

The measurement of light pollution of the night sky near the city of Sulęcín



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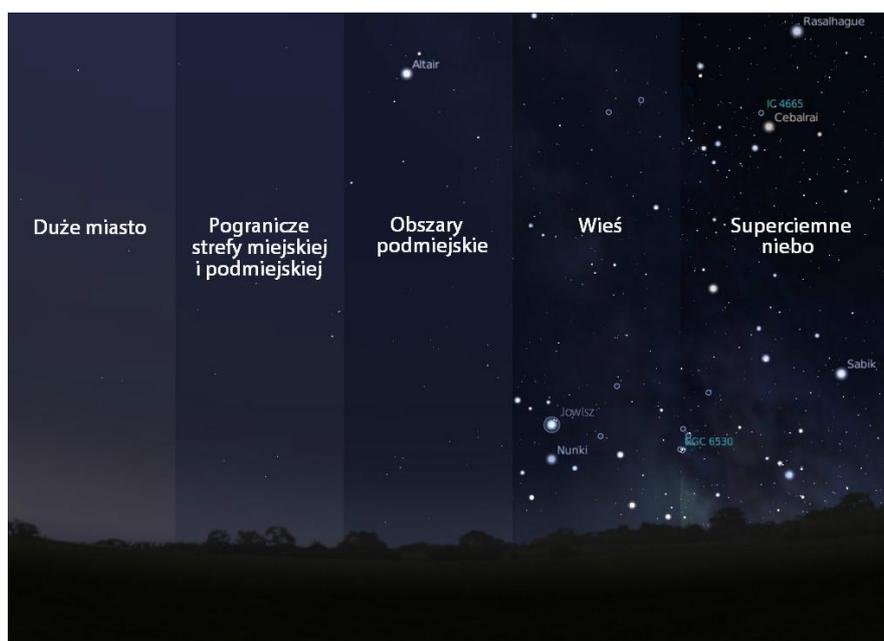
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1. Light pollution

At the beginning we should get familiar with the term of light pollution. It is a disorder of the night environment by anthropogenic sources, another way- external light. About 150 years ago, people could leave the house and see the sky with thousands of stars of the Milky Way. Today they cannot. It is completely different. During watching the sky in urban areas they can only see the brightest stars and the Moon. The cause of the disappearance of the stars and other celestial bodies is *light pollution*.



Picture 1. Visibility of stars depending on lighting.

<http://www.twojapogoda.pl/wiadomosci/107331,sprawdz-jakie-widzisz-niebo>

2. Categories of risks and the impact of light pollution

a. Categories of risks:

- increasing brightness of the dark sky.
- degradation of the image of the sky in the public consciousness.
- Disturbance of the natural cycle of diurnal fauna and flora.
- The decrease in road safety.
- Pollution and financial loss.

b. Impact of light pollution:

- On astronomy
- On ecology
- On the economy
- On security
- On health

3. Measurements of the brightness of the night sky by SQM-L metre.

Measurements have been done by SQM-L metre numer 8449, hired from the Astronomical Institute of the University of Wrocław. The measured Surface brightness is given in the mag/arcsec². It is a magnitude unit, converted into a second arc square. Categories of risks and the impact of light pollution.

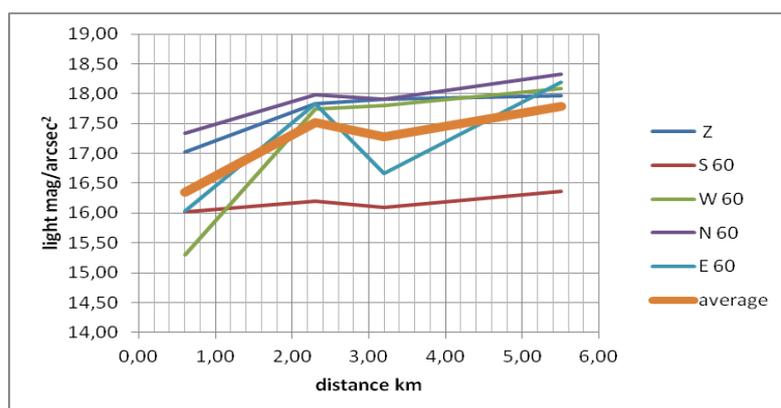
Due to limited size of work, the results of my measurements I added at the end in the form of attachments. The names of places of observation are „contractual” and their coordinates are given in the reports. Information about the degree of pollution comes from the mobile stations monitoring air pollution in Sulęcín. - http://80.53.180.198/dane_pomiarowe/automatyczne/stacja/6/parametry/wszystkie.

4. Analysis of obtained results:

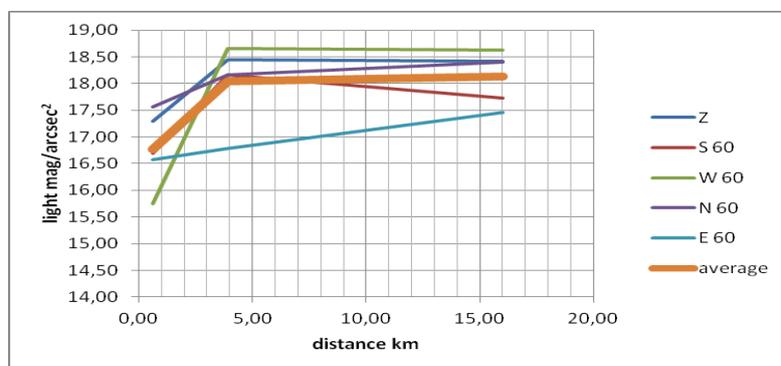
a) Depending on the distance from Sulęcín

For this analysis there were used reports measurements made at three different routes:

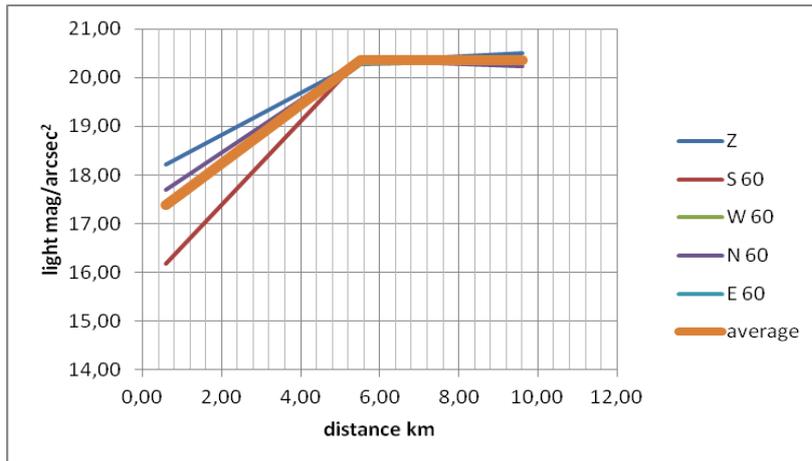
Sulęcín, Brzezno, Zubrow (attachment 1, raport 3 – full moon)



Sulęcín, Długoszyn, Krzeszyce (attachment 1, raport 4 – full moon)



Sulecin, Zubrów, Miechow (attachment 1, raport 6 – no moon)



On the basis of these statements it can be said that the further away from the town of Sulecin the level of light pollution drops significantly (the meter grows). I have observed the decrease of different conditions (the full moon, and the absence of moon) It can be observed that above about 4 km from Sulecin, brightness is maintained more or less at the same level. The town of Sulecin is basically the only source of unwanted night light in our neighborhood. On the road Sulecin, Długoszyn, Krzeszyce the measurement was completed within about 5 km in front of Krzeszyce, since further was visible glow of light coming from this town.

In addition to road Sulecin, Brzezno, Zubrow you can clearly see a greater brightness of the sky in the direction of south. There was a Moon.

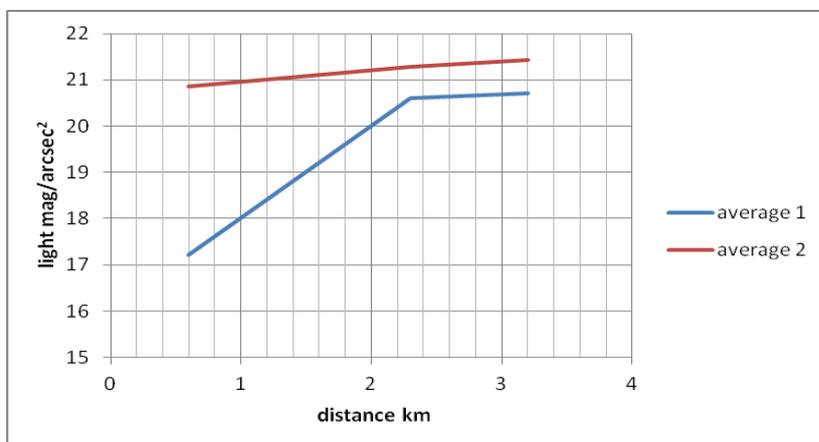
Striking is also the fact of „strange” read the meter in Brzezno for the East.- Indication of the extremely low- big light pollution.

The only explanation that comes to mind is a little careful reading of the geographical directions of the compass. (The mistake resulted that greater brightness was turned more towards the east) - The full moon was located in the south and probably the reader of the meter turned around overmuch the South. Nearby there are no light sources.

a) Depending on the presence of snow

For this analysis, we used the measurement reports made in :

- 1 – the presence of snow cover and lack of Moon
- 2 – lack of cover snowing and the absence of the Moon



At a time when we had a measure we also have manager to measure the brightness in the presence of snow cover. Based on the analysis of the presented data we can clearly see the difference in the results especially in the town. On the outskirts of Sulęcín the brightness of the order of 16-18 mag/arcsec², and outside the city 20,75-21,75 mag/arcsec². It is connected with the fact that the Surface of the earth is covered with snow, the more light the streetlights reflected up into the sky, it increase the brightness. Outside the town there are no light sources, within of 2 km from Sulęcín there is no snow visible.

Depending on the degree of dustiness

For this analysis, we used the measurements reports made:

- 1 - visible smoke, particulate matter PM10 - 130 $\mu\text{g}/\text{m}^3$
- 2 – particulate matter 35 $\mu\text{g}/\text{m}^3$



Analyzing the results it can be stated that the degree of dust particulate matter PM10 has a important influence on the conditions for astronomical observations. The transparency of the air depends on the amount of dust and aerosols. The more transparent air the less is to dispersed in the light and that's why the brightness of the sky is smaller. Especially this is visible on the site of the town, but just 2 km above the impact is less visible. In the area of Sulęcín are no major industrial plants, so dustiness is a result of smoking in furnaces households and in boiler room, because with the distance simply decreases.

a) depending on the visibility of the Moon

For this analysis were reports measurements made:

- 1-the Moon invisible
- 2-the Moon visible – 97%

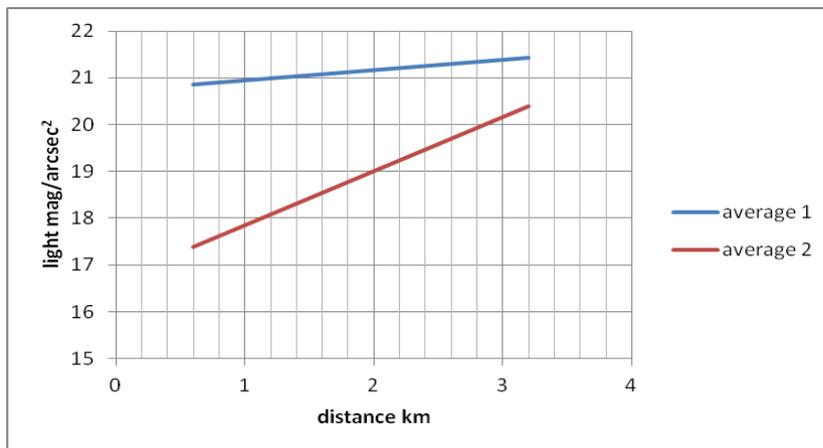


When analyzing the measurements it can be stated clearly influence the presence of the Moon on the results lighting sky. The presence of the Moon can increase the brightness of the sky even dozens of times. It's hard to be surprised since the full moon has a brightness-12.7 mag, and, for comparison, the sun -26.7 mag. This difference is very visible. Our reports show that for the full moon average brightness of the sky is about **17 mag/arcsec²**, and for the sky without the presence of the Moon about **21 mag/arcsec²**. This is about 40-times difference in brightness. The improvement of the dark sky with distance dues from the fact the distance from the source of light pollution-that is the city.

d) depending on the degree of cloudiness

For this analysis, reports the measurements made were used:

- 1- cloudiness 0%
- 2- cloudiness 60%



On the basis of the analysis of the results we can conclude that the cloud cover also has a significant impact on the status of the light pollution of the night sky. The light source is in this case, the light pollution associated with light reflected from clouds and from the not too distant city.

Therefore a large difference in brightness on the outskirts of Sulęcín and less 3 km away

5. Compare the results with other methods of measurement

To compare of our results with other methods of measurement, we will use the results obtained in the absence of the Moon, no shade, small dust and a lack of snow cover. The average surface brightness for such conditions recorded during our measurements is **18,90 mag/arcsec²** for outskirts of Sulęcín **21,05 mag/arcsec²** for our permanent place of observation for example swimming pools, and keeps it together with increases in the directions of Brzeźno and Żubrów. The average takes refers to the zenith and all directions.

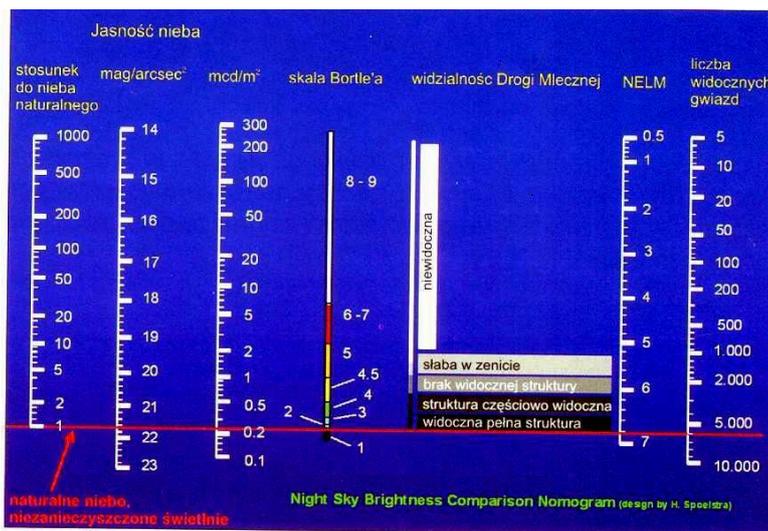
These results we will try to compare with other methods.

In the school year 2012\13 students of our school have participated in action counting stars through the tube. The results presented in the appendix. 2 and 3 have been sent to the Astronomical Institute of the University of Wrocław. The average number of stars visible from the area of Sulęcína is approximately 1014. The number of stars visible from places outside of Sulęcín is about 1370. This result was obtained after the rejection of two extreme, unreliable amounts marked in red on the report. The result of the lowest (600) received was in Długoszyn by the observer, who did not

have eyes adapted to the darkness, while the highest (over 4000) in Ownice by an officious observer, which had counted the star only in the area of the sky where there were many, and not in random directions in accordance with the instructions in the method using.

It means this that the result obtained SQML meter- **18,90 mag/arcsec²** would correspond to the amount of 1014 stars accrued method by tube. And for places outside the city **21,05 mag/arcsec²** and about 1400 stars.

Comparison of brightness with SQM with the number of stars is difficult and fraught with a lot of uncertainty. The following nomograph (published in number 6 Urania Progress of astronomy) need to be thought of as that allows only rough comparison, not suited to accurate conversion results obtained with different methods.



Picture 2. A comparison of the night sky brightness nomogram-Urania. Progress Of Astronomy 6/2015

The result of the brightness between **20,36 – 21,43 mag/arcsec²** should correspond to the 4 or 5 class of the night sky by Bortle scale, that is, in principle, the rural sky passing into the suburban. This is confirmed by our observations. By observing the sky during our measurements we saw the glow of light from Sulęcín, or Krzeszyce. Appearing clouds near these glow it was quite clearly illuminated. The milky way was visible at its zenith, near the horizon a bit worse. These conditions correspond to just the sky from rural in the suburban.

The brightness of our night sky also corresponds to 3 or 4 level on a scale of Berry. The milky way low on the horizon is poorly visible or not visible, the clouds are gray at its zenith while clear on the horizon.

During the observation we estimated the brightness of the sky based on the visibility of stars near the constellation Ursa minor.

to the results in the V.

$$\text{Brightness in filter V} = \text{brightness SQM} - 0.17 \text{ mag/arcsec}^2$$

(the error of this conversion to $\pm 0.07 \text{ mag/arcsec}^2$)

In the Atlas of these places have clarity: Jaško Sulęcín i Baseny 20.91-21.25 mag/arcsec², Brzeźno 21.25-21.51 mag/arcsec².

If we accept for the average of the value of Jaško Sulęcín and Pools and for Brzeźno value less (it lies on the border of two areas) we have: **21,08 mag/arcsec²**; **21,08 mag/arcsec²**; **21,25 mag/arcsec²**.

To convert them to the result os SQM the add 0. 17 them we receive: **21,25 mag/arcsec²**; **21,25 mag/arcsec²**; **21,42 mag/arcsec²**.

After the calculation of the standard deviation of the mean (average) and the average error of the average and the Administration as a result of his taking into account we obtain the following ranges of brightness:

- for Jaško from **(20,47 – 20,55) mag/arcsec²**, from Atlas **21,25 mag/arcsec²**
- for Pools from **(20,94 – 21,08) mag/arcsec²**, from Atlas **21,25 mag/arcsec²**
- for Brzeźno from **(21,04– 21,26) mag/arcsec²**, from Atlas **21.42mag/arcsec²**

Jaško	1	2	3	4	5	Śr	σ	\bar{S}_x	Min	Max
Zenit Z	20,28	20.67	20,69	20.71	20,57	20,51	0,0889	0,040	20,474	20,553
Baseny	1	2	3	4	5	Śr	σ	\bar{S}_x	Min	Max
Zenit Z	20,78	21.06	21,14	21,07	21,05	21,01	0,1581	0,071	20,939	21,081
Brzeźno	1	2	3	4	5	Śr	σ	\bar{S}_x	Min	Max
Zenit Z	20,82	21.32	21,41	21,16	21,21	21,15	0,2451	0,110	21,040	21,260

Pic. 6. Calculations the standard deviation of the mean value at the zenith for 1 report.

In the table above, the first measurement for each of the sites is clearly less than the other four. We were thinking of the cause, we considered whether or not it is a problem of instrumental. To check if the SQM meter does not require "warm up" of electronics for a stable result we have several measurements by breaks consecutive minutes. It turned out, however, that the first result in each series does not deviate from the other. Unfortunately we are not able to explain the situation.

With this statement, it appears that both the town itself Sulęcína and places concerned our result differs from the result recorded in the Atlas 10 years ago. Values read by the US are smaller (more pollution), but similar to the value marked on the map.

Since the creation of the maps to this day have passed 10 years. During this time, an increase in the number of street lights in sulęcín, and in a westerly direction from the center of a new settlement houses, which is an additional source of light. And it has to grow into pollution observed in our work.