Attachment 2b

Tomasz Ściężor
Institute of Water Supply and Environmental Engineering
Faculty of Environmental Engineering
Cracow University of Technology
ul. Warszawska 24, 31-155 Kraków,
sciezor@vistula.pk.edu.pl

SUMMARY OF PROFESSIONAL ACCOMPLISHMENTS

1. Full name

Tomasz Jan Ściężor

2. Academic diplomas and degrees

1988 **M. Sc. In Physics**
Jagiellonian University, Faculty of Mathematics and Physics
Master's thesis entitled: „*Investigation of kinetics of phase transformations in the Cu25%-Mn alloy*" (in Polish). Supervisor: dr hab. Jacek Sołtys

1995 **Ph. D. in Materials Engineering**
AGH University of Science and Technology, Faculty of Materials Science and Metallurgy. Ph.D. dissertation: „*The influence of granularity on the magnetic properties of high-temperature superconductors*" (in Polish). Supervisor: prof. dr hab. Andrzej Kołodziejczyk; reviewers: prof. dr hab. Karol Krop, prof. dr hab. Andrzej Stokłosa, dr hab. inż. Jan Kusiński, prof. AGH.

3. Information on employment in scientific institutions

1988-1989: **Assistant trainee** at the Department of Solid State Physics, Faculty of Materials Science and Metallurgy, AGH University of Science and Technology in Cracow

1996-now: **Adjunct** in the Department of Water Supply, Sewage and Environmental Monitoring, Institute of Water Supply and Environmental Protection, Cracow University of Technology.

4. Wskazanie osiągnięcia wynikającego z art. 16 ust. 2 ustawy z dnia 14 marca 2003 o stopniach naukowych i tytule naukowym oraz o stopniach i tytule w zakresie sztuki (Dz. U. nr 65. poz. 595 ze zm.)

4.1. Scientific accomplishment according to article 16 section 2 of the Act of 14thMarch 2003 on Academic Degrees, Academic Title and Degrees and Title in Arts (Dz. U. nr 65, p. 595, as amended)

Natural and anthropogenic factors of the night sky glow (in Polish)

The basis for the habilitation application is a monograph, which is the effect of a long-term research of light pollution. The results of this research are also publications, compiled in the section 6.1 of this summary.

4.2. Author, title of publication, year, publisher, reviewers

Tomasz Ściężor Naturalne i antropogeniczne czynniki łuny świetlnej nocnego nieba. Monografia nr 448: Wydawnictwo Politechniki Krakowskiej, Seria Inżynieria Środowiska, ss. 202, Kraków 2018,
ISBN 978-83-7242-986-5

Reviewers: prof. dr hab. Jerzy M. Kreiner, prof. dr hab. Janina Trepińska

4.3. Discussing the scientific purpose of the monograph and the results achieved, and discussing their possible use

4.3.1. Introduction

The negative human impact on the natural environment is manifested not only in the widely known and widely described phenomena of pollution with combustion products or industrial emissions, but also in the emission of electromagnetic waves in a wide range of the spectrum, interfering with the natural electromagnetic background. The harmfulness of some types of electromagnetic radiation has been known for a long time (e.g. X-rays), others have been known relatively recently (microwave radiation) or are just being investigated (radio waves). However, there is a range of electromagnetic radiation, the harmfulness of which is virtually unnoticed. It is visible light in the range from infrared to ultraviolet. This type of environmental pollution is called *light pollution*.

The negative impact of light on living organisms was noticed as early as in the 19th century, but only in the mid-20th century the concept of photopollution was introduced. At the same time astronomers noticed the negative impact of artificial lighting on the environment, introducing the concept of light pollution. At the end of the 20th century several organizations were set up in the world whose aim was to counteract the uncontrolled growth of this type of pollution, and this problem was also highlighted by the UNESCO.

Four types of light pollution can be distinguished:

- artificial skyglow caused by the scattering of artificial light in the atmosphere. It is often incorrectly identified with the so-called *astronomical light pollution*
- *light tresspass*, when the unwanted light illuminates someone else's property,
- *over-illumination* consisting of using disproportionately strong lighting in relation to the needs
- dazzling, when one (*glare*) or multiple (*clutter*) light sources produces excessive contrast between the lit and shaded areas in the field of view.

Among the mentioned types of light pollution, the least researched is the artificial illumination of the night sky, referred to in my monograph as a light glow. It is also the most common component of light pollution. It involves the glowing of the night sky as a result of scattering of an artificial ground lighting in the atmosphere. It is this element of light pollution, which has the strongest influence on the urban (or other settlements) surroundings which are sources of this pollution. It occurs in particular even in areas that are protected from other direct components of light pollution.

The interested in this type of light pollution are first of all astronomers, because it greatly disrupts visual observations both in the cities and in their surroundings. However, the impact of artificial night sky glow on local ecosystems is poorly researched. The widespread use of street and squares lighting, even in small towns and especially in tourist destinations, means that in areas of dense population this phenomenon occurs not only in the vicinity of

large urban centers. This is a problem even for astronomical observatories or nature reserves located in isolated places.

Described problem was discussed in the world literature most often in terms of modelling the propagation of artificial light in the atmosphere. Regardless of the modelling, various measurements of this pollution were also carried out. Due to the fact that the problem was first of all interested in astronomers, almost all publications and studies were devoted to the case of cloudless sky. Only the appearance of the relatively cheap night sky brightness meters (Sky Quality Meters - SQM) at the beginning of the 21st century allow to research also the light pollution of the overcast sky. The first such measurements were carried out in parallel in Poland and Germany.

4.3.2. Objectives of the study

The monograph *Natural and anthropogenic factors of the night sky glow* constitute **my contribution** to the environmental engineering in the field of protection against light pollution. The basic scientific goal of the monograph is to show the relationship between the state of the atmosphere, represented by a number of meteorological parameters, and the brightness of the night sky glow. The shown dependences will allow, among others, for optimization of lighting design both on a local and a global scale. **The utilitarian aim** of monograph is also to demonstrate that this type of light pollution affects not only astronomical observations, but also the state of selected ecosystems and the changes in the natural environment. Consideration of this relationship will allow a proper lighting design both in the vicinity of astronomical observatories, also near and within a protected areas, as well as in the vicinity of a water supply reservoirs.

It should be emphasized that in the presented monograph I introduce an additional element of environmental engineering, not taken into account in Poland, which is the science of protection against light pollution.

4.3.3. Discussion of results

In the current literature devoted to the problem of light pollution, a clear division between the papers related to the astronomical aspect of the problem and the natural or ecological one was noticeable. The same phenomenon was one-sided researched and analysed, depending on the interests of researchers. The concept of the night sky glow was most often associated only directly with the scattered artificial light coming from ground sources. As a result, many, often false, ideas or even myths about artificial light pollution appeared, as well as about the natural night sky glow. In addition, authors of the papers often present only models of light pollution, with their limited verification.

During many years of research on this phenomenon, it became clear to me that the artificial sky glow, which is the effect of scattering of artificial light in the atmosphere, is only one of many factors, both independent and interconnected, resulting in the brightening of the night sky. It turned out that the sky glow includes not only the anthropogenic factors, often called light pollution, but also the natural ones. The contribution of one or the other in the brightening of the night sky depends on many parameters, in particular on the

location of the research site. Moreover, some anthropogenic factors, such as particulate matter, change also the brightness of the natural sky glow. This means that the phenomenon of the sky glow should be treated as a whole, considering each of the potential factors causing it, both separately and in combination with other, often seemingly unrelated factors.

Certainly, the presented work is **the first in Polish** trying to describe in a comprehensive way the problem of the night sky glow. It is also probably **the first in the world literature**, in such a wide range describing this problem. The presented comprehensive description will allow the development of proper ground lighting systems, minimally interfering with the natural environment, while maintaining optimal lighting efficiency.

In the presented monograph I clarified the terminology of the problem. So far in Polish literature there were several terms describing the artificial lighting of the night sky. It was often a simple translation from English, but it did not convey the character of the phenomenon in Polish. I believe that the concept of **łuna niebieska** (eng. sky glow) I have introduced in Polish, also referred to as the **łuna świetlna nocnego nieba** (eng. night sky glow), best reflects the character of the phenomenon and will permanently enter Polish scientific terminology.

The main purpose of this monograph is to link the state of the atmosphere, determined by a series of meteorological parameters, with the brightness of the night sky. For this purpose I used the database of continuous measurements of the night sky brightness, carried out since 2014 at the three light pollution monitoring stations, including two designed by me: at the Mt. Suhora Astronomical Observatory of the Pedagogical University in Cracow (SUH) and at the water intake of the Municipal Water and Sewage Company in Cracow located in Dobczyce (DOB). The third station is located at the "Fort Skała" Astronomical Observatory of the Jagiellonian University in Cracow (FSK). In addition, I used the database of the night sky brightness measurements made by my research group using the mobile SQM meters. In the case of the SUH and FSK stations, I also used the in-situ measurements of meteorological parameters. In the case of DOB stations these data were provided by the Institute of Geography and Spatial Management of the Jagiellonian University. For the first two stations I also had continuous colour photographs of the whole visible hemisphere of the night sky, which allowed me to visualize its state. I made my own script in the MATLAB language, which allows me to measure the relative brightness of the night sky in any cross-section of such a photo. These so-called **photometric sections of the sky**, used for **the first time** for the research of light pollution, allow to determine the distribution of the brightness of the celestial sphere, which is especially helpful in identifying the main sources of light pollution (Fig.1). In 2012, I also established an additional measurement station in Zabierzów near Cracow (ZAB) where apart from sky brightness also the horizontal visibility, air temperature and the size and type of cloudiness are have been recorded.

In order to combine the brightness of the sky glow with the state of the atmosphere, first of all I described the ways of scattering of light in the

atmosphere. **I have defined the primary and secondary sources of light** in the atmosphere. I included all the extra-atmospheric sources (the Moon, planets, stars), the airglow and the northern lights, as well as the artificial ground lighting. The second group includes the atmospheric phenomena scattering the light of the above-defined primary sources (e.g. clouds, aerosols, particulate matter). This division, the first of its kind in the world literature, allowed to research the impact of each of these sources on the brightness of the night sky glow.

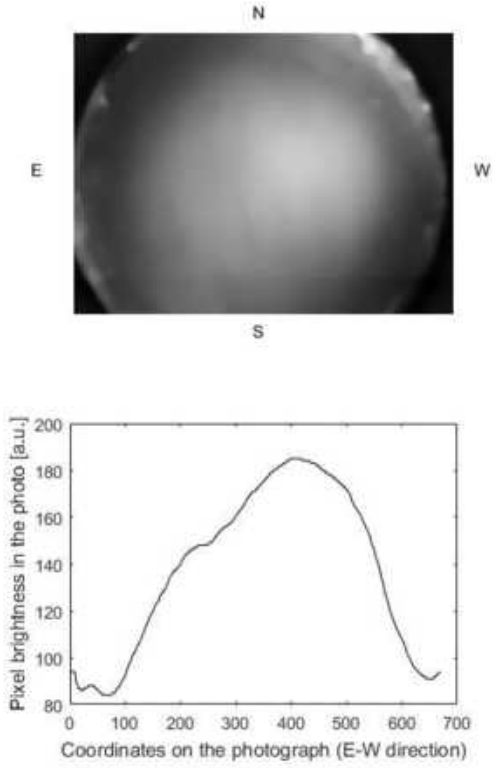


Fig. 1 The photograph of the night sky at the BLU measuring position (Lutowiska in Bieszczady Mountains) and its photometric section

Of course, I confirmed the already known fact that the main source of natural light at night is the Moon. I have found, however, **what has not been taken into account so far**, that it is not only a strong source of primary light, but also a source of secondary light, scattered by various types of atmospheric aerosols, including particular matter from the combustion of solid fuels. It means that **the Moon indirectly also contributes to the anthropogenic brightening of the night sky**, becoming a source of unnatural brightening of the sky even in areas where there is no ground sources of artificial light, but in which there is an increased concentration of this type of aerosols. As a result, when designing industrial plants or other sources of particulate matter, the possibility of light pollution in nearby protected areas should be taken into account, especially if night ecosystems are protected there.

I also described the other natural sources of light, such as the Milky Way, zodiacal light or airglow. **For the first time in literature** I have considered the influence of aurora luminosity in latitudes of Poland on the brightness of the night sky.

In the case of secondary light sources I paid particular attention to atmospheric aerosols, especially in dusts of both natural origin (desert dusts or volcanic dusts) and anthropogenic dust (particular matter). For the first time I noticed the brightening of the night sky associated with the scattering of light (of both natural and artificial origin) on the Sahara desert dust. In particular in this way I explained a strong increase in the brightness of the night sky in the British Isles observed sometimes in the spring period, which can be related to the atmospheric circulation directing large amounts of dust from the Sahara desert over that period. Similarly, I have shown a significant effect of strong volcanic explosions on the brightness of the night sky.

One of the most important result presented in the monograph is **showing a strong correlation** between the brightness of the cloudless night sky and the concentration of the particulate matter of anthropogenic origin (Fig.2).

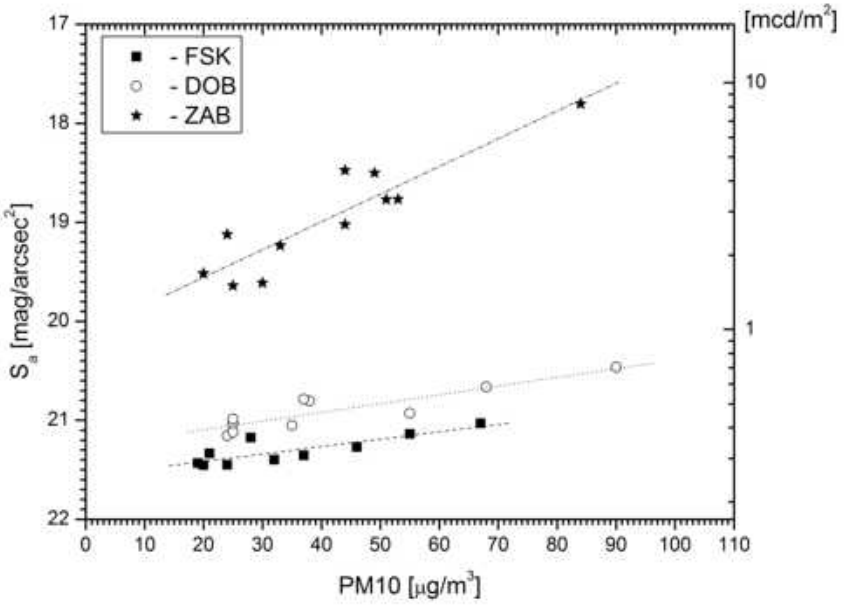


Fig. 2. The brightness of the cloudless night sky vs. the concentrations of PM10 at FSK (Cracow), DOB (Dobczyce) and ZAB (Zabierzow) measuring stations.

This correlation was noticed by me earlier and published in the previous monograph[1]. Now it is fully confirmed as a result of systematic research. The analysis of parameters of this correlation for a given area **allows to determine**

[1] Ściężor T., Kubala M., Kaszowski W., Dworak T.Z., *Zanieczyszczenie świetlne nocnego nieba w obszarze aglomeracji krakowskiej. Analiza pomiarów sztucznej poświaty niebieskiej*, Monografia 388, Politechnika Krakowska, Kraków 2010

the concentration of particulate matter (especially PM10 type) on the basis of measurements or estimations of the night sky brightness. Considering the level of air pollution in Poland (especially in Silesia and in Małopolska) with particulate matter coming from low emission (especially in the winter season - the so-called popular *smog*), my research allows to easily determine the level of this pollution without the need for specialized measurement equipment, e.g. based on astronomical observations, using the so-called cometary method, developed by me. It allows to significantly extend the scope of research, both spatially and temporally, limited so far to only a few places in Poland and only up to the last few years. Determining the concentration of particulate matter in the atmosphere is extremely important in the design of heating systems or industry and in the analysis of the its impact for the natural environment on a given area. **For the first time I introduced the astronomical observations, including amateur ones, to the methodology of scientific research in environmental engineering.**

I also described the preliminary results of the analysis of the vertical distribution of particulate matter in the atmosphere, determined by a SODAR measurements, and it's importance for the brightness of the night sky glow. This research was in cooperation with the Cracow Branch of the Institute of Meteorology and Water Management, the National Research Institute (IMGW). I found that the scattering of light at night in a rural conditions (SUH) probably occurs on dusts suspended in the atmosphere residual layer (RL), coming from even distant, high emitters. In the case of urban sites (FSK and DOB), predominant is the scattering on near-surface dust originating from local low emission, concentrating in the nocturnal stable layer (SBL). These research will be continued.

In the monograph I made a detailed analysis of all available meteorological parameters in 2014-2016 at the measuring stations. An important result of the research, presented in the monograph, is to show the **strong impact of clouds** (including haze and fog) on the brightness of the night sky. I have shown that in the presence of ground sources of light pollution, the clouds become the **brightest component of the night sky glow**. The lighting of the ground in the city by the light scattered on the clouds often exceeds the lighting from the full moon. Considering a domination of cloudy nights in Poland, and particularly in Małopolska, this phenomenon should be considered as strongly affecting local ecosystems. This means that when designing lighting systems in a given area, the most frequent cloudiness should be taken into account.

I showed that the brightness of the night sky changes linearly with increasing cloudiness. I believe that an **important scientific achievement** of practical importance is the demonstration that the **basic indicator of the level of light pollution is the directional coefficient of this relationship**, designated as CLS (Fig.3). On this basis, I distinguished three groups of light polluted areas in Poland: the first covering mountain areas in which CLS accepts values close to zero, the second covering both large cities and small towns where CLS equals approx. -0.016, and the third, which includes suburban areas of large urban centres, where CLS reaches approx. -0,022

(the only area completely free of light pollution is the southern Bieszczady Mountains - only there CLS>0 which means that with the increase of cloudiness the brightness of the sky decreases). The analysis showed that the dominance for the brightness of the night sky is not the size of population, as given in the literature, but the **density of population** (Fig. 4). I believe that this is one of the most important finding described in the monograph, allowing in particular to determine the dependence between the light pollution environmental hazard and the type and degree of urbanization of the area. In the aspect of possible ecological impact of light pollution on the quality of drinking water, this observation may be helpful in designing residential buildings near an open water intakes or the other types of protected areas. Distributed buildings should dominate in these areas.

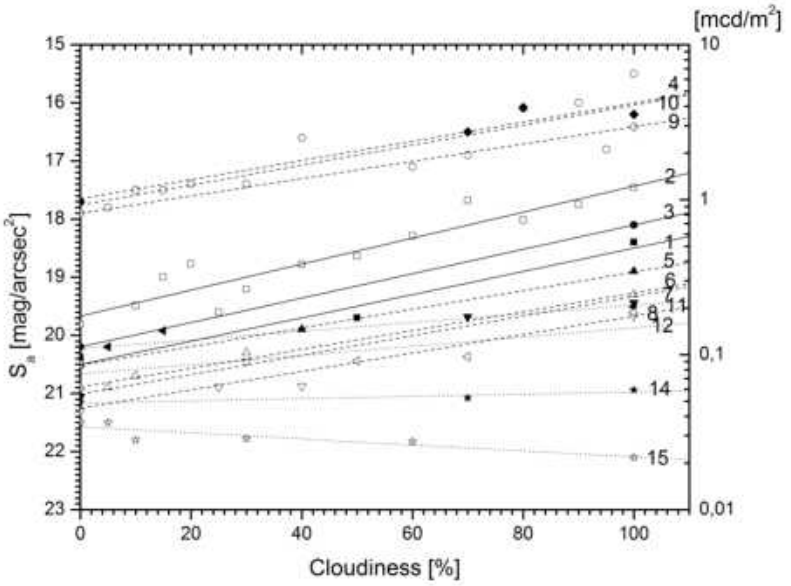


Fig. 3. Impact of the cloudiness on the brightness of the night sky in various areas. Continuous lines: localities situated near the large urban centres; dashed lines: big cities and "isolated" towns surrounded by areas with less light pollution; dotted lines: areas with low population density. The numbers specify specific measurement points, described in the monograph.

I found that each of the researched environments is characterized by a specific distribution of night brightness during the year. These observation has enabled the development of an **innovative method for determining the level of light pollution** based on histograms of all nights, moonless nights and cloudless nights at a given measurement point. This method can be used even in an absence of meteorological data or photos of the night sky. I confirmed the correctness of this method by developing the measurements data made with the help of mobile meters for the previous monograph. Of course, as expected, the lowest light pollution was found at the mountain position of SUH, and the highest for the urban FSK position. I also showed the preliminary results of research conducted at the measurement points located in the Bieszczady Mountains, but an exceptionally large database requires a careful analysis and its results will be published in the future.

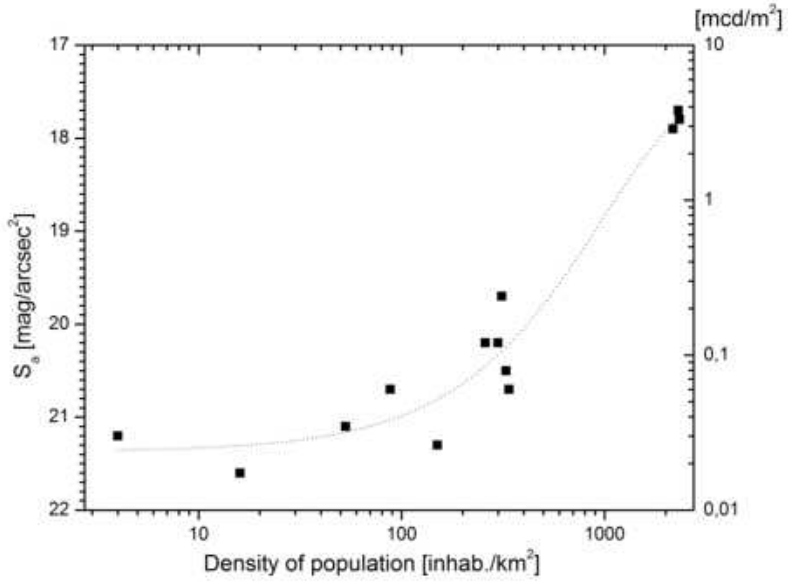


Fig. 4. The brightness of the night cloudless sky vs. the density of population

Because I did not have photographs of the night sky for all measurement nights, which could allow me to determine the state of the atmosphere, I developed the **innovative analytical method**, allowing the definite distinction between a clouded sky and a cloudless one only on the basis of a continuous, all-night measurement of the sky brightness. With less probability, this method also allows to determine the type of cloudiness, in particular to distinguish high clouds from the low- and medium clouds.

In order to determine the impact of the type of clouds on the brightness of the night sky I used the measurements made at the ZAB station and, to a lesser extent, on the other measuring stations. In the case of ZAB stations, for each measurement night a trained observer specified a detailed type of clouds. In the case of SUH and FSK stations, the type of clouds was determined visually on the base of the night all-sky photos, which, however, did not always allow to determine the exact one. Also helpful was the previously mentioned analytical method for determining the type of clouds based on all-night continuous measurements of the night sky brightness. These analyses allowed me to examine the impact of the cloud type on the brightness of the sky glow. **I think this is the first such study in the world literature.** I found that the essential is not so much the type of clouds as the height of its base. Night low clouds of *Stratus* and *Nimbostratus* are very effective in brightening the night sky, while the high *Cirrus*, *Cirrostratus* and *Cirrocumulus* clouds are much less effective in this. I showed that with the strong light pollution, the sky overcast with low clouds is nearly five times brighter than the sky with high clouds and more than ten times brighter than the cloudless sky (Fig.5). This observation allows to take into account the local climate, and in particular the type of clouds dominating during the year, in determining the location of astronomical observatories, as well as ground lighting the buildings in their vicinity.

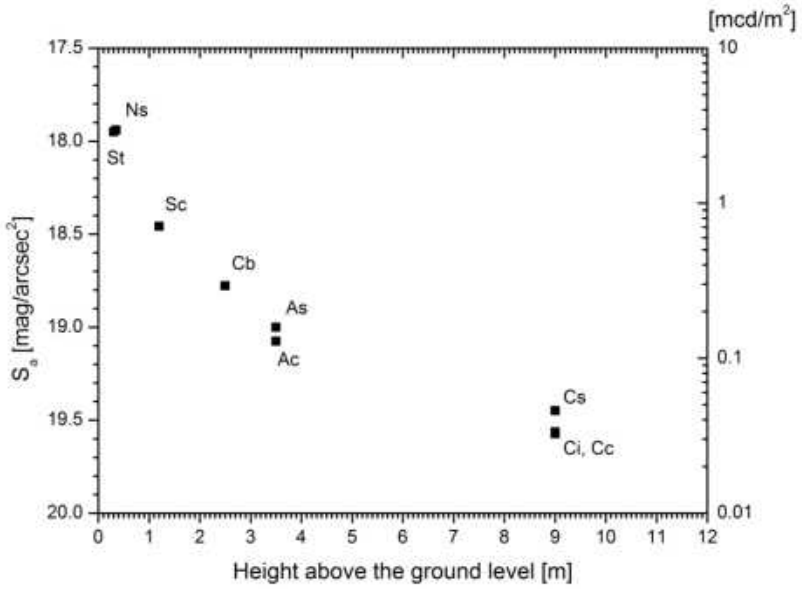


Fig. 5. The brightness of the night sky vs. the type of clouds and the height of their base

In the presented monograph I also showed a clear correlation between the night sky brightness and the relative humidity of the air or on the dew point. This correlation, different depending on the location of the measurement station, allows to determine the level of light pollution in a given area. In particular, I showed that with high humidity or low dew point, with the appearance of fog in brightly contaminated areas the brightness of the night sky remains constant or even increases, whereas in areas free from light pollution the sky becomes darker. This is another, **innovative method of determining a level of light pollution in a given area.**

I have shown that the wind direction affects the brightness of the cloudless night sky in the case when the predominant secondary source of light is dust suspended in the residual atmosphere layer (RL), which occurs in mountain areas remote from local low emission sources. In the case of urban areas where low-emission particulate matter become a secondary source of light, the wind direction does not seem to affect the brightness of the sky glow.

The light propagation in the atmosphere is another important problem described in the monograph. On the basis of photographs and also SQM measurements I showed that the zenith angle of the propagation of the ground light is equal to about 60°. **This is of great importance in determining the horizontal range of the zenithal light glow coming from the ground source of light.** In the case of a cloudless sky, the vertical structure of the atmosphere plays a large role. On the basis of the analysis of remote photographs of light glows of several cities, I found these glows consist of three clearly visible layers: I - the lowest and the brightest one, with a ceiling of several hundred meters, whose surface brightness is practically independent of height, II - higher, with a ceiling of up to 2 km, with lower brightness, also practically independent of the height, and III - the highest, whose surface brightness systematically decreases with the altitude until it merges with the sky background. I identified layer I with a nocturnal boundary layer (NBL),

layer II with a residual layer (RL), while layer III I associated with higher parts of the troposphere. The known ceiling height of the above layers, in connection with the propagation angle given above, allowed me to state that the horizontal range of illumination of the cloudless sky in the zenith can be determined at about 30 km from the ground light source. With high clouds this range decreases to about 21 km. This means that it is also **the minimum distance of the location of astronomical observatories from the nearest human settlements**. Such brightening of the sky, however, is small and is unlikely to have an ecological significance. In the case of middle clouds, with a base of approx. 2 km, the horizontal range of the zenithal sky glow slightly exceeds 3 km, while in the case of low clouds, which lightens the sky most strongly, i.e. having the strongest ecological impact, the zenithal sky glow reaches to only 0,5 km from the light source. These are, in this case, the **minimum distances that must be met by the protection zones surrounding nature reserves** (in particular, dark sky reserves). Moreover, in such reserves there cannot be any exposed ground light sources. These applications are of great practical importance in the design of both astronomical observatories and the determination of boundaries of nature reserves. I also drew attention to the basic meaning of the lack of any light sources inside the protected areas, indicating a violation of this principle in the case of the Starry Sky Park "Bieszczady".

With the help of the maps of the distribution of the night sky brightness (named **photomaps**), I determined the azimuthal relationship of this parameter and the degree of cloudiness. I found that in the case of low clouds the distribution of the sky brightness are dominated by a local light sources, while with a cloudless sky much more important are distant ones. This observation can have a practical significance in determining the main sources of light pollution in a given area.

With the help of a high-sensitive luxmeter, I determined the level of the ground illumination, lighted both directly through ground light sources, as well as by the sky glow. I found that the horizontal range of direct lighting by light sources, even with such a high intensity as housing estates or street lighting, is small. Just at a distance of a few dozen meters (in the case of lamps) or a few hundred meters (housing estates, shopping malls, etc.) such lighting is smaller than that of the full moon (Fig.6).

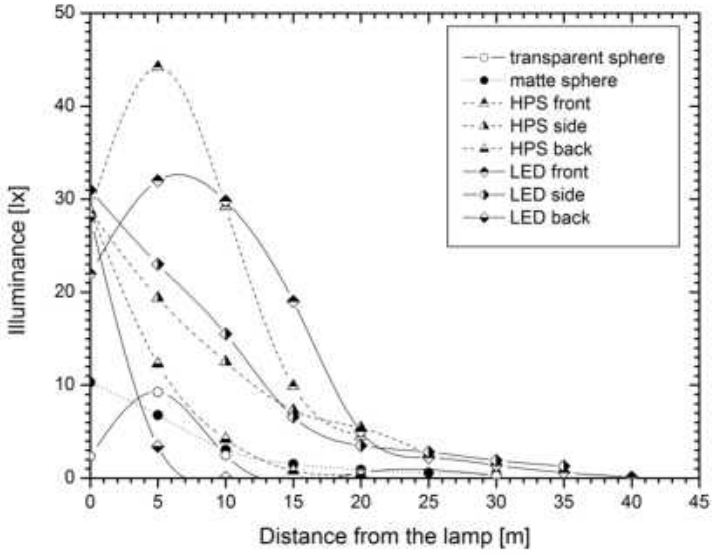


Fig. 6. The illuminance of the ground surface vs. the distance from various types of artificial light sources (transparent or matte spheres: residential decorative lamps, HPS: high pressure sodium street lamps, LED: LED street lamps.

At the same time, these light sources, visible from such distances at low elevations above the horizon, are not noticed by ground organisms, thus not affecting their life cycles. In the case of sky glow, in urban conditions the light reflected from the low clouds illuminates the surface of the earth to a greater extent than the full Moon. I determined the potential ecological impact of point light sources (street lamps) as well as surface light sources (housing estates, shopping malls). This part of the monograph should be helpful in designing new sources of light and protecting the existing ones in such a way as to minimally interfere with the natural environment, especially in the case of organisms whose life rhythm is regulated by the light of the Moon.

Due to the fact that the drinking water intake for Cracow is located on the Dobczyce Reservoir, situated almost in the centre of Dobczyce city, a few years ago I put forward the thesis that the sky glow deriving from this city, especially in the case of an overcast sky, may affect the behaviour of zooplankton, and thus the development of phytoplankton in the surface layers of the reservoir. The measurements confirmed this thesis. I found both the distinct periodicity of chlorophyll *a* concentration and also several other water quality indicators directly related to the phytoplankton concentration (Fig.7).

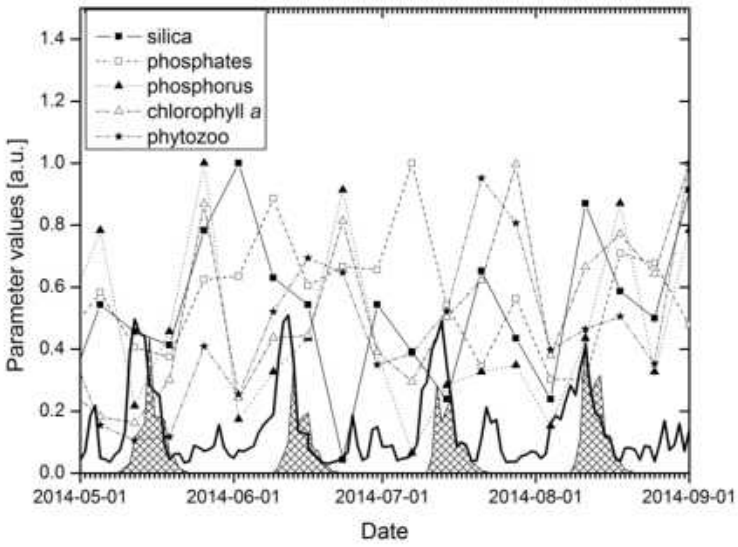


Fig. 7. Periodicity of selected water quality parameters in the growing season of 2014, determined on the Dobczyce Reservoir. I also indicated changes in the brightness of the sky (bold line) and the illumination of the surface of the reservoir by the Moon calculated by me (hatched areas). In order to allow comparison, all these values have been normalized, on an annual scale, to unity.

This periodicity is clearly correlated to the changes of the Moon's phases. At the same time, I showed a linear correlation between the monthly average brightness of the night sky and the value of chlorophyll *a* concentration (Fig.8).

This problem will be the subject of further research, also conducted on other reservoirs. I consider the discovered **correlation between the brightness of the night sky and the content of phytoplankton** in the surface layers of the Dobczyce Reservoir one of the most important results presented in the monograph. There are described such correlations in the world literature, but regarding zooplankton, while so far nobody has noticed the correlation with phytoplankton. The observed correlations are of great practical importance when designing lighting around the water intakes. D**ecreasing night lighting will reduce the content of phytoplankton, thus reducing the eutrophication of the reservoir.**

In conclusion, it should be noted that the presented monograph for the first time captures the issue of the night sky glow as a whole. Thanks to this, I have noticed previously undiscovered effects and dependencies, at the same time disproving a number of widely circulating false views.

This comprehensive approach to this subject allows taking into account many described factors in the design and construction of various types of engineering systems in such a way, that they interfere as little as possible with this element of the natural environment such as night-time darkness.

I believe that this monograph can be a starting point for further, detailed research in this field.

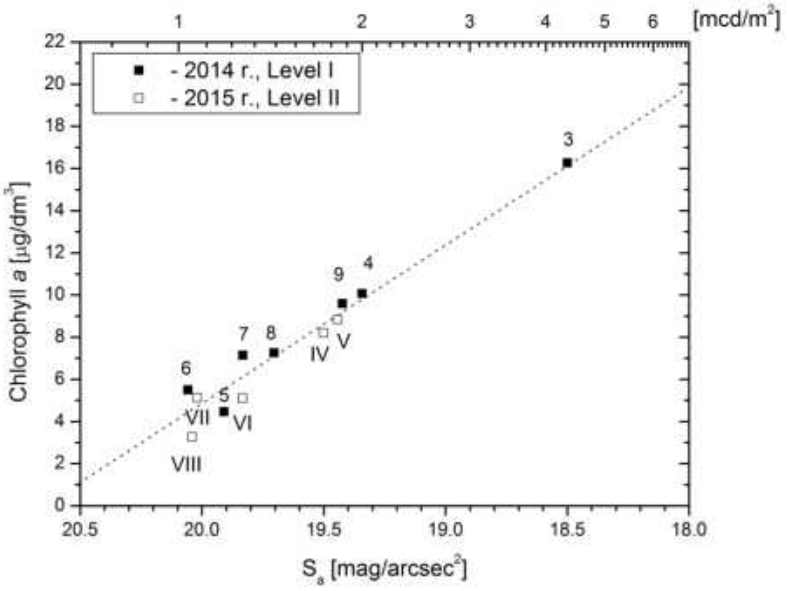


Fig. 8. Concentration of chlorophyll *a* vs. the brightness of the night sky at the Level I (2014) and at the Level II (2015) of the Dobczyce Reservoir (Arabic numerals mean the consecutive months of 2014, Roman numerals – the same of 2015).

4.3.4. Practical application of the results

Presented research and conclusions may find practical applications in many fields of environmental engineering and environmental protection.

- First of all, these results will be applicable in the design of lighting devices, both in built-up areas as well as outside them. Properly constructed light sources will allow better lighting of the facility or the target area, at the same time consuming less energy.
- Observations made during the research of the glow of a cloudless sky can be used in planning the location of astronomical observatories. Most often the so-called astroclimate, i.e. the number of cloudless nights in the year, also the scale of thermal movements of the atmosphere (the so-called seeing) or the presence of nearby population centres are taken into account. From my research it seems that the location of even the distant sources of dust pollution, both natural (volcanoes, deserts) and artificial origin (factories), and the dominant wind directions should also be taken into account. Light scattering on particulate matter coming from low emission should also be avoided, which can be achieved not only by moving away from its source, but also by locating the observatory above the ground level of the atmosphere. Such observatory has to be located at least 30 km from the nearest settlements or other exposed light sources.
- Similar conclusions can be given to provide natural nocturnal darkness in protected areas, both in the case of inanimate nature reserves, which include the so-called dark sky reserves, but also in the case of wildlife reserves, protecting species of plants and animals sensitive to the change of the natural daily cycle (especially nocturnal animals). The data

presented in the monograph show that in this case, the protection zone around such protected area, in which there are no exposed light sources, must extend to a distance of at least 3 km from the border of such area (in special cases, this distance should be reduced to 0.5 km). Of course, the lack of any light sources inside the protected area is very important.

- An equally important practical application of the presented research is the ability to determine the concentration of particulate matter on the base on measurements or estimates of the cloudless night sky brightness in a given area. The correlations shown in this study allow to determine this value. They also provide the possibility of research the level of particulate matter in areas or in periods where no direct measurements of it have been made. In particular, it allows, for example, to study the changes of air pollution with solid particles in industrial areas based on archival astronomical observations (in particular comet observations).
- The analysis of the impact of the night sky brightness on the chlorophyll *a* concentration in the surface layers of the water reservoir allows for proper design and construction of lighting around the water intakes, in order to reduce the risk of eutrophication associated with disruption of zoo- and phytoplankton life cycle. It is also necessary to ensure proper character of housing development of these areas.

I believe that the presented monograph can become a fundamental work in studying the problem of light pollution and in preventing its negative effects.

5. Presentation of other scientific accomplishments

5.1. Prior to receiving Ph.D.

I started my scientific activity, from the beginning connected with the problems of environmental engineering, during my studies at the Faculty of Mathematics and Physics of the Jagiellonian University. In 1987, I was a member of a three-person research group investigating the effects of radioactive contamination of Małopolska with long-lived radioactive isotopes after the failure of the Chernobyl nuclear power plant. My task was to collect field samples, their laboratory tests and the development of a field map of the soil contamination distribution in Małopolska with these isotopes, mainly ^{137}Cs. The result of these pioneering research in Poland was the publication in the renowned journal Acta Physica Polonica[2]. The research itself was awarded with the Team Award of the 3rd degree of Minister of Science and Higher Education. It was the first case of awarding students with a ministerial award in the history of the Jagiellonian University. Then I gained experience in field tests, in working in a research group and in developing data.

From 1988, initially as an assistant trainee, later as a Ph.D. student, I studied the impact of physicochemical parameters of high temperature superconductors on their magnetic properties, carrying out research under the guidance of prof. A. Kołodziejczyk in the Department of Solid State Physics, Faculty of Materials Science and Metallurgy, AGH University of Science and Technology in Cracow. As measuring methods I used, among others, measurement of dynamic susceptibility, electrical resistance and microwave

[2] Królas K., Kubala M., Ściężor T. *Ground deposition of long-lived gamma emitters in Poland from the Chernobyl accident*, Acta Physica Polonica B, vol 18, 12, 1179-1186.

absorption in these materials. I constructed an automated computer measuring system of these quantities. I was also involved in the construction of measuring equipment.

In 1993-1994 I was the head of one of the subgroups of the multidisciplinary research group, headed by prof. Andrzej Manecki (AGH) to investigate the nature of the so-called Jerzmanowice event of January 14th, 1993. Based on the field and laboratory experiments, as well as on the conversations with witnesses, a hypothetical model of the phenomenon was developed, which was probably associated with a rare type of atmospheric discharge, so-called positive discharge. In the published summary in a theoretical manner I showed the groundlessness of the thesis put forward at that time about the relation of the described event to the fall of a meteorite[3]. I also published the description of the phenomenon in the English-language Fireball Data Center bulletin[4].

In 1994, I was appointed the coordinator of comet observations in Poland by the Main Board of the Polish Amateur Astronomical Society (PTMA) as part of a research program carried out by the Harvard-Smithsonian Center for Astrophysics (CfA) at Harvard University (Cambridge, USA). Initially, in the first two years, my area of activity also included Lithuania, Belarus and Sweden, until the appointment of separate coordinators in these countries. I am still the coordinator of this program in Poland. The multi-thousand database created by me (currently exceeding 14 thousand records) specifying the various parameters of comets observed in Poland has become the basis for the development of an original, innovative method of determining the brightness of the night sky, and ultimately determining the concentration of particulate matter in atmosphere. In this way I showed the possibility of using natural objects visible in the sky, such as comets, as the measuring tools in environmental engineering. The results of my observations sent to the CfA headquarters are published in the International Comet Quarterly journal, published by CfA in cooperation with the New England Light Pollution Advisory Group (NELPAG).

5.2. After receiving Ph.D.

I carried out and continued my research interests and activities in the following research areas:

- Evaluation of the quality of artificial light sources as causes of light pollution, in particular in the form of a night sky glow.
- Observations of comets and their application in determining the level of light pollution of the natural environment.
- Device measurements of brightness of the night sky glow.
- Development of new methods for the analysis of measurement data regarding the brightness and spatial distribution of the night sky glow.
- Creating a light pollution map of Poland.
- Establishment of a network of light pollution monitoring stations.
- Determination of the nature of short- and long-term changes in the level of light pollution in selected places in Poland.

[3] Ściężor T., Płeszka J., *Analiza ruchu obiektu jerzmanowickiego w atmosferze przy założeniu jego natury meteorytowej.* Przegląd Geofizyczny, XL, 4, 1995,

[4] Ściężor T., Płeszka J., *The mystery of the "Jerzmanowice Event"*, FIDAC news, International Meteor Organization Fireball Data Center, Vol.3 (1), Düsseldorf, 1995.

- Determination of the impact of the state of the atmosphere on the brightness of the night sky glow including a number of meteorological elements.
- Determination of the effect of the particulate matter on the brightness of the night sky glow.
- Research of the astronomical aspects of the night sky glow.
- Research of the ecological aspects of the night sky glow.

For the first time I discussed the problem of light pollution at the 5th Conference of the Comet Observers Section (SOK) of PTMA on October 10-12, 2003 in the paper "Light pollution and the problem of cometary observation"[5] subsequently published in conference materials. It was the first publication in our country dedicated to this problem. In the paper I presented the history of the problem in the world and in Poland. I mentioned the types of light pollution with particular attention to the sky glow. I also described the sources of artificial light, dividing them into polluting and non-polluting the environment. I have provided examples of legal regulations already in force in other countries. I also proposed ways to reduce light pollution. For the first time at this conference, I presented the innovative method of estimating the night sky brightness on the base of observations of comets, treated as a natural photometric indicators. This method consists in determining the surface brightness (marked as S_a) of a highly fuzzy object, which is a comet with a low degree of condensation (DC). In the case of a comet with a flat photometric section of the envelope, which barely stands out from the sky, one can assume that its surface brightness is almost equal to the upper limit of the surface brightness of the night sky. Using this method, on the base of long-term comet observation coming from the rich archive of SOK PTMA, I presented the preliminary results of the light pollution analysis in Poland by classifying areas polluted with light. Using this method, I also made the first attempts to determine changes in the brightness of the night sky in 1994-2002 near the Dobczyce Reservoir.

I described the problem of light pollution at the next, 6th Conference of the SOK PTMA, which took place on October 15-17th, 2004.[6] I presented a statistical data processing of the base of comet observations from the archive of SOK PTMA, made in 1994-2004. I positively verified the cometary method for estimating the brightness of the night sky comparing the seasonal changes in the sky brightness with the literature data. Positive verification of the method allowed me to determine changes in the brightness of the night sky in 1994-2004 for selected cities in Poland. I have noticed a significant increase in this value for the localities in the vicinity of Cracow since 2000, and for Lublin since 2003. At the same time in Białystok, widely recognized as a city with low level of light pollution, I confirmed the constant low value of night sky brightness throughout the research period.

At the next, 7th Conference of SOK PTMA, which took place on October 14-16th, 2005, I presented the paper *Where to look for the darkest sky? The*

[5] Ściężor T. *Zanieczyszczenie świetlne a problem obserwacji komet*, Biuletyn Naukowy Sekcji Obserwatorów Komet PTMA „Komeciarz" (33), 3/2003
[6] Ściężor T. *Zmiany zanieczyszczenia świetlnego w Polsce w okresie działalności SOK PTMA: 1994-2004*, Biuletyn Naukowy Sekcji Obserwatorów Komet PTMA „Komeciarz" (38), 4/2004

current state of light pollution in Poland and in the world[7]. In this paper, I made a careful analysis of the cometary method, comparing the changes of night sky brightness in the month, year and many years range with natural changes in the brightness of the sky caused respectively by changing the phases of the Moon, changing the depth of the Sun at local midnight and by variable solar activity. Application of this method to data coming from the comet observation dataset, being the result of observations made during the PTMA observation camps in the Lubomir and Łysina range in the Beskid Makowski Mountains in 1994-2004, allowed me to conclude that up to 2001 the sky brightness in this area remained at a constant low level, however, since 2002, there has been visible a systematic growth, which should undoubtedly be associated with the increase in the area's population.

I described the problem of light pollution in 2006 in a paper published in the Czasopismo Techniczne journal published by the Cracow University of Technology[8]. In this paper I also presented, still developed, my original method for determining the brightness of the cloudless night sky on the base of comet observations. It is worth noting here that this was the first paper in Poland, published in a scoring scientific journal, devoted entirely to the problem of light pollution.

Recognizing the need for systematic scientific research of this problem, in 2008 I initiated the foundation of a research group at the Cracow University of Technology, dealing with light pollution in the form of artificial sky glow, not only in astronomical but also in ecological aspect. This group, led by me, includes scientists from the Cracow University of Technology, AGH University of Science and Technology and the Institute of Meteorology and Water Management. In the same year, the research project prepared by this group was accepted for implementation entitled *Determination of changes in light pollution of the night sky for a large city based on the example of Cracow and an attempt to determine its correlation with atmospheric pollution with aerosols and suspended dusts* (PB 3361/B/P01/2008/34), of which I became the **manager**. In this project the measuring equipment, such as a dozen portable meters of the night sky brightness type SQM (Sky Quality Meter), a dozen or so narrowband filters and a high-sensitivity luxmeter was purchased. This equipment allowed me to made measurements independent of weather conditions. For the first time it was possible to measure the brightness not only the cloudless sky, but also in the conditions of changing cloudiness, haze or fog. These meters also allowed me for measurement verification of the cometary method described earlier[9]. This method, described by me in a paper published in the renowned magazine Monthly Notices of the Royal Astronomical Society, was in the following years accepted in the astronomical

[7] Ściężor T. *Gdzie szukać najciemniejszego nieba? Aktualny stan zanieczyszczenia świetlnego w Polsce i na świecie*, Biuletyn Naukowy Sekcji Obserwatorów Komet PTMA „Komeciarz" (41), 3/2005
[8] Ściężor T. *Problem środowiskowego zanieczyszczenia świetlnego oraz zastosowanie amatorskich obserwacji astronomicznych dla określenia jego wielkości*, T. Ściężor, "Czasopismo Techniczne - Środowisko", t. 102, z. 16, 2006, str. 145-164
[9] Ściężor T., Kubala M., Dworak T.Z., Kaszowski W., *A method to describe light pollution and results from Poland 1994-2008* , Environmental Engineering III, Taylor & Francis, 2010, pp. 89-96

environment as one of the methods of assessing the quality of the cloudless night sky[10].

The measurement network created on the basis of these meters included a few parts of Cracow and the surrounding areas, involving not only members of the mentioned research group, but also a dozen or so adequately trained volunteers. There were both mobile and outgoing measurements, as well as daily stationary measurements, independent on weather conditions. At the same time a number of meteorological parameters were also recorded, in particular cloudiness, fog or haze. As a result, a database containing several thousand measurements was created. This type of systematic measurement of the brightness of the night sky was only the second in the world after the similar made in 2008 in Hong Kong, the scale of which, however, was incomparably smaller[11].

As a result of mobile measurements, determining the range of Cracow's light glow, I introduced the concept of light islands, widely used in literature. Stationary measurements allowed noticing previously unrecognized dependences of the brightness of the night sky glow, in particular on the cloudiness or particulate matter concentration. The results of the research were regularly published in journals from the A[12], and B lists[13] and as a chapters in monographs[14]. The summary of this research was the monograph entitled *Light pollution of the night sky in Cracow agglomeration. Data analysis of the artificial sky glow measurements*, of which I was the main author (my author's contribution was 50%)[15]. This monograph was the first publication in Polish scientific literature devoted entirely to the problem of light pollution. It suggested to undertake a systematic research on this problem, in particular on its meteorological and ecological aspects. The monograph describes the assumptions of the cometary method described earlier. The historical data obtained by this method are presented, regarding changes in light pollution in selected regions of Poland. For the first time, the brightness of the night sky was clearly connected not only with the intensity of the ground lighting, but also with the degree of industrialization. A close correlation was found between the concentration of particulate matter and the brightness of the cloudless night sky. This dependence, after full elaboration, was published in the Monthly Notices of the Royal Astronomical Society journal[16]. It allows not

[10] Ściężor T., *A new astronomical method for determining the brightness of the night sky and its application to study long-term changes in the level of light pollution*, Monthly Notices of the Royal Astronomical Society, Vol. 435, No. 1, 2013, pp. 303-310

[11] However, as a result of methodological errors, the Hong Kong group did not reach in fact any conclusions.

[12] Kubala M., Ściężor T., Dworak T. Z., Kaszowski W., *Artificial Sky Glow in Cracow Agglomeration*, Polish Journal of Environmental Studies, 18, 3A, 2009, pp. 194-199

[13] Dworak T. Z., Ściężor T., *Pomiar jasności tła nocnego nieba*, Aura, 3, 2009, ss. 29-30; Dworak T. Z., Kubala Z., Ściężor T., Kaszowski W., *Wstępne wyniki pomiarów jasności tła nocnego nieba*, Aura, 8, 2009, ss. 27-29

[14] Kaszowski W., Ściężor T., Kubala M., Dworak T. Z., *Wpływ warunków meteorologicznych na sztuczną poświatę niebieską* [w:] Ochrona powietrza w teorii i praktyce, tom 1, Zabrze 2010, ss. 103-112.

[15] Ściężor T., Kubala M., Kaszowski W., Dworak T.Z., *Zanieczyszczenie świetlne nocnego nieba w obszarze aglomeracji krakowskiej. Analiza pomiarów sztucznej poświaty niebieskiej*, Monografia 388, Politechnika Krakowska, Kraków 2010

[16] Ściężor T., Kubala M., *Particulate matter as an amplifier for astronomical light pollution*, Monthly Notices of the Royal Astronomical Society, Vol. 444, No. 3, 2014, pp. 2487-2493

only to determine changes in atmospheric pollution with particulate matter, in particular PM10, basing on measurements of night sky brightness, but also, using the previously developed cometary method, to reconstruct this value in the past in areas where astronomical observations were carried out[17]. In this way I have introduced comets as a natural tools for assessing the state of the atmosphere. **This is the first of its kind, innovative application of observation of these objects in environmental engineering**.

In connection with the correlation found above, I decided to check whether the vertical distribution of dust suspended in the atmosphere affects in any way the brightness of the night sky. The cooperation with the Cracow Branch of the Institute of Meteorology and Water Management - the National Research Institute has made it possible to carry out SODAR surveys of the lower atmosphere[18]. The results, along with their interpretation, are presented in the monograph.

Due to the, earlier noticed, possible correlation between the brightness of the night sky and the chlorophyll *a* content in the surface layers of the Dobczyce Reservoir in 2011 were made the measurements of the brightness of the night sky in various meteorological conditions around this reservoir and the Żywieckie Reservoir[19]. The research done by my group allowed to determine the possible impact of terrain on the brightness of the night sky glow. This is one of the first such works in the world.[20].

The earlier measurements made near the Dobczyce Reservoir showed the possibility of impact of the brightness of the night sky on its eutrophication[21], which effect was not previously described in the literature. In order to check this hypothesis in 2014, in cooperation with Municipal Water and Sewage Company in Cracow, I put a light pollution measuring station at the Dobczyce Reservoir (designated DOB), continuously recording the brightness of the sky every night, in 5 minutes interval, regardless of the weather. Preliminary results confirmed the thesis about the possible correlation between brightness of the night sky and the of chlorophyll *a* concentration in the surface layer of the reservoir and prompted us to continue the research[22]. The effects of several-year measurements, which also showed the existence of other correlations, were presented at the environmental conference[23] and detailed described in the monograph.

---

[17] Ściężor T., Kubala M., *Wpływ zapylenia atmosfery na jasność nocnego nieba*, KOSMOS - Problemy Nauk Biologicznych, nr 4/2015 (309), str.579-587.

[18] Kaszowski W., Ściężor T., Kubala M., Dworak T. Z., *Wpływ warstw hamujących w atmosferze na sztuczną poświatę niebieską* [w:] Ochrona powietrza w teorii i praktyce, tom 2, Zabrze 2012, ss. 111-118.

[19] Ściężor T., Kubala M., *Zanieczyszczenie świetlne w otoczeniu wybranych zbiorników retencyjnych Małopolski*, Czasopismo Techniczne - Środowisko, t. 108, z. 6, 2011, ss. 235-245

[20] Ściężor T., Kubala M., Kaszowski W., *Light Pollution of the Mountain Areas in Poland*, Archives of Environental Protection, Vol.38, No.4, 2012, pp. 59-69.

[21] Opisywany był wpływ jasności nocnego nieba na rozwój zooplanktonu.

[22] Ściężor T., Balcerzak W., *Wpływ zanieczyszczenia świetlnego na eutrofizację Zbiornika Dobczyckiego*, KOSMOS - Problemy Nauk Biologicznych, nr 4/2015 (309), str.599-610

[23] Ściężor T., *Wpływ jasności nocnego nieba na wartości wskaźników jakości wody w Zbiorniku Dobczyckim*, [w:] "Ochrona i rekultywacja jezior", Grudziądz 2017, s.117-132

Research, presented in the earlier monograph[24], drew my attention to the effect of reflecting the ground lights by clouds. The measured values allowed to conclude that this type of light pollution, not interesting for astronomers, can be of great ecological importance. The first such research done in 2011[25], confirmed the importance of the problem and prompted to do a detailed research to link the brightness of the night sky with the state of the atmosphere. As a result in 2012 I set up a measurement station in Zabierzów near Cracow (ZAB), where a properly trained observer does nocturnal measurements of the brightness of the night sky with the simultaneous recording of a number of meteorological parameters. These measurements, in connection with the analysis of satellite images, night-time photographs and control measurements of the night sky brightness, allowed to develop a preliminary scheme of the so-called light islands, refuting some of the erroneous statements that can be found in the literature on the subject[26].

Following the necessity of systematic research of seasonal changes in the night sky brightness in connection with the state of the atmosphere, at the beginning of 2015 I was created the light-pollution monitoring station at the Astronomical Observatory of the Pedagogical University of Cracow on the Suhora Mountain in Gorce (SUH). This station, besides the SQM-LE meter measuring the night sky brightness, includes also a meteorological station measuring a number of meteorological elements, such as temperature, humidity, wind speed and direction, dew point, precipitation, and also the all-sky camera, every 3 minutes recording the image of the whole sky. All this data is available on-line on the Observatory website[27].

Earlier in 2014, I established cooperation with the "Fort Skala" Astronomical Observatory of the Jagiellonian University, where in effect a third light pollution monitoring station (FSK) was created, in a similar set as for SUH. Measurement data, both from this station and from the aforementioned stations, are available on the website of the Light Pollution Monitoring Laboratory made by me in 2015[28]. In February 2018, on my initiative, the fourth light pollution monitoring station was launched, located in the Youth Astronomical Observatory in Niepołomice (MOA)[29].

The launch of the described measurement stations enabled, from 2014, continuous monitoring of the brightness of the night sky, which together with the meteorological data, coming from our stations (SUH, DOB) or acquired under cooperation with the UJ Astronomical Observatory “Fort Skała” (FSK), enabled a full analysis of the relationship between the state of the atmosphere and the brightness of the night sky. It is worth noticed that the analysis presented in the monograph is the **first of its kind in the world** and is intended to be the basis for further, detailed research. At present, there are agreements on cooperation in the measurement of the level of light pollution

[24] Ściężor T., Kubala M., Kaszowski W., Dworak T.Z., *Zanieczyszczenie świetlne nocnego nieba w obszarze aglomeracji krakowskiej. Analiza pomiarów sztucznej poświaty niebieskiej*, Monografia 388, Politechnika Krakowska, Kraków 2010

[25] Ściężor T., Kubala M., *Wpływ chmur niskich i wysokich na bliskie i dalekie zanieczyszczenie świetlne*, Czasopismo Techniczne 2-Ś, t. 109, z. 23, 2012, str. 253-260

[26] Ściężor T., *Propagacja sztucznego oświetlenia naziemnego w atmosferze*, Polish Journal for Sustainable Development, t. 21 (2), str.125-136.

[27] http://www.as.up.krakow.pl/main/snieg.php?lang=pl

[28] http://lightpollution.pk.edu.pl/

[29] http://moa.home.pl/pogoda/

with Municipal Water and Sewage Company S.A. in Cracow, with the Pedagogical University of Cracow and the Youth Astronomical Observatory in Niepołomice. On several occasions, I also performed an assessment of the quality of night sky protection, including the city of Świeradów in the Izerskie Mountains[30] or for the municipality of Lutowiska in the Bieszczady Mountains[31]. In April 2016, at my initiative, the Cracow University of Technology supported the amendment defining protection zones around astronomical observatories to the Regulation of the Minister of Infrastructure and Construction (MIiB) regarding technical conditions (WT), which should be met by buildings and their location (amendment of § 293 section 6)[32]. The change in WT was proposed by the Association of Modern Buildings and positively evaluated by the Polish Lighting Committee of CIE Polska.

5.3. Research and other works, not related to the subject of monograph

In 1997-1999, as the head of the Comet Observers Section of the Polish Amateur Astronomical Society, I was the coordinator of the observations of comets in the research project *Observations of astronomical objects and astronomical phenomena as a service for professional astronomy* (KBN 838/P/DS/97, KBN 642/P/DS/98, KBN 733/P/DS/99).

In 2000 I directed a field research group analysing the circumstances of the Moravka meteorite fall on May 6th this year. The results of the research have been published in a thematic study[33].

Since 1989 I have been a member of the Society of Friends of Prokocim name of Erazm and Anna Jerzmanowski, acting as the Chairman of the Historical Section. In 2017, I was the chairman of the organizing committee of a multidisciplinary scientific conference, organized on my initiative, in the 650th anniversary of Prokocim[34]. In addition to papers in the field of history, there were also several ones devoted to the natural environment and its protection. In connection with my interests in historical sciences, I am the author of two reviewed monographs in this field[35], and an editor and co-author of a monograph devoted to the village of Klecza near Wadowice[36], as well as the author of several chapters in group monographs on similar subjects. These monographs have been highly rated by reviewers and are often cited in historical publications. Similarly, a very frequently quoted is the book, edited

[30] *Opinia dotycząca działań miasta Świeradów na rzecz ochrony ciemnego nieba*, grudzień 2012 r.
[31] *Ocena działań gminy Lutowiska przeciwdziałającym zanieczyszczeniu światłem obszaru projektowanego Parku Gwiezdnego Nieba*, marzec 2013 r.
[32] Dz.U. 2015, poz. 1422
[33] Ściężor T. *Bolidy. Zjawisko i metodologia badań na przykładzie bolidu Moravka z 6 maja 2000 r.*, PTMA, Kraków 2000
[34] http://prokocim2017.wis.pk.edu.pl/
[35] Ściężor T. *Augustiański Prokocim: OO. Augustianie w Prokocimiu w latach 1910-1950.* Polska Prowincja Zakonu św. Augustyna, Kraków 2006; Ściężor T. *Historyczny Prokocim: monografia wsi podkrakowskiej XIV-XX w.* Polska Prowincja Zakonu św. Augustyna. Kraków 2008.
[36] *Klecza pod Wadowicami: praca wydana z okazji 700-lecia wsi i 650-lecia parafii.* Praca zbiorowa, Klecza 2004

by me and Marek Kubala, which is a collection of memoirs of Polish officers from the 17th century[37].

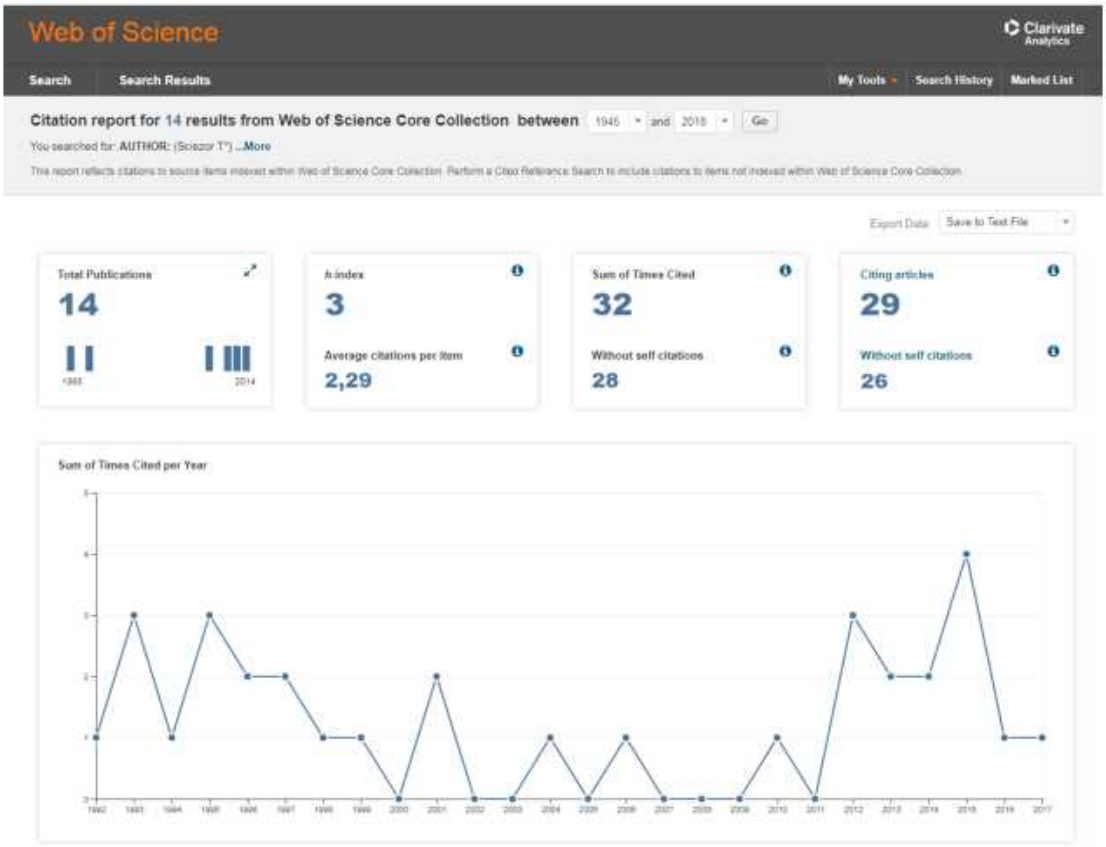
6. Summary of achievements

6.1. Research activity (including items listed in section 4)

Type of achievement	Before Ph.D.	After Ph.D.	TOTAL
Monographs in Polish (including the only or main author)	4 (4)	37 (37) [6]*	41 (41) [6]*
Articles in journals **listed in JCR** (list A)	5 (0)	5 (4)	10 (4)
Articles in journals other than listed in JCR (list B)	5 (3)	9 (7)	14 (10)
Chapters in monographs (including the only or main author)		7 (4)	7 (4)
Papers in proceedings of conferences (including the only or main author)	3 (1)	11 (11)	14 (12)
Organization of conferences		8 [4]*	8 [4]*
Presentations at conferences	10	18	28
Participation in domestic research projects **	2	1	3
Managing of research project		1	1
Reviewing of articles and conference papers		4	4
Awards for scientific activity	1	1	2
Total IF according to Web of Science (according to publication year)		11,786	11,786
Number of citations according to Web of Science (excluding self-citations) *(as on 10.01.2018)*		32 (28)	32 (28)
Hirsch index according to Web of Science		3	3
Hirsch index according to Google Scholar		5	5
Number of citations according to Scopus (excluding self-citations) *(as on 10.01.2018)*		26 (21)	26 (21)
Number of citations according to Google Scholar *(as on 10.01.2018)*		67	67
Sum of MNiSW points, according to publication year (*including those devoted entirely or partly to the described problem*)***	57,6 (0)	629,8 (266,0)	687,4 (266,0)
Participation in research carried out as part of statutory activities		1	1

*) including those devoted entirely or partly to the described problem
**) excluding "statutory activities" (DS) and "own research" (BW)
***) including the percentage share in the total publication

[37] *Moskwa w rękach Polaków. Pamiętniki dowódców i oficerów garnizonu polskiego w Moskwie 1610-1612*. Opracowali: M. Kubala, T. Ściężor, Kraków 2005 (kilka wznowień)



List of publications devoted entirely or partly to the problem of light pollution

- **Ściężor T.**, *Environmental light pollution problem and application of amateur astronomical observation for determining its range*. Czasopismo Techniczne - Środowisko, t. 102, z. 16, 2005, 145-164. (in Polish)
- Dworak T. Z., **Ściężor T.**, *Measurement of night sky brightness - determination of dust and light pollution.* Aura. Miesięcznik Naczelnej Organizacji Technicznej poświęcony kształtowaniu i ochronie środowiska, 3, 2009, 29-30. (in Polish)
- Dworak T. Z., Kubala M., **Ściężor T.**, Kaszowski W., *Preliminary measurements of the brightness of the night sky background*, Aura. Miesięcznik Naczelnej Organizacji Technicznej poświęcony kształtowaniu i ochronie środowiska, 8, 2009, 27-29. (in Polish)
- Kubala M., **Ściężor T.**, Dworak T. Z., Kaszowski W., *Artificial Sky Glow in Cracow Agglomeration*, Polish Journal of Environmental Studies, vol. 18, no. 3A, 2009, 194-199.
- **Ściężor T.**, Kubala M., Dworak T. Z, Kaszowski W., *A method to describe light pollution and results from Poland 1994-2008*, [w:] *Environmental Engineering III,* eds. Pawłowski A, Pawłowski L. et al., Taylor & Francis, 2010, 89-96.
- Kaszowski W., **Ściężor T.**, Kubala M., Dworak T. Z., *Impact of meteorological conditions on artificial sky glow*, [in:] *Ochrona powietrza w*

teorii i praktyce, tom 1, red. Konieczyński J., Instytut Podstaw Inżynierii Środowiska Polskiej Akademii Nauk, Zabrze 2010, 103-112. [in Polish)

- **Ściężor T.**, Kubala M., Kaszowski W., Dworak T. Z., *Light pollution of the night sky in the area of the Krakow agglomeration. Analysis of measurements of artificial sky glow*, Monografia 388, seria Inżynieria Środowiska, Politechnika Krakowska, Kraków 2010. [in Polish]
- **Ściężor T.**, Kubala M., *Light pollution in the vicinity of selected Małopolska retention reservoirs*, Czasopismo Techniczne – Środowisko, t. 108, z. 6, 2011, 235-245. [in Polish]
- **Ściężor T.**, Kubala M., Kaszowski W., *Is light pollution a real problem in Poland?* [in:] *Interdyscyplinarne zagadnienia w inżynierii i ochronie środowiska 1*, red. Traczewska T., Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2011, 425-432. [in Polish]
- Kubala M., **Ściężor T.**, *Illumination of the ground through a lightl-polluted night sky.* [in:] *Interdyscyplinarne zagadnienia w inżynierii i ochronie środowiska 2*, red. Traczewska T., Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2012, ss. 301-308. [in Polish]
- Kaszowski W., **Ściężor T.**, Kubala M. *The impact of the inhibitory layers in the atmosphere on the artificial sky glow*, [in:] *Ochrona powietrza w teorii i praktyce*, tom 2, wyd. Konieczyński J., Instytut Podstaw Inżynierii Środowiska Polskiej Akademii Nauk, Zabrze 2012, 111-118. [in Polish]
- **Ściężor T.**, Kubala M. *The effect of low and high clouds on near and far light pollution*, Czasopismo Techniczne – Środowisko, t. 109, z. 23, 2012, 253-260. [in Polish]
- **Ściężor T.**, Kubala M., Kaszowski W., *Light Pollution of the Mountain Areas in Poland*, Archives of Environental Protection, Vol.38, No.4, 2012, 59-69.
- **Ściężor T.**, *A new astronomical method for determining the brightness of the night sky and its application to study long-term changes in the level of light pollution*, Monthly Notices of the Royal Astronomical Society, Vol. 435, No. 1, 2013, 303-310, doi: 10.1093/mnras/stt1297
- **Ściężor T.**, Kubala M. *Particulate matter as an amplifier for astronomical light pollution*, Monthly Notices of the Royal Astronomical Society, Vol. 444, No. 3, 2014, 2487-2493, doi: 10.1093/mnras/stu1577
- **Ściężor T.**, *Determining the nature of changes in the brightness of the night sky in Poland in 1994-2009 based on amateur observations of comets*, Prace i Studia Geograficzne, Vol.53, 2014, 61-79. [in Polish]
- **Ściężor T.**, *The Astronomical Almanac for the year 2015*, Almanach Astronomiczny, Polskie Towarzystwo Astronomiczne, Kraków 2014, ISSN 2083-4802. [in Polish]
- **Ściężor T.**, Kubala M., *The light pollution*, LUX Magazyn, nr 3/2015 (16), 34-37 [in Polish]
- **Ściężor T.** *Astrotourism as a new form of ecotourism*, EVENT *Jesteś kreatorem? Zostań ekoinnowatorem!*, materiały konferencyjne, Poznań 2015 [in Polish]
- **Ściężor T.**, Kubala M., *Impact of the particulate matter on the night sky brightness*, KOSMOS - Problemy Nauk Biologicznych, nr 4/2015 (309), 579-587. [in Polish]

- **Ściężor T.**, Balcerzak W., *The impact of light pollution on euthrophication of the Dobczyce Reservoir*, KOSMOS – Problemy Nauk Biologicznych, nr 4/2015 (309), 599-610. [in Polish]
- **Ściężor T.**, *Comets in the service of the dark sky*, Urania - Postępy Astronomii, nr 6/2015 (780), 15-21. [in Polish]
- **Ściężor T.**, *The Astronomical Almanac for the year 2016*, Almanach Astronomiczny, Polskie Towarzystwo Astronomiczne, Kraków 2015, ISSN 2083-4802. [in Polish]
- **Ściężor T.**, *Current status and prospects for protection of the dark sky in Poland*, AURA – Ochrona Środowiska, 7-8, 2016, 12-16. [in Polish]
- **Ściężor T.**, *The Astronomical Almanac for the year 2017*, Almanach Astronomiczny, Polskie Towarzystwo Astronomiczne, Kraków 2016, ISBN 978-83-938279-4-7. [in Polish]
- **Ściężor T.**, *The impact of the night sky brightness on the values of water quality indicators in the Dobczyce Reservoir,* [in:] "Ochrona i rekultywacja jezior", Grudziądz 2017, 117-132. [in Polish]
- **Ściężor T.**, *Propagation of artificial ground lighting in the atmosphere*, Polish Journal for Sustainable Development, t. 21 (2), 2017, 125-136. [in Polish]
- **Ściężor T.**, *The Astronomical Almanac for the year 2018*, Almanach Astronomiczny, Polskie Towarzystwo Astronomiczne, Kraków 2017, ISBN 978-83-938279-7-8. [in Polish]
- **Ściężor T.**, *Natural and anthropogenic factors of the night sky glow*, Monografie Politechniki Krakowskiej, seria Inżynieria Środowiska, Politechnika Krakowska, Kraków 2018. [in Polish]

6.2. Teaching activity and scientific dissemination

6.2.1 Teaching activity

My didactic activity is connected above all with the use of computers in engineering work. As the head of the computer lab of the Ś-3 Institute (Cracow University of Technology), I assure readiness for both hardware and software to conduct various types of didactic classes on this lab.

As a part of my classes, I disseminate knowledge related to the problem of light pollution by using in the work with students the measurement database obtained during my research. I am the head of modules Information Technology and Geographic Information Systems (GIS) at the 1st degree of studies in the field of Environmental Engineering, as well as the Applied Mathematics module at the second level of these studies.

In addition to classes conducted in Polish, for several years I have been giving a five-hour lecture in English for foreign students in the subject of Environmental Science and Technology in Poland and CEE, dedicated to the problem of light pollution, entitled *Light pollution. A real problem*.

On my initiative, light pollution is discussed at one lecture delivered as part of the Global Environment Changes and Anthropogenic Environmental Pollution modules at the first degree of full-time studies in the field of Environmental Engineering.

Course title	Activity type	Comments
Cracow University of Technology		
Information technology *(30h, 1st level programme)*	Computer laboratory	present (course leader)
Applied mathematics *(30h, 2nd level programme)*	Lectures, sem., exerc.	present (course leader)
IT basics of design *(21h, 1st level programme)*	Lectures, computer lab.	present
GIS in Environmental Engineering *(30h, 1st level optional module)*	Lectures, computer lab.	present (course leader)
Computer application programs *(45h, 1st level programme)*	Exerc., computer lab.	discontinued (course leader)
Programming in Pascal language *(26h, 1st level programme)*	Lectures, computer lab.	discontinued (course leader)
Electronic Calculation Techniques *(45h, 1st level programme)*	Lectures	discontinued
Computer Technical Drawing (ETO+CAD) *(40h, 1st level programme)*	Lectures, exerc. computer lab.	discontinued
Basics of computer science *(45h, 1st level programme)*	Lectures, computer lab.	discontinued
AGH University of Science and Technology		
Physical Laboratory I *(45h, full-time studies)*	Laboratory	discontinued
Physical Laboratory II *(30h, full-time studies)*	Laboratory	discontinued
Physics *(30h, full-time studies)*	Exercises	discontinued

In 1996, I developed the *Eutrophication* program (in Borland Delphi v.1.0) that facilitates the simulation of eutrophication of water reservoirs based on the commonly used WASP module. This program has been applied as part of didactic classes conducted at the Department of Environmental Technologies of the Ś-3 Institute.

I am the author of the syllabus of the Information Technologies module. I also prepared an e-course of this subject in the Moodle system. For the preparation of this e-course in 2016, I received the Rector of the PK award.

I am the author of an extensive (258 pages) student's book entitled *Environmental Engineering for students of Information Technology at the Cracow University of Technology* (in Polish), issued in 2016[38]. The book is the first publication of this type showing the application of a number of popular office programs, such as the MS Office, in the work of an engineer and a researcher. The methods presented in this book can be used not only by the first year students of the Environmental Engineering, but also by students of other faculties, and even by academic teachers and scientists in their daily academic work.

[38] Ściężor T., *Technologia Informacyjna dla studentów kierunku Inżynieria Środowiska Politechniki Krakowskiej*, Wydawnictwo Politechniki Krakowskiej, Kraków 2016

6.2.2. Scientific dissemination

For many years, I have been propagating knowledge about light pollution and hazards associated with it. One of the most important forms of popularizing this problem is the thematic chapters published in the reviewed monographic yearbook *The Astronomical Almanac* (in Polish)[39]. Starting from 2015, in each volume of this publication, dedicated primarily to observational astronomy, one of the main chapters is devoted to light pollution. This part represents approximately 11% (over 30 pages) of the volume of the entire book. The content of these chapters allows to get acquainted with the problem of light pollution. It also has a training functions that allow anyone interested in this subject taking the measurements or assessing the brightness of the night sky.

In 2003-2005, I delivered thematic presentations at consecutive conferences of the Comet Observers Section of Polish Amateur Astronomical Society[40]. In 2009 I took part in the 3rd National Congress of Environmental Engineering in Lublin with a speech describing the method of determining the brightness of the night sky based on amateur observations of comets and presenting the first preliminary results showing the state of light pollution in Poland. It is worth noting that for the first time the problem of light pollution has been presented in a nationwide conference. From 2011 this problem is also regularly (at least once a year) raised by me in lectures delivered at the meetings of the Cracow Branch of the Polish Amateur Astronomical Society.

As part of the awareness of the scientific community, in particular young science workers, about the existence of this previously unsettled civilization threat, I twice appeared at the National Conference of PhD Students and Young Workers of Science - Interdisciplinary Problems in Environmental Protection and Engineering EKO-DOK with lectures entitled *Is light pollution the real problem in Poland?* (2011) and *Ground illumination by the light polluted night sky* (2012) (both in Polish).

In 2012, I took part in the 12th European Symposium for the Protection of the Night Sky, where the lecture devoted to the use of the cometary method in determining the brightness of the night sky met with great interest of the participants.

On March 8th, 2013, on behalf of the Faculty of Environmental Engineering, I took part in a thematic conference related to the establishment of the Starry-Sky Park Bieszczady, where I was appointed as the scientific coordinator of the light pollution monitoring network in this area. Performing this function I receive measurement data from three monitoring stations installed in the Park. The analysis of this database is currently under way and its results will be published.

In 2013, I took part in the First National Conference on Light Pollution organized at the University of Warsaw. Such conferences have been held annually in few research centres in Poland (2013: Warsaw, 2014: Wrocław, 2015: Cracow, 2016: Rzeszów, 2017: Warsaw). In 2016 and 2017 I was a member of the Scientific Committee of these conferences.

---

[39] Ściężor T., *Almanach Astronomiczny*, years: 2015, 2016, 2017, 2018, Polskie Towarzystwo Astronomiczne, Warszawa [online] http://www.urania.edu.pl/almanach

[40] In 2003 r.: *Zanieczyszczenie świetlne a problem obserwacji komet*; in 2004 r.: *Zmiany zanieczyszczenia świetlnego w Polsce w okresie działalności SOK PTMA: 1994-2004;* in 2005 r.: *Gdzie szukać najciemniejszego nieba? Aktualny stan zanieczyszczenia świetlnego w Polsce i na świecie*

In 2015, at my initiative, the 3rd National Conference on Light Pollution was held in Cracow. I was the **chairman of the Organizing Committee** of this conference. It was the largest science conference so far in Poland dedicated entirely to the problem of light pollution. Its aim was to present the problem of light pollution in an interdisciplinary approach and to discuss ways of minimizing this phenomenon and its negative effects. Due to the wide range of topics discussed, the conference was divided into a series of thematic blocks, such as:

- lighting technologies
- protection of the dark sky
- astronomy, meteorology and atmosphere physics
- medicine and sociology
- architecture
- biology and ecology

The conference was attended by over 60 participants (including 8 foreign guests from Hungary, Slovakia and Ukraine), 33 presentations and 6 posters. The conference was also associated with an open photography competition, the aim of which was to popularize the subject matter among the general public. For the organization of this conference, the team managed by me received in 2016 the **Team Award of the Rector of the Cracow University of Technology**.

I also gave lectures on various aspects of light pollution at many seminars: at the Institute of Water Supply and Environmental Protection at the Cracow University of Technology[41], at the Pedagogical University in Cracow[42], at the Institute of Physics at the Jagiellonian University[43] or at the Collegium Medicum of the Jagiellonian University[44].

In connection with the aforementioned scientific supervision of the Starry-Sky Park Bieszczady, I also took up the subject of the so-called *astrotourism*, or night tourism connected with admiring this component of the natural human environment, which is the starry sky. The result was the lecture delivered in 2015 in Poznan on the *EVENING about the EKOinnovations* entitled *Astrotourism as a new form of ecotourism*[45] and the publication entitled *Light pollution* in a regional magazine[46].

I presented the problem of the ecological impact of the night sky glow in the conference *Protection and reclamation of lakes*, which took place in Grudziądz in June 2017.

Another ecological aspect of light pollution, associated with an existing and designed dark sky protection areas, I presented in the journal AURA – Ochrona Środowiska[47].

I also took up the problem of light pollution in the lighting aspect in a popular lighting quarterly LUX[48].

---

[41] April 3rd, 2014; 25th march, 2015; 30th March, 2015 (in English, in the Polish-Japan seminar); 28th October, 2015

[42] Seminarium Katedry Astronomii Uniwersytetu Pedagogicznego, Kraków, 12th April, 2011

[43] Seminarium astrofizyczne Polskiej Akademii Umiejętności, Instytutu Fizyki Jądrowej i Uniwersytetu Jagiellońskiego, Kraków, 13th Arpil, 2011

[44] Seminar of the Institute of Public Health, Collegium Medicum uf the Jagiellonian University, Cracow, 29th February, 2012

[45] Ściężor T., *Astroturystyka jako nowa forma ekoturystyki*, Jesteś kreatorem? Zostań ekoinnowatorem!, conference proceedings, Poznań 2015

[46] Ściężor T., *Zanieczyszczenie świetlne,* Prace Pienińskie, t.27, 2017. s.41-57.

[47] Ściężor T. *Stan obecny i perspektywy ochrony ciemnego nieba w Polsce*, AURA - Ochrona Środowiska, 7-8, 2016, str.12-16.

The astronomical aspects of light pollution I described in the article published in the journal Urania-Postępy Astronomii published by the Polish Amateur Astronomical Society[49].

Starting from 2012, every year I am on duty in the tent of the Faculty of Environmental Engineering as part of the Science Festival in Cracow. In my position, I explain the problem of light pollution based on posters made by my research group, as well as demonstrate proper and improper urban lighting using self-constructed models. I am also the co-author of the information brochure entitled *Light pollution* (in Polish)[50].

Since 2011 I have been regularly providing press, radio and television interviews, making the public aware of the scale of the threat of light pollution and describing ways to reduce this problem[51].

6.3. Organizational activities

In 1988-1990 I was the president, in 1990-1994 secretary, in 1994-1995 vice-president, and in 1997-2007 again president of the Cracow Branch of the Polish Amateur Astronomical Society (PTMA). In 2000-2003 I was the member of the General Board of PTMA. As part of the weekly Cracow Branch meetings organized by me, open public lectures were given, devoted to many problems of astronomy, geophysics and environmental protection, including the problem of light pollution. The speakers were invited guests from Polish and foreign science centres, including scientists of recognized global reputation. In 2002-2006 I also organized five summer field mountain astronomical training and observation camps, in which, apart from performing astronomical observations, the brightness level of the night sky was also determined. I was also the organizer and head of the two PTMA scientific solar-eclipse expeditions: in 1999 in Hungary and in 2006 in Turkey.

In 1994-2007 I was the scientific coordinator of the PTMA Comet Observers Section (SOK). In 1995, on my initiative, was created the *SOK Scientific Bulletin "Komeciarz"*, which in 1999 was transformed into a still published scientific journal (ISSN 1644-1303). In 1992-2004 I was the editor-in-chief of this journal. In 1999-2006, on my initiative, were held eight scientific conferences of the SOK (I was their respective chairman), on which several times the problem of light pollution was discussed[52].

In 1996-1999 I was the member of the editorial committee of the bi-monthly astronomical popular magazine *Urania-Postępy Astronomii*.

Since 1995, I have been the administrator of computer networks of the Institute of Water Supply and Environmental Protection (Ś-3) at the Cracow University of

[48] Ściężor T., Kubala M., *Zanieczyszczenie świetlne*, LUX Magazyn, nr 3/2015 (16), str.34-37

[49] Ściężor T. *Komety w służbie ciemnego nieba*, Urania - Postępy Astronomii, nr 6/2015 (780), str.15-21

[50] Kubala M., T. Ściężor. *Zanieczyszczenie świetlne*, Kraków 2011

[51] *Krakowianie nie mogą spać*, Dziennik Polski 4.02.2011; *Naukowcy z Krakowa spojrzą w ciemne niebo Bieszczadów*, Dziennik Polski 13.03.2013; Radio Z, 13.03.2013; radio RMF FM, 14.03.2013; Teleexpres (TVP), 25.03.2013; Kronika Krakowska (TVP Kraków), 24.04.2013; *Siedem tysięcy gwiazd nad Bieszczadami*, 24.05.2013; *Najciemniej w Bieszczadach i... pod latarnią*, serwis PAP „Nauka w Polsce", 20.08.2013; *Zanieczyszczenie świetlne – nie nowy problem*, Dzikie Życie 11/233, listopad 2013; *Oślepiający róż Areny nie pozwala spać mieszkańcom*, Dziennik Polski 23.02.2015; Radio Kraków 12.06.2015; Radio Kraków 18.09.2015; *Kraków trzeba oczyścić ze złego oświetlenia*, Dziennik Polski 28.09.2015; Radio Kraków 24.12.2016; *Zanieczyszczenie nieba światłem to problem nas wszystkich*, Dziennik Polski 11.03.2017; portal Krakow.pl, 6.10.2017.

[52] V Konferencja SOK PTMA, Kraków, 10-12 października 2003; VI Konferencja SOK PTMA, Kraków, 15-17 października 2004; VII Konferencja SOK PTMA, Niepołomice, 14-16 października 2005.

Technology. On the main server of the Institute, I support not only the institute website, but also the website of the Light Pollution Monitoring Laboratory[53].

I'm also the head of the computer lab at the Ś-3 Institute. I created in this lab, both in terms of software and hardware, 14 student positions and one employee, connected to the intranet network working under the control of the Novell Netware system.

In 2009, I created a research group to systematically carry out field research of light pollution using the provided measuring equipment. The group consisted of five scientific employees of the Faculty of Environmental Engineering of the Cracow University of Technology, two academic employees of the Institute of Astronomy of the Pedagogical University in Cracow, an employee of the Institute of Meteorology and Water Management in Warsaw - Department in Cracow and nine trained volunteers performing measurements. In 2015, on the basis of this group, a Light Pollution Monitoring Laboratory (LPML) was established at the Cracow University of Technology. I am the head of the LPML. Information on the LPML activities, including measurement data and selected research are given on the Laboratory website[54].

In 2017, on my initiative the Dark Sky Protection Section (SOCN) was established at the Polish Amateur Astronomical Society. I am the scientific coordinator of SOCN. I am also the author of the SOCN website, whose main goal is to coordinate the measurements of the level of light pollution in Poland by providing appropriate, mostly developed by me, observation and measurement methods and archiving of the obtained results[55].

T. Ściężor

[53] http://lightpollution.pk.edu.pl/
[54] http://lightpollution.pk.edu.pl/
[55] http://lightpollution.pk.edu.pl/SOCN/