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Night Sky Quality Measurements at the ATA50 Telescope

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Abstract: One of the most important factors affecting the quality of the sky in astronomy is the light pollution (luminance of the night sky). This effect occurs by using artificial light sources of outdoor lighting in the wrong way (in the wrong place and at the wrong time, incorrect choice of fixtures or light bulbs, misdirected lighting or excessive amount of light, etc). As a consequence of that, a large proportion of this artificial light, and the energy generated to produce, is wasted in this way. Light pollution can be controlled by simply turning off unnecessary light and using light only what is actually needed, when and where it is needed. Although, in many countries legislation is designed to limit light pollution from outdoor light fixtures, but still in many places especially in our country we face with light pollution problem due to wrong outdoor lighting.

ATA50 Teleskobunda Gece Gökyüzü Kalitesi Ölçümleri

Anahtar Kelimeler
SQM
Işık Kirliliği
ATA50

Özet: Astronomide gökyüzü kalitesini etkileyen en önemli unsurlardan birisi ışık kirliliğidir (gece gökyüzünün parlaklığı). Bu etki, dış aydınlatmanın yapay ışık kaynakları tarafından yanlış kullanılmasından (yanlış yerde, yanlış zamanda, yanlış armatür veya ampül seçimi ve yanlış yönlendirilmiş aydınlatma veya aşırı ışık miktarı gibi) oluşur. Bunun sonucu olarak, bu ışığı üretmek için harcanan enerjinin önemli bir kısmı da boşa harcanmaktadır. Işık kirliliği, ışığın ne zaman ve nerede ihtiyaç duyulduğuna bakılarak, sadece gerçekten ihtiyaç olduğunda kullanılmasıyla ve gereksiz ışığın kapatılmasıyla kontrol edilebilir. Birçok ülkede dış aydınlatma armatürlerinden kaynaklanan ışık kirliliğini sınırlandırmak için yasal düzenlemeler yapılsa da hala yanlış kullanımlar yüzünden özellikle ülkemizde olmak üzere birçok yerde ışık kirliliği sorunu ile karşılaşmaktayız.

1. Introduction

Light pollution adversely affects both humans and wildlife as well as scientific research in many ways (disrupts ecosystems, effects animal migration and navigation, interferes with astronomical observations, etc.). The artificial light which is directly emitted toward the sky (or reflected ground or building) is scattered in all direction by the tiny air molecules and aerosols (solid or liquid particles) in the Earth's atmosphere, increases the night sky brightness above the natural background light, and thereby impeding the observation of many stars to be seen in the sky. Most young people don't know what the night sky actually looks like, and they are unable to see the stars that can be seen so well in a rural area [1,2]. Night-sky brightness can be used as an environmental assessment indicator for astronomical observations to project the condition of light pollution on a location, such as the magnitude of the dimmest star visible with the naked eyes depends on the level of light pollution [3].

The best methods to reduce the light pollution problem include: i. Evaluating and improving existing lighting plans, using appropriate fixtures and lamps, and design for lighting efficiency, so that most of the light is more accurately towards where it is needed and not to where it is unwanted (Figure 1). ii. Utilizing light sources of minimum intensity required to achieve the light's purpose. iii. Turning off unnecessary light using a timer or occupancy sensor or manually when not needed. iv. Adjusting the type of lights used, so that the light waves emitted are those that are less likely to cause severe light pollution problems [1,2,4].

There are different tools and techniques for measuring the night sky quality. Unihedron SQM (Sky Quality Meter- Clear Sky Detector) a small and easy-to-use tool, is used to measures the brightness of the night-sky in unit of magnitudes per square arcsecond, in a particular direction and monitor sky brightness through the night, night-to-night, and year-to-year [5]. In this study, we present night sky brightness measurements performed at 37 points, at the Ataturk University Astrophysics Research Telescope (ATA50) and the surrounding area (Erzurum, Turkey) by using SQM device during the new moon phase (when it appears dark at night) and during a full moon (when it appears bright at night).

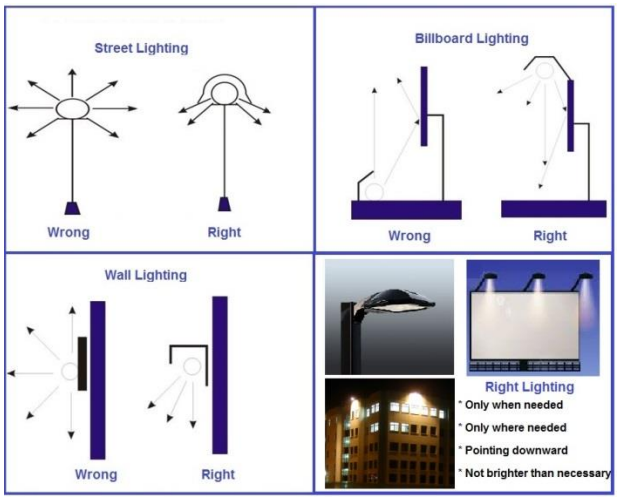

Figure 1. Examples for right and wrong direction for light fixtures [1].

2. Measurements and Results

The best observation time in space-related research is the 'late night' time interval which is between dusk and morning darkness, during the new moon phase. The light pollution which is product of over illumination of the night sky, causes skyglow and reduces the clarity of the sky which are adverse effects for observation and the observation period of stars and other celestial bodies. These effects reduce the signal/noise ratio (S/N) of the celestial bodies during the observation. Therefore, the signal received from a dim object will disappear in the noise and prevents performing high quality observations during the night.

In this study, we performed night sky brightness measurements around the ATA50 telescope at the Ataturk University Campus in 37 different points (marked on the map in Figure 3), in 5 separate directions (45^{o} above the horizon in the North, South, East, West sides, and at the Zenith point, 90^{o} above the horizon). The measurements were performed during the new moon phase (dark night) and full moon phase (bright night) at 23:00-24:00 (total 8 nights). During the measurement the precipitation and cloudiness rate is taken into account (completely clear sky with humidity level about 40%-60%).

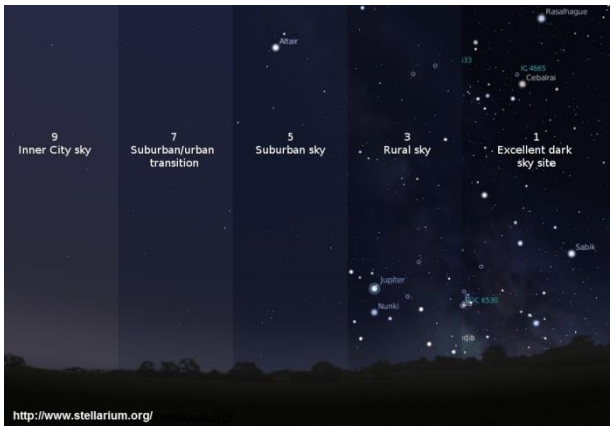

Figure 2. Comparative sky brightness at different sites at different levels of light pollution [7].

Figure 3. The distribution of night sky-brightness values at Ataturk University campus. The measured points are colored according to level of sky-brightness based on Table 2. The results were obtained from an average of measurements taken from four different nights.

The BMPAS values (magnitude /arcsec^{2}, Brightness in Magnitudes per Square Arcsecond, produced by the SQM) were converted to the NELM (Magnitude, Naked Eye Limiting Magnitude) values visible magnitude to the naked eyes [8]. This conversion is obtained by the Eqs. (1). Our results are shown in the Table 1 and Table 2.

$$NELM = 7{,}93 - 5\log\left(10^{\left(4{,}316-\left(\frac{BMPAS}{5}\right)\right)}+1\right) \quad (1)$$

During the measurements, in some points the BMPAS values changed with time due to installation of new light source or some surrounding lighting was switched on/off. The sky brightness around ATA50 Telescope is a little brighter than in countryside, because of its closeness to the city center. Here the naked eye limiting magnitude values are vary between 3-5 magnitudes. To perform efficient and high quality observations we should reduce the light pollution by shielding and improving outdoor lighting fixtures close the telescope and by lighting only what is actually needed, when and where it is needed. Prevention of light pollution provide the conservation of energy and natural resources, reducing lighting costs, improving safety of night and protecting the beauty of nature and sky.

Table 1. The values of the night sky-brightness in different directions at same point close to ATA50 telescope (Figure 1). The measurements were performed during the new moon phase at 24:00 in different 8 nights.

Sky brightness in different directions at a point close to ATA50 Telescope						
	Date	North	East	South	West	Zenith
BMPAS: magnitude /arcsec², produced by the SQM)						
New Moon Dark Night	27.08.2014	18.45	17.82	17.98	18.50	18.70
	27.09.2014	19.32	19.08	19.08	19.26	19.26
	22.10.2014	18.55	18.60	18.46	18.83	18.68
	25.12.2014	18.37	17.97	18.44	18.62	18.93
Full Moon Bright Night	14.07.2014	18.19	17.43	16.99	18.39	18.41
	09.08.2014	17.93	17.51	14.34	17.74	17.75
	10.09.2014	18.06	14.30	17.33	18.17	17.70
	05.11.2014	18.01	17.80	16.41	18.48	18.12
NELM: Naked Eye Limiting Magnitude						
New Moon Dark Night	27.08.2014	4.34	3.82	3.95	4.38	4.54
	27.09.2014	5.01	4.83	4.83	4.97	4.97
	22.10.2014	4.42	4.46	4.35	4.64	4.52
	25.12.2014	4.27	3.94	4.33	4.48	4.72
Full Moon Bright Night	14.07.2014	4.13	3.48	3.09	4.29	4.31
	09.08.2014	3.91	3.55	0.61	3.75	3.76
	10.09.2014	4.02	0.58	3.39	4.11	3.71
	05.11.2014	3.98	3.80	2.57	4.36	4.07

Table 2. The average of the sky-brightness values measured at the Ataturk University campus in 37 points (4 nights) during the new Moon phase. The brightness range of these points are divided into 6 step (2.5-5.5 magnitude) and marked with colors as shown in Figure 1.

Sky-brightness Values of 37 Points at Ataturk University Campus					
Points	BMPAS	NELM	Points	BMPAS	NELM
1	17.84	3.83	24	18.68	4.53
2	17.96	3.93	25	18.39	4.29
3	18.03	4.00	26	16.75	2.88
4	17.15	3.23	27	18.21	4.14
5	17.90	3.88	28	16.81	2.93
6	19.51	5.15	29	18.43	4.32
7	19.43	5.09	30	16.79	2.91
8	19.43	5.10	31	19.08	4.84
9	19.36	5.04	32	18.96	4.74
10	19.21	4.93	33	18.93	4.72
11	17.23	3.30	34	18.91	4.70
12	17.04	3.14	35	18.88	4.68
13	16.90	3.01	36	18.87	4.67
14	18.13	4.08	37	18.85	4.66
15	16.66	2.79			
16	16.83	2.95		The values in Fig. 1	
17	18.94	4.72		NELM (Magnitude)	
18	19.04	4.80		2.5-3.0	
19	19.35	5.04		3.0-3.5	
20	18.67	4.52		3.5-4.0	
21	19.03	4.79		4.0-4.5	
22	19.48	5.13		4.5-5.0	
23	18.87	4.67		5.0-5.5	

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