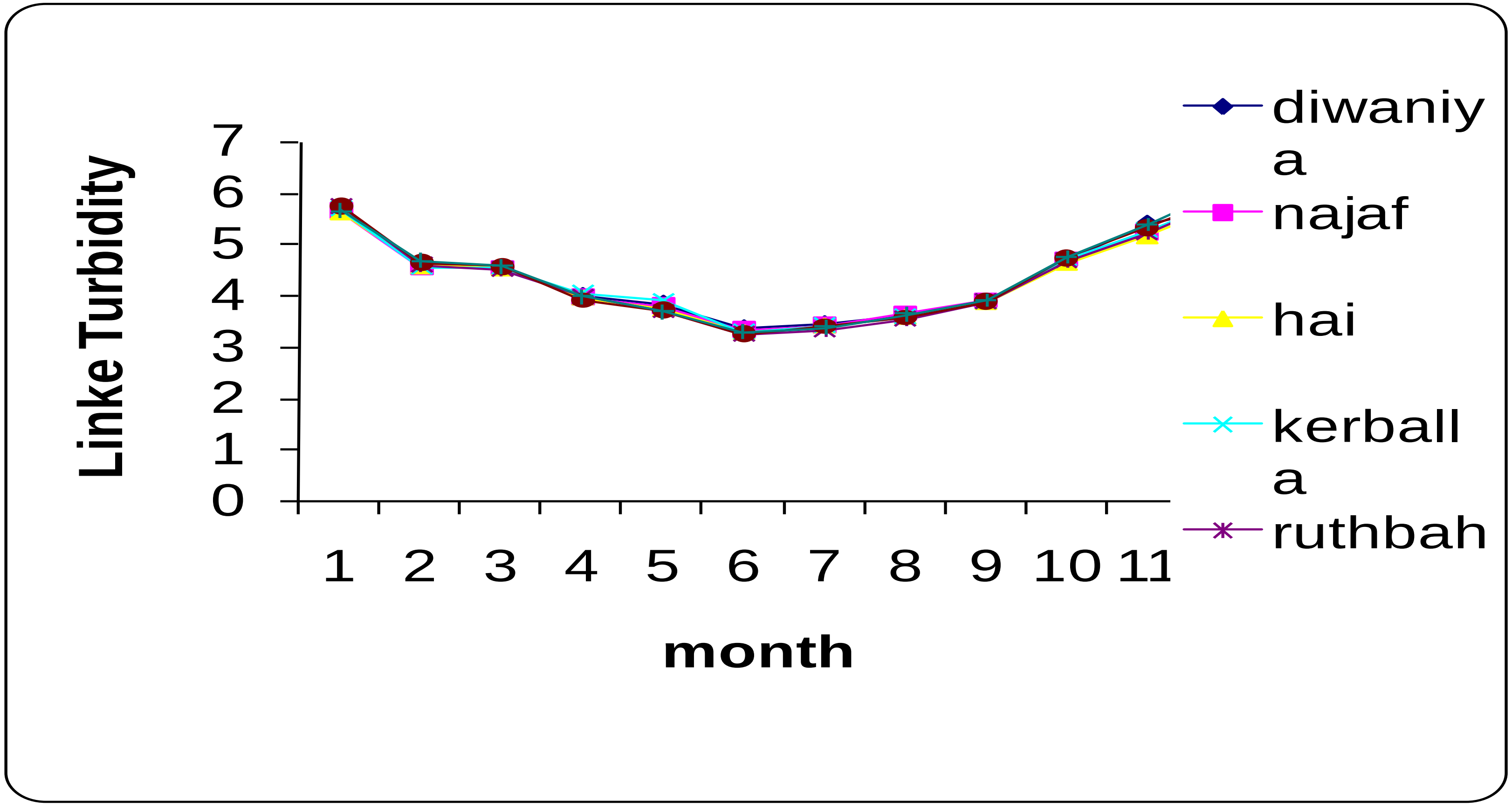


Fig (2): The variation of Linke turbidity against number of months for (middle of Iraq)

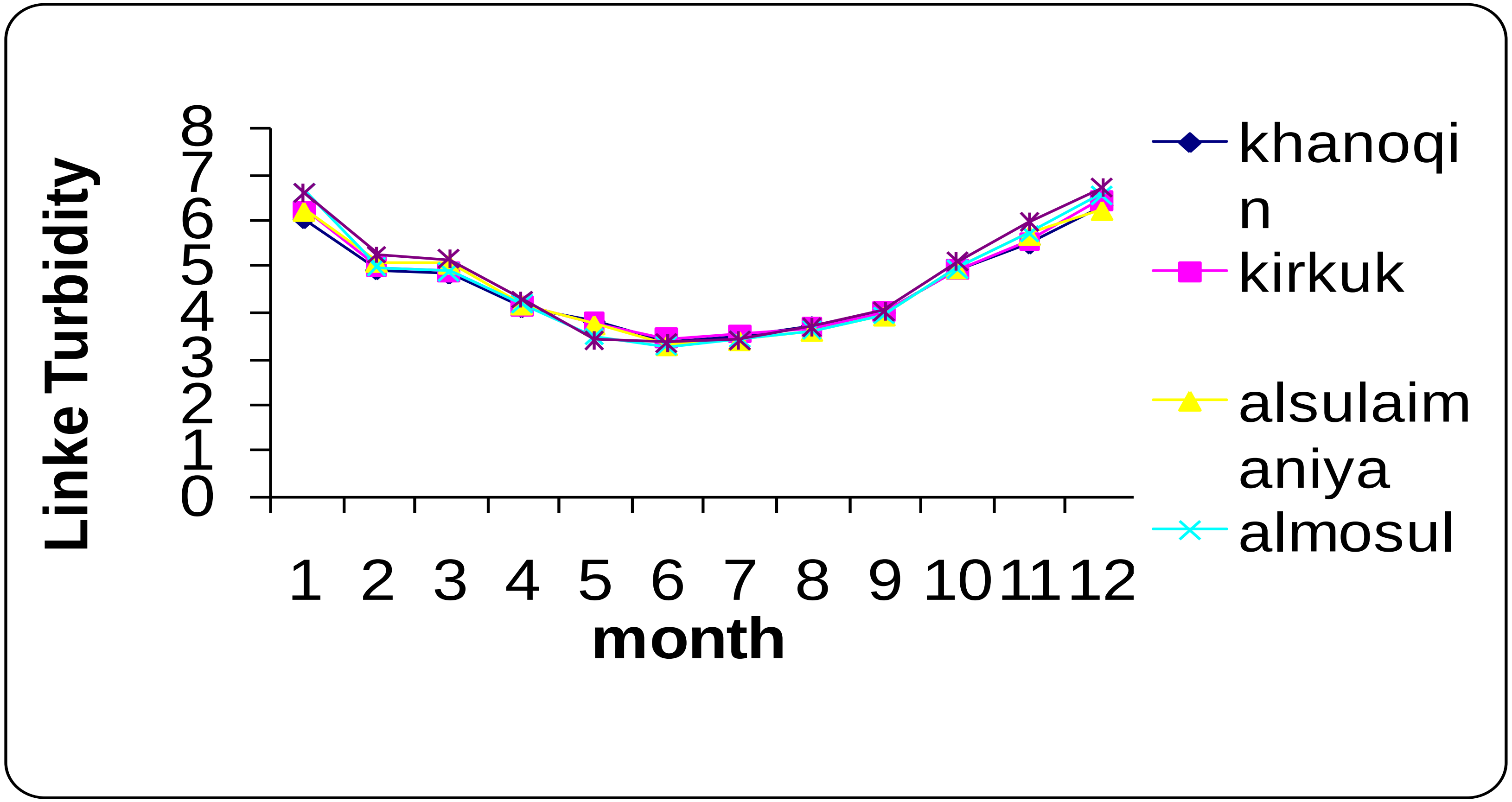


Fig (3): The variation of Linke turbidity against number of months for (North of Iraq)

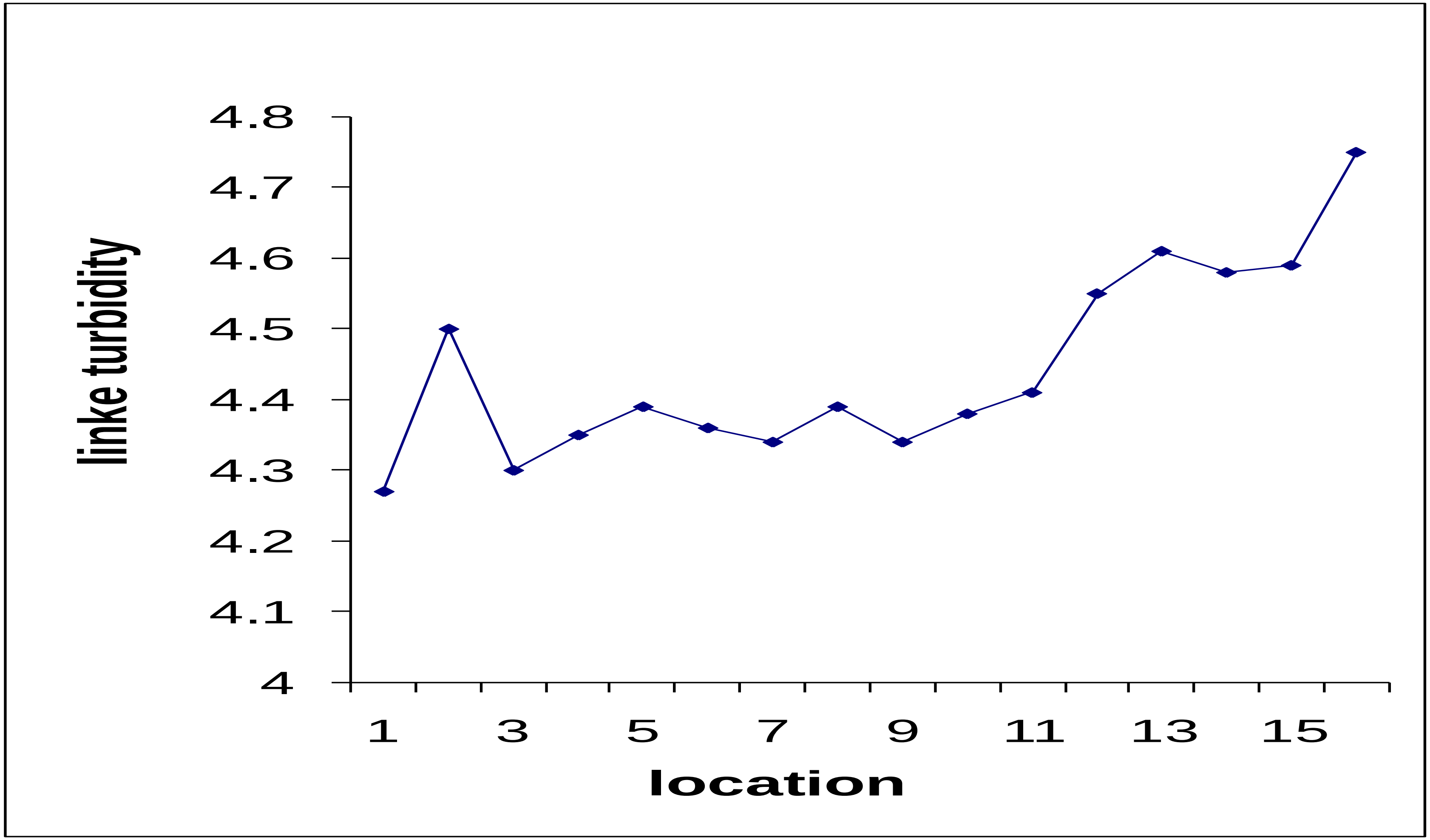
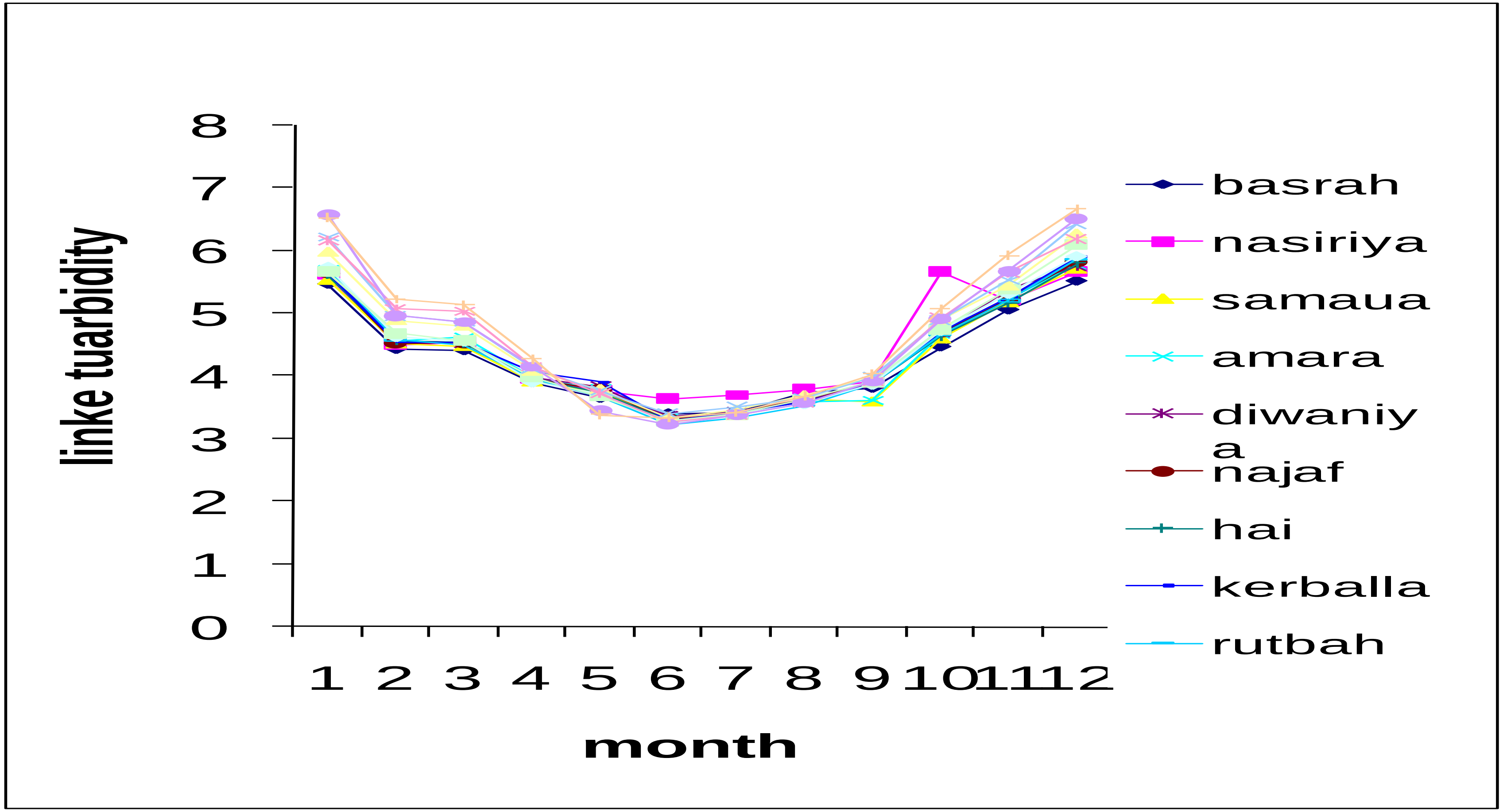


Fig (4): The variations of Linke turbidity for all locations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Appendix (A)

	Location	Latitudes(N)	Elevation(m)
1	Al-Basrah	$30^{\circ} 31'$	2.4
2	Al- Nasiriya	$31^{\circ} 01'$	3
3	Al-Samaua	$31^{\circ} 16'$	6
4	Al-Amara	$31^{\circ} 50'$	7.5
5	Al-Diwaniya	$31^{\circ} 57'$	20.4
6	Al-Najaf	$31^{\circ} 57'$	50
7	Al-Hai	$32^{\circ} 08'$	14.9
8	Kerballa	$32^{\circ} 34'$	29.0
9	Al-Rutbah	$33^{\circ} 02'$	615.5
10	Baghdad	$33^{\circ} 18'$	34.1
11	Haditha	$34^{\circ} 08'$	108
12	Khanoqin	$34^{\circ} 21'$	202.2
13	Kirkuk	$35^{\circ} 28'$	330.8
14	Al-Sulaimaniya	$35^{\circ} 32'$	853.0
15	Al-Mosul	$36^{\circ} 19'$	222.9
16	Zakho	$37^{\circ} 08'$	442.

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حساب عكورة لينك باستخدام الاشعاع الشمسي الى 16 موقعا عراقيا

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الملخص:

استخدم الإشعاع الشمسي الخارجي والإشعاع الكلي والثابت الشمسي والاعلومة K_R وعامل تصحيح المسافة بين الأرض والشمس كمدخلات في نماذج رياضية لحساب عكورة لينك إلى ستة عشر موقعاً عراقياً بالاعتماد على معطيات الإشعاع لمدة ثلاثين عاماً من 1961 – 1991 . وكان المعدل الشهري إلى قيمة عكورة لينك يتراوح بين 4.27 – 4.75 والقيمة الدنيا في محافظة البصرة والعظمى في محافظة زاخو. وهذه النتائج التي حصلت عليها أنجزت في هذا البحث ولاحظنا هناك اختلاف بسيط من موقع إلى آخر وكان معدل القيمة يتدرج من الشمال إلى جنوب العراق.