LIGHT POLLUTION AND NIGHT SKY BRIGHTNESS AT THE SITE OF KOTTAMIA OBSERVATORY

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Abstract. Photoelectric measurements of the night sky brightness and the light pollution of Kottamia Observatory have been carried out and the deduced results are expressed in mag/sec^2. The maximum brightness of the sky in the direction of Cairo city at zenith distance 45° and azimuth 70° when the sun is almost 60° below the horizon are 22.68; 21.54 and 19.82 mag/sec^2 for blue, yellow and red colours respectively. The corresponding values of night sky background are 22.94; 21.85 and 20.14 mag/sec^2 respectively.

The isophotes of the sky brightness at Kottamia Observatory have been drawn for blue, yellow and red colours. The variations of the night sky brightness and the (B-V) colour index with altitude of the observed point have been studied.

The light pollution and the night sky brightness at the site of Kottamia Observatory is compared with that deduced by different investigators at other sites. It has been shown that the sky brightness at zenith distance 45° at Kottamia Observatory site is similar to Kitt Peak and Palomar Observatory sites. Kottamia Observatory site is slightly brighter than Junipero Serra while it is darker than Mount Hamilton and San Jose sites. The comparative results have been carried out at blue and yellow colours. No comparison is obtained at red as there is no data published for the red colour.

1. Introduction

The study of the distribution of the night sky brightness and its variation at different directions due to light pollution is very important to future protection of the sites of the astronomical observatories. Different investigators have studied the effect of light scattered from different cities laying near the observatories. Walker (1973) has studied the light pollution in California and Arizona sites. By means of spectrophotometric studies, Turnrose (1974) has obtained the absolute spectral energy distribution of the night sky at Palomar and Mount Wilson observatories. He has found that the sky brightness at Mount Wilson observatory is typically close to two magnitudes brighter than that at the Palomar Observatory. Walker (1977) has made a new study of urban lighting and its effect on the brightness of the night sky. Atmospheric extinction and night sky brightness at Mauna Kea site have been studied by Krisciunas *et al.* (1987). They have used 17 filters having wavelengths between 0.44 μm to 32 μm to deduce the zenith night sky brightness at altitude 2800 m above sea level and the values that have been obtained for the year 1986 equal 21.5 and 22.3 mag/sec^2 for visual and blue measurements respectively.

Asaad *et al.* (1982) have studied the effect of light scattered from Cairo and Seuz cities on Kottamia Observatory site. They also have studied the expected effect of other new cities laying near Kottamia site. Their results are expressed

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in number of stars of 10th magnitude per square degree ($S(\lambda)$ units), where λ is the wavelength at certain colour. Pilachowski *et al.* (1989) have found that the average brightness of night sky during solar minimum are approximately 21.9 and 23.0 mag/sec^2 for visual and blue colours respectively. Massey *et al.* (1990) have studied the spectrophotometry of the night sky at the site of Kitt Peak Observatory. Their observations are taken on a moonless night (1988 Feb. 18) at different values of zenith distances and azimuthal angles through the night. The average values of the brightness are 22.8 mag/sec^2 and 21.9 mag/sec^2 for blue and yellow colours respectively.

In the present work we have studied the night sky brightness and colour distribution at Kottamia Observatory site in the western direction where Cairo is an extended city that cause light pollution.

2. Observations and Results

Photoelectric observations of the night sky brightness at Kottamia Observatory have been carried out using semi – automatic photo – electric photometer. The photometer is mainly designed for measuring the intensity of the night sky and zodiacal light. The photoelectric measurements have been carried out using blue, yellow and red filters having the effective wavelengths 4400, 5500 and 7900 Å respectively. The observations are mainly concentrated in the area around west direction, to study the night sky brightness and the light pollution caused by Cairo city

The Kottamia Observatory site is situated at about 70 km east of Cairo and at altitude 470 m above sea level. The coordinates of the observatory are $\phi = 29°55.9'$ N; $\lambda = 31°49.5'$ E. The sensitivity of the photometer have been checked from time to time by using standard source, and the linearity of the amplifier have been tested. The observations are carried out on a moonless night (1980 Dec. 27) and the visibility is extended. The scans along the night cover about 270° in azimuth and 45° altitude above the horizon. The measurements have been corrected for dark current and step factors. No correction has been made for hole factors, since the night sky measurements are taken by the same hole. The deduced results of the night sky brightness are expressed in mag/sec^2 and given in Tables I, II and III for blue, yellow and red colours respectively.

3. Discussion of the Results

It can be seen from Tables I, II and III for the three filters, the maximum sky brightness is showing up almost at azimuth(A) 70° from the north towards the west. At altitudes 10° above the horizon and azimuth 70° the night sky brightness are 21.73, 20.34 and 18.56 mag/sec^2, for blue, yellow and red filters respectively,

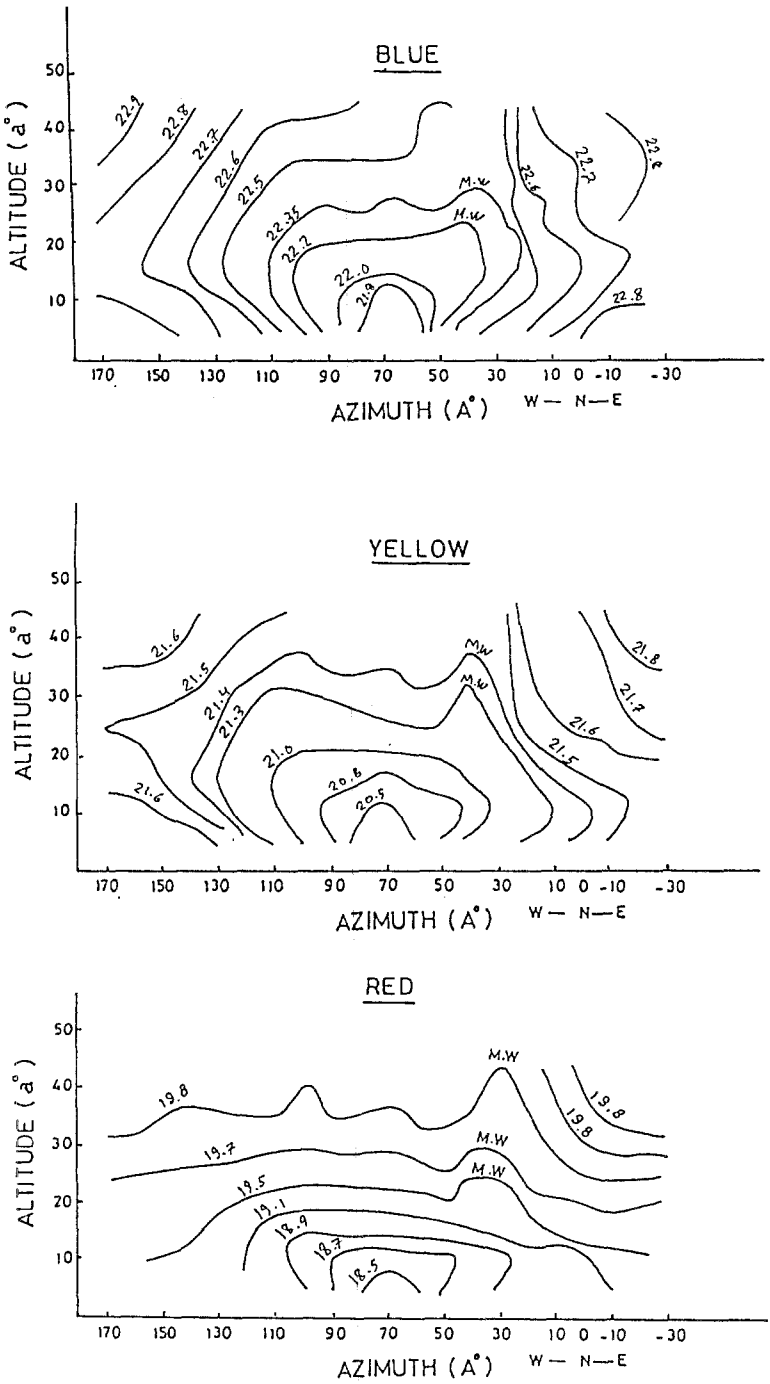

Fig. 1. The isophotes of night sky brightness due to light pollution deduced at Kottamia Observatory for blue, yellow and red colours.

TABLE I

Night sky brightness at Kottamia Observatory expressed in mag/sec^2 using blue filter

å Å	5	10	15	25	35	45
170	23.00	22.92	22.73	22.80	22.89	22.87
160	22.97	22.89	22.72	22.76	22.89	22.89
150	22.94	22.85	22.67	22.73	22.77	22.89
140	22.87	22.78	22.60	22.67	22.74	22.87
130	22.78	22.66	22.50	22.58	22.68	22.76
120	22.68	22.51	22.41	22.49	22.58	22.69
110	22.53	22.35	22.35	22.39	22.53	22.67
100	22.35	22.20	22.16	22.34	22.51	22.66
90	22.18	22.05	22.11	22.33	22.50	22.64
80	21.80	21.90	22.04	22.35	22.52	22.60
70	21.54	21.73	21.96	22.25	22.50	22.68
60	21.73	21.80	22.07	22.33	22.50	22.61
50*	22.20	21.99	21.99	22.35	22.49	22.54
40*	22.45	22.20	22.12	22.19	22.17	22.52
30*	22.58	22.41	22.27	22.42	22.21	22.40
20	22.64	22.50	22.45	22.52	22.63	22.63
10	22.67	22.61	22.54	22.63	22.67	22.77
00 N	22.75	22.68	22.58	22.69	22.69	22.82
−10	22.87	22.74	22.65	22.78	22.75	22.81
−20	22.91	22.75	22.66	22.84	22.80	22.85
−30	22.88	22.75	22.67	22.82	22.78	22.92
−40	22.74	22.75	22.68	22.80	22.76	22.94
−50	22.89	22.73	22.65	22.78	22.75	22.94
−60	22.89	22.73	22.63	22.77	22.72	22.92
−70	22.89	22.71	22.60	22.72	22.75	22.84
−80	22.89	22.69	22.57	22.66	22.62	22.78

* Gives the position of Milky Way (M.W.).
N, North direction.
−, Negative sign means that the observations are carried out from north to east otherwise from north to west.

while the corresponding background for the three colours are 22.92, 21.64 and 19.39 mag/sec^2. For a = 45° and A =70° the sky brightness are 22.68, 21.54 and 19.82 mag/sec^2 for blue, yellow and red colours respectively. The corresponding background are 22.94, 21.85 and 20.14 mag/sec^2. Using the data of Tables I; II and III the contour maps of the sky brightness have been drawn. Figure 1, gives the isophotes of the night sky brightness at Kottamia Observatory for blue, yellow

TABLE II

Night sky brightness at Kottamia Observatory expressed in mag/sec^2 using yellow filter

å Å	5	10	15	25	35	45
170	21.87	21.64	21.54	21.50	21.59	21.72
160	21.87	21.64	21.53	21.49	21.57	21.72
150	21.81	21.57	21.49	21.47	21.58	21.70
140	21.73	21.45	21.40	21.47	21.55	21.68
130	21.60	21.45	21.29	21.40	21.49	21.56
120	21.45	21.25	21.16	21.29	21.44	21.56
110	21.28	21.05	21.00	21.20	21.38	21.53
100	21.04	20.87	20.85	21.15	21.39	21.44
90	20.83	20.72	20.86	21.18	21.42	21.47
80	20.44	20.53	20.80	21.24	21.45	21.50
70	20.25	20.34	20.77	21.28	21.40	21.54
60	20.52	20.44	20.84	21.28	21.53	21.55
50*	20.89	20.64	21.89	21.29	21.46	21.53
40*	21.14	20.91	21.03	21.11	21.37	21.46
30*	21.28	21.04	21.18	21.33	21.43	21.43
20	21.31	21.18	21.31	21.50	21.59	21.59
10	21.35	21.26	21.44	21.59	21.70	21.66
00 N	21.43	21.36	21.48	21.63	21.74	21.72
−10	21.53	21.46	21.52	21.63	21.75	21.81
−20	21.59	21.52	21.52	21.76	21.82	21.82
−30	21.58	21.52	21.49	21.73	21.79	21.84
−40	21.59	21.50	21.48	21.76	21.79	21.88
−50	21.64	21.47	21.52	21.70	21.79	21.85
−60	21.64	21.50	21.42	21.67	21.76	21.81
−70	21.64	21.45	21.43	21.59	21.68	21.72
−80	21.62	21.43	21.36	21.53	21.56	21.70

* Gives the position of Milky Way (M.W.).
N, North direction.
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and red filters. The number on each isophote gives the night sky brightness value, expressed in mag/sec^2 at different coordinates. Simple interpolation of the isophote values can be used for the other in between regions. It can be seen from Figure 1, that the shape of the isophotes in the blue and yellow filters are nearly similar, while it has other shape for red filter. The reason may be due to the system of lighting of Cairo city and the humidity, dust and smoke spreaded. The slight increase appears

TABLE III

Night sky brightness at Kottamia Observatory expressed in mag/sec^2 using red filter

å 5	10	15	25	35	45
Å					
170	19.59	19.39	19.42	19.51	19.78	19.83
160	19.56	19.31	19.40	19.50	19.78	19.83
150	19.50	19.28	19.39	19.49	19.70	19.79
140	19.42	19.23	19.34	19.48	19.68	19.81
130	19.19	19.16	19.24	19.45	19.68	19.82
120	19.05	19.07	19.12	19.43	19.72	19.82
110	18.98	18.91	18.98	19.39	19.71	19.78
100	18.89	18.76	18.92	19.36	19.66	19.75
90	18.72	18.67	18.98	19.37	19.71	19.78
80	18.51	18.61	18.96	19.39	19.66	19.81
70	18.39	18.56	18.94	19.38	19.66	19.82
60	18.50	18.65	18.97	19.41	19.74	19.78
50*	18.74	18.65	19.04	19.47	19.74	19.71
40*	18.81	18.83	19.09	19.32	19.67	19.71
30*	18.94	18.83	19.20	19.32	19.64	19.68
20	18.95	19.04	19.26	19.62	19.69	19.72
10	19.06	18.91	19.30	19.62	19.80	19.91
00 N	19.03	19.05	19.27	19.68	19.83	19.93
−10	19.13	19.27	19.39	19.72	19.95	19.95
−20	19.36	19.24	19.29	19.70	19.93	20.00
−30	19.28	19.18	19.30	19.64	19.95	20.04
−40	19.33	19.24	19.33	19.64	19.84	20.14
−50	19.34	19.30	19.38	19.65	19.95	20.14
−60	19.39	19.35	19.38	19.62	19.87	20.14
−70	19.44	19.30	19.23	19.64	19.83	20.11
−80	19.43	19.26	19.33	19.58	19.79	20.03

* Gives the position of Milky Way (M.W.).
N, North direction.
−, Negative sign means that the observations are carried out from north to east otherwise from north to west.

in the isophotes of the night sky at azimuth angles between 30° and 50°, is due to the brightness of the Milky way (M.W.).

The variation of the night sky brightness with wavelength at different altitudes above the horizon and at certain azimuth (A = 70°) has been drawn in Figure 2. The figure gives the relation between the sky brightness expressed in mag/sec^2 with wavelength (λ). Figure 2 indicates that for all altitudes, the values of the sky

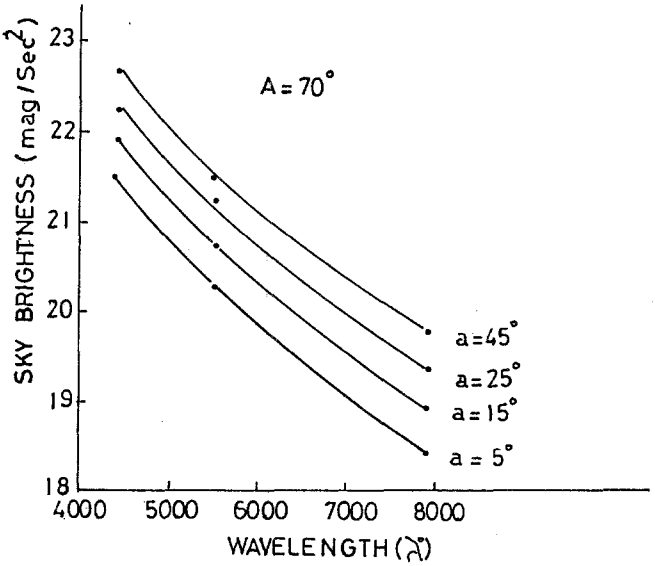

Fig. 2. The variation of night sky brightness and wavelength at different altitudes above the horizon.

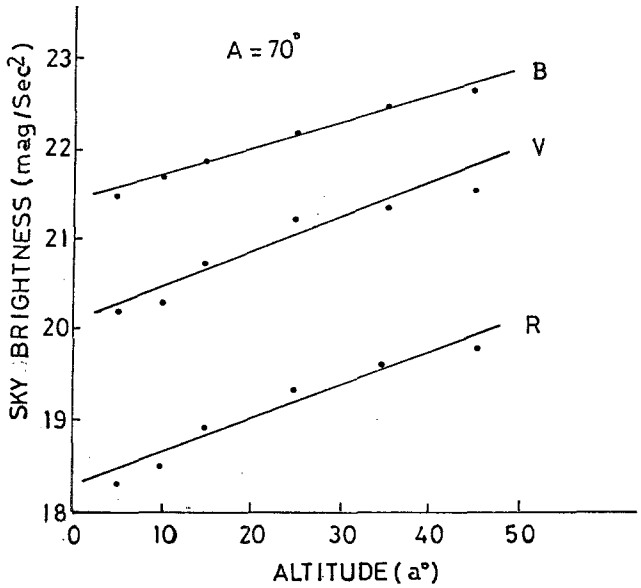

Fig. 3. The relation between the night sky brightness and the altitude of the observed point above the horizon for blue, yellow and red colours.

brightness increase with increasing wavelength. Simple interpolation can be applied to the figure to obtain the values of the sky brightness at Kottamia Observatory for other wavelengths.

The relation between the night sky brightness and the altitude of the observed point at certain azimuth (A = 70°) is drawn in Figure 3. It has been found from

TABLE IV

Comparison between the night sky brightness expressed in mag/sec^2 obtained at different sites

a°	Filter	Kitt Peak	Palomar	Pions	Junipero Serra	Mount Hamilton	San Jose	Kottamia
17	B	–	22.44	22.27	22.51	–	22.31	22.44
	V	–	21.19	21.16	21.33	–	21.23	21.26
34	B	–	22.53	22.73	22.66	–	22.58	22.66
	V	–	21.49	21.60	21.60	–	21.54	21.58
45	B	22.75	22.73	22.49	22.89	21.70	22.05	22.75
	V	21.96	21.67	21.14	21.88	20.82	21.05	21.65

TABLE V

Comparison between $(B - V)$ colour index obtained at different sites

a°	Kitt Peak	Palomar	Pions	Junipero Serra	Mount Hamilton	San Jose	Kottamia
17	–	1.25	1.35	1.18	–	1.08	1.18
34	–	1.04	1.13	1.06	–	1.04	1.02
45	1.05	1.06	1.11	1.01	0.88	1.00	1.10

Figure 3 that there is a linear relation between the sky brightness and the altitude of the observed point above the horizon. This means that the sky brightness at the other altitudes in the sky can be obtained by simple interpolation of the data of Tables I, II and III.

4. Comparison with the Results Obtained for Other Observatory Sites

The present results of the night sky brightness at Kottamia Observatory have been compared with the results obtained by other investigators. This comparison is given in Table IV. The results of the night sky brightness at Kottamia at altitudes 17° and 34° above the horizon, listed in Table IV, are deduced by simple interpolation as mentioned before. It can be seen from Table IV that, at altitude 17° above the horizon there are slight differences in the night sky brightness between Kottamia and other observatories. These differences are not exceeding 0.12 mag/sec^2 for visual (V) and 0.07 mag/sec^2 for blue (B). At altitude 34°, values of the night sky brightness at Kottamia for both B and V are similar to Junipero Serra and San Jose sites and slightly darker than Palomar and Pions sites. At altitude 45°

the values of the night sky brightness at Kottamia for B and V colours are similar to Kitt Peak and Palomar Observatories, while they are slightly brighter than Junipero Serra site, however they are darker than Mount Hamilton and San Jose sites. No comparison are given for the red wavelength (λ = 7900 Å) as there is no photoelectric observations are published for the night sky brightness, due to the light pollution, at other observatories using red colour.

Using the data of Table IV the (B−V) colour index is calculated at Kottamia Observatory and other sites. The comparison between the results is given in Table V. It has been found from Table V, that there are no correlation between ($B - V$) colour index and altitudes above the horizon at both Kottamia and Palomar sites. At Pions, Junipero Serra and San Jose sites, the ($B - V$) colour index decrease with the increase of the altitude of the observed point.

However this program is wide and will last for more observations and studies at different seasons and conditions, as well as finding the possible changes after considerable interval of time.

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