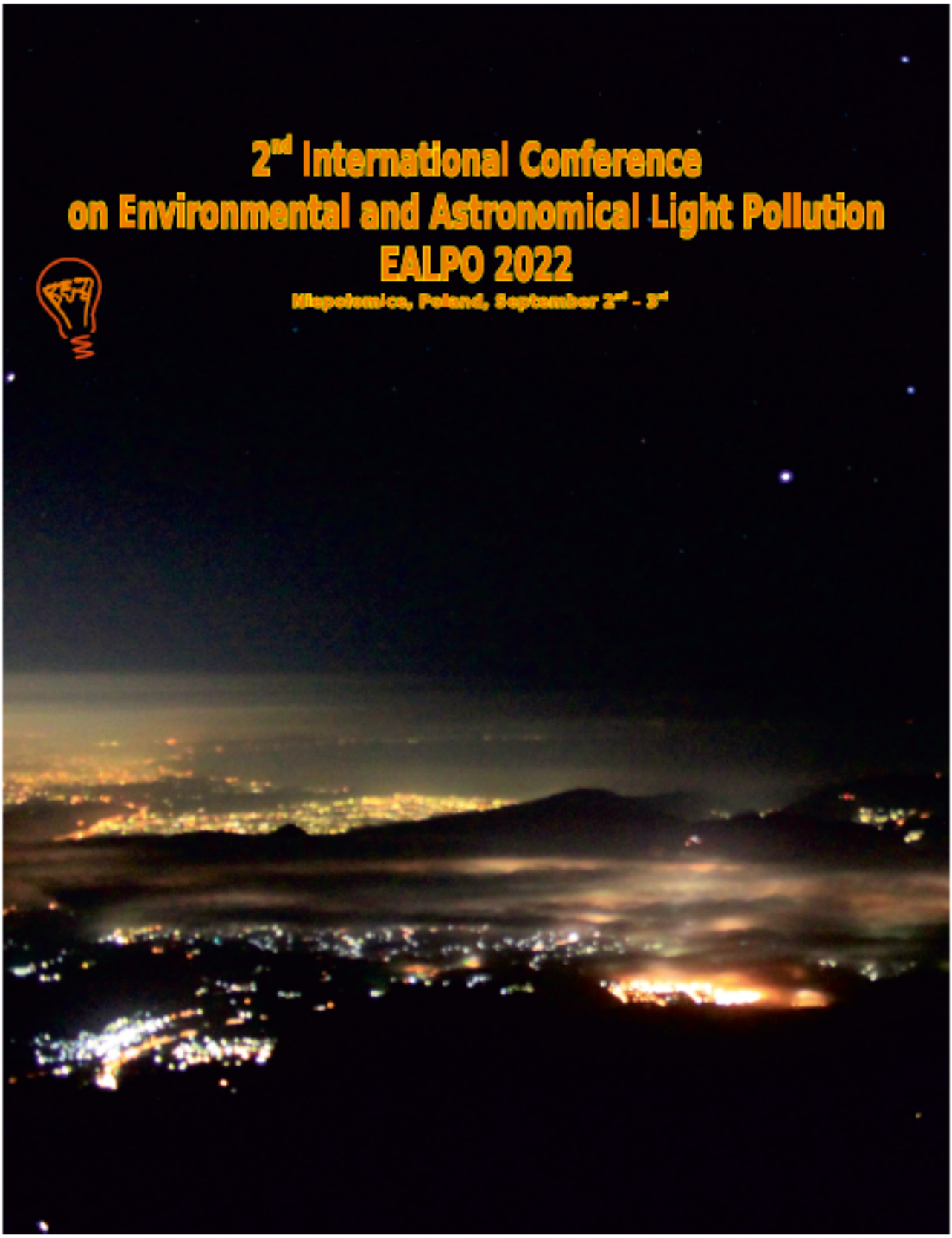
2nd International Conference on Environmental and Astronomical Light Pollution EALPO 2022

Miłopolomice, Poland, September 2nd - 3rd



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Cracow University of Technology
Faculty of Environmental Engineering and Energy

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2nd International Conference on Environmental and Astronomical Light Pollution

EALPO 2022

Niepołomice, Poland, September 2-3, 2022

Polish Amateur Astronomical Society Publishing
Cracow 2022

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Opening lecture

1st session (Theory and practice of light pollution)

Poster session

2nd session (Protection of the dark sky I)

3rd session (Protection of the dark sky II)

4th session (Biology and medicine)

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A new paradigm for external illumination in healthier and environmentally friendlier cities at night

Since the invention of electricity, artificial light after dark has supported humanity in its growth and expansion. This includes aspects such as: safety and security, wayfinding, travel, manufacturing, night time entertainment tourism, and hospitality etc. However, over the past 20 years, thanks to research in various fields, it is now understood that lighting at night and the light pollution it generates, is not benign. These numerous impacts also include the adverse effects linked to new lighting technology all of which can have negative, long lasting consequences.

Cities in the context of artificial light at night (ALAN) and light pollution, play a key role because incorrectly designed night-time illumination(s) may adversely affect human health and well-being (road accidents and collisions, reduced pedestrian safety, lowered life quality, lack of sleep and related health consequences). Moreover, it can impact the natural environment, not only disrupting the physiology and behaviour of flora, but also local and migratory fauna. It's important to know that due to the far reaching impact of ALAN, light pollution in the form of urban skyglow, can also affect non-urban areas that exist well beyond the boundaries of a city or town by up to 200 km away, negatively affecting protected national parks, nature parks, strict nature reserves, special nature reserves, outstanding natural landscapes, monuments of nature, and protected habitats, such as Natura 2000 ecological network.

Although sustainable development is a priority these days, a recent analysis showed not one of the 17th Sustainable Developments Goals (SDGs) established by United Nations addresses the topic in question. This is why it is critical that politicians and city authorities who are willing to adapt these goals, are made aware of this gap, and that appropriate actions to minimise this phenomenon and its negative effects are established and implemented.

This work provides a timeline overview of when light pollution was identified as an issue worldwide, and includes major contributing factors identified by astronomers, biologists, ecologists, medical researchers, lawyers, lighting professionals, and the general public.

It also provides an important holistic approach in the form of (1) missing vocabulary and definitions – to enable communication between all parties involved and further their understanding; (2) key aspects of sustainable cities at night so that SDGs goals can be redefined; (3) existing and missing actors; (4) research and design processes, (5) the proposal of counteractive actions and measures, and lastly (6) planning tools and techniques.

Furthermore, international initiatives such as: Artificial Light at Night (ALAN), Environmental and Astronomical Light Pollution (EALPO), Responsible Outdoor Lighting at Night (ROLAN), and Dark and Quiet Skies for Science and Society conferences, have been analysed as they present the problem of light pollution in an interdisciplinary way.

Hence, this work adds to the ongoing discussion that involves a crucial new paradigm shift in cities at night, and how to design them in a more sustainable way, by ensuring that aspects of health and the environment are considered equally. It is directed towards ALAN researchers, lighting professionals, architects, urban planners, landscape designers, representatives of municipalities, representatives of territorial self-governments, and non-governmental organisations, as well as the general public.

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Ground-based methods to characterize the lower atmosphere

Retrieval of the optical properties of the lower atmosphere is crucial for understanding the light pollution propagation into the nocturnal environment. All of the skyglow models currently in use require information on the aerosol optical depth (AOD) and scattering phase function (P) as both significantly influence the ground reaching diffuse radiation at night. The methods (Fig. 1a-b) we have developed are novel and allow for mining the data which are absolutely necessary for modeling purposes. Specifically, AOD is very rarely available for an observing site selected randomly during a field experiment. In general, AOD and P are largely missing for the night time atmosphere at any site.

We strongly believe that the methods become useful to the light pollution community, mostly because they fill the gap between experiments and numerical predictions. A systematic harvesting of AOD and P at various sites should allow us to test and improve upon the theoretical predictions, which otherwise suffer from large uncertainties when these key parameters are unavailable.

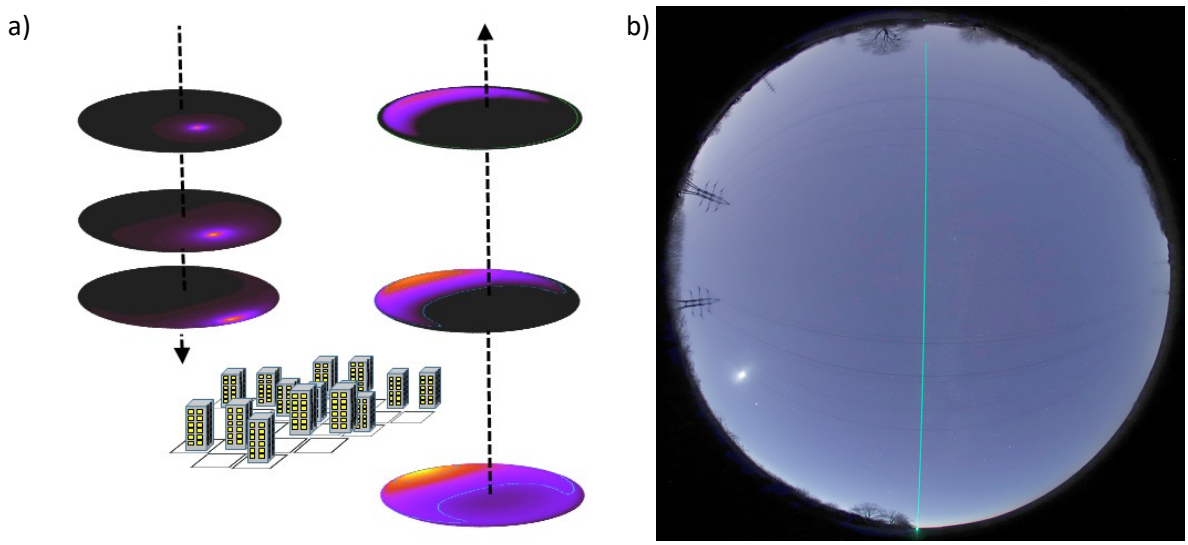

Fig. 1. a) Night sky brightness distribution measured at two distinct altitudes can be interpreted in terms of aerosol optical depth of an atmospheric layer monitored. Analogously, the radiance of the bottom hemisphere (when looking from an elevated altitude downwards) provides information on aerosol envelope of a city under study. b) Intensity changes measured along the laser beam path in the atmosphere reflect the changes of the atmospheric scattering phase function.

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Whole-sky automatic multispectral scanner for brightness and polarization characterization of the night sky

The night-sky brightness is commonly characterized by its distribution of the luminance/radiance. However, the degree of the polarization of the night-sky, as well as the orientation of the main axis of the polarization ellipse, proved to carry a detailed information on sources of light pollution.

Fig. 1. The sky-scanner mounted on a robotic mount

We have developed a computer-controlled sky-scanner (Fig. 1) based on photomultiplier tube, and narrow-band interference and polarizing filters. The wavelength can be set to any of 350, 400, 450, …, 800 nm. For any wavelength one from 6 orientations of the polarizing filter (0, 30, 60, 90, 120 and 150 degrees) can be chosen. The field of view of the device is about 10 degrees and the sensor can be oriented to any position by computer-controlled robotic mount. The sensitivity of the photomultiplier can be controlled over 3 orders of magnitude, the dynamic range of the photomultiplier itself is another 3 orders of magnitude. So, the device is capable to characterize suburban areas, as well as dark-sky regions. Whole measurement is automated and can be controlled by a notebook, for example.

Preliminary measurements show a very interesting features in the polarization maps. Fig. 2a-c shows the analysis of the suburban sky near the Bratislava-city.

As can be seen in Fig. 2, significant features in the polarization patterns can be seen also in dark areas of the sky. This implies that the polarization brings an important information about light pollution of the night sky.

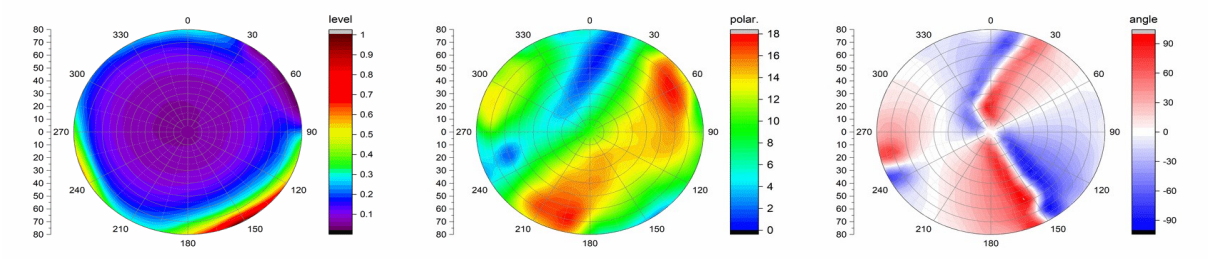

Fig. 2. The suburban sky near Bratislava city viewed at 600 nm (Bratislava is at azimuth of 150 deg, Vienna at 250 deg, Malacky at 20 deg). a) radiance (relative units), b) degree of polarization (in percent) c) angle of the main axis of the polarization ellipse relative to the local meridian (in degrees, -90 deg and +90 deg means the same orientation)

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Is there a relation between atmospheric elements and night sky brightness? Conducting a study in urban, sub-urban and rural areas

Aerosols are important modulators of night sky brightness (NSB) due to their manifold impacts on spectral and angular properties of scattered light. It seems obvious that more emitted artificial light at night is causing more light pollution. However, there are barely any detailed long-term studies about the relation to specified atmospheric elements and their impact to the resulting NSB. Connections between meteorological parameters and night sky brightness would improve not just the knowledge of light pollution in general but would also provide a useful extent of a theoretical sky brightness model, especially for predicting skyglow conditions. Moreover, locations for (potential) astronomical observations would profit from this. Especially in astronomical research, pristine night conditions are a prime factor in order to receive precise measurements. Particularly, in the optical wavelength scientist strive for cloudless, moonless nights with little to no light and air pollution. On such cloudless and moonless nights, light pollution can be primarily be effected by particulate matter, emitted mainly from low-emission sources, especially in winter. Ścięžor and Kubala (2014) found a clear linear relationship between the concentration of particulate matter and the brightness of the clear and cloudless night sky. Their measurements were done in Krakow, Poland, one of the most polluted areas in Europe. The aim of this work is to continue at this point and look at various atmospheric elements and their potential relation on NSB. This is possible in great detail by using data of the Upper Austrian light monitoring network, consisting out of 24 Sky Quality Meter (SQM) distributed over the provincial area, and air quality network. Data can be traced back to 2015 when the SQM-network was built. Atmospheric elements being able to be included are PM10, PM2.5, CO, O_3, SO_2, H_2S, NO, NO_2 and relative humidity. First results were presented at the LPTMM 2022 conference, now we want to draw a conclusion at the EALPO 2022 conference and show results separated for urban, suburban and rural locations.

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The night sky light pollution monitoring network in the city of Toruń – experiences from the first year of operation and assumptions for the future

Monitoring of selected environmental components is a key element in understanding complex processes taking place in the geographic space and in making their horizontal and vertical distributions. For the analyzes and visualizations to be representative of the entire settlement or geographical unit, monitoring should cover the largest possible area of impact of the phenomenon, and also ensure effective archiving of measurement data from the longest period of time. One of such components that has recently been subject to targeted monitoring and in-depth scientific research is the light pollution of the night sky. Interdisciplinary research groups from around the world are trying to find out about the properties and regularities in the spatial distribution of this phenomenon, although there are not many monitoring networks specially established for these purposes. Officially, only four such measurement networks can be distinguished in Poland.

In Toruń, from 2020, a measurement network measuring the brightness of the night sky is systematically expanded by the Faculty of Earth Sciences and Spatial Management Nicolaus Copernicus University in Toruń, which operates under the working name of the Toruń City Monitoring Network (SPMT). This network is based on LoRaWAN technology that enables wireless and low-cost data transmission over long distances. The use of this technology is in line with the assumptions of the *Smart City* idea and *Industry 4.0*, i.e. modern technology and IT solutions. To enable dispersed and simultaneous measurement in the city, a mobile, automatic measuring device was constructed, equipped with a LoRa module and a light sensor with high sensitivity, identical to that in the factory SQM photometers. Recorders of their own design have been tested both in laboratory and field conditions. In the area of Toruń and its vicinity, there are currently 19 such devices and 4 communication gates that collect data from end devices and send them to the central server.

This paper presents the process of creating and extension a network for monitoring light pollution of the night sky in Toruń along with the technical characteristics of the proprietary measuring device, as well as the main assumptions to be implemented in the near further future. Additionally, data recorded in the first year of SPMT's operational activity will be presented. It is now possible to compare the obtained results, not only spatially, but also temporally (seasonal variability).

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Assessing light pollution in environmental planning

Awareness of the effects of artificial light on human beings and the environment has recently increased. Scientists and planners are looking for ways to avoid the negative environmental impact that can result from artificial lighting. Germany has no applicable law aiming at the use of artificial lighting in outdoor areas. The task of environmental planning in Germany is to protect nature and landscape including biological diversity, the performance and functioning of the natural balance as well as the diversity, characteristic features and beauty of nature and landscape. Such protection includes management, development, and restoration. However, the landscape planning in Germany does currently not consider light pollution. It is not taking its responsibility to protect nature and landscape in this matter. It can be assumed that the insufficient consideration is due to a lack of knowledge amongst planners about how they can incorporate the issue. Therefore, the PhD-project will develop a recommendation for future landscape planning processes (as spatial planning or environmental assessment). This recommendation can help planners to include the topic of light use and its regulation. The resulting guideline will include each single step to carry out in practice when faced with a landscape and the task to assess the impacts of lighting in place.

Es a first step existing ways to measure and model light pollution have been reviewed to find those that are suitability for the use in nature conservation to map existing lighting. Furthermore, areas are identified that are particularly vulnerable to light pollution, either because of the occurrence of light-sensitive species or habitats or because of the landscape's aesthetics or its use. As a result of the overlay areas of conflict and undisturbed areas worth of protection are determined and assigned spatial planning objectives and measures that contribute to a reduction of light pollution in general and the negative effects of species, habitats, and landscape features in particular. Finally, the method should help planners in practice to integrate light pollution into landscape and spatial planning and thus provide a basis for the implementation of meaningful measures.

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Light pollution changes in terms of VIIRS measurements and numerical modeling

Aim of the work is to determine the level of light pollution changes over the years in the city of Trnava, Slovakia. The long term measurements from VIIRS DNB datasets for the period 2012–2020 in Trnava city are presented and analyzed. The Skyglow simulations of the same city considering varying artificially lit area and light source changes over the years are compared with SQM measurements and remote sensing data.

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Capturing of electromagnetic waves by decorated micro-mechanical (granular) systems formed as layered periodic structures

In this paper, we propose an approach to protection against electromagnetic radiation based on the provisions of modern photonics, in which the role of the main element is played by decorated micro-mechanical (granular) materials.

In his seminal work, Rayleigh showed that a plane wave propagating in a one-dimensional periodic unbounded structure is, for some wavelengths, completely reflected at fragment boundaries, called in modern terminology (accepted for structures such as photonic crystals) the band gap. In this case (upon the Bloch-Floquet theorem) the amplitude of the wave inside the periodic system decays exponentially. If the symmetry of the initial state of the system is violated, say, due to particular decoration, for example, due to formation of defects, the generation of exponentially growing and decaying components is possible with the formation of a mode localized in the vicinity of the defect [1, 2].

We will study the wave transport in a horizontal chain composed of isolated identical particles – granules under the condition that particles contact each other tightly, without breaks, and also experience oriented precompression configured along the chain axis, which does not violate the topological order. The system thus looks like horizontally alternating segments filled with undeformed particles and areas of their mutual overlap (so-called layered-periodic structure) [3].

We show that in such a systems with a decrease in the frequency of the corresponding defect, the corresponding components in the spectrum shift to the lower boundary of the band gap. This state does not correspond to the propagating models, and so in our model, which, however, corresponds to a real prototype (decorated granular chain), an electro-magnetic wave is “captured” by a defect, and “arrested” in some of its own vicinity.

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Multicolour photometry of the night sky with the ALPS network

Astronomical observatories in Poland are under increasing anthropogenic pressure exerted by the light pollution. The ALPS network was created for continuous monitoring of the sky in the observatories. The stations record images of the entire sky and measure its brightness. The goal of the network is to quantify degradation of the night sky due to artificial light.

Each station of the network is equipped with the SQM photometer and colour all-sky camera. Thus, accumulated data contain information on the sky brightness in four photometric bands. We present how this multicolour photometry can be used for better evaluation of the night sky over Polish astronomical observatories.

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The first results of light pollution measurements in the Transcarpathian Dark-Sky Park

On June 11, 2016, a memorandum on the establishment of the Transcarpathian Dark-Sky Park was signed in the Chorni Mlaky tract (Kniahynia village, Uzhhorod district). The Transcarpathian Dark-Sky Park (with an area of 46,302 ha) includes the territory of the Uzhansky National Nature Park (39,159 ha) and selected areas in the cadastral area of the villages of Sukhyi, Tykhyi, Husnyi, Lyuta, Ruskyi Mochar and part of the village of Velykyi Bereznyi.

Transcarpathian Dark-Sky Park is proclaimed in order to inform both the general public and experts in the field of astronomy about the problems of light pollution of the night environment and environmental protection. The park area allows everyone to conduct astronomical observations on its territory, free of light pollution, promotes astronomy among children and youth, as well as the development of astrotourism in the Transcarpathian region.

From June to November 2021, measurements of the night sky background were carried out in Transcarpathian Dark-Sky Park. All measurements were performed at night, when the Moon passes the following phases of illumination: New Moon or Crescent Moon. We carried out measurements along the perimeter of Transcarpathian Dark-Sky Park, namely: on Mount Yavirnyk (near the town of Velykyi Bereznyi), as well as near the following settlements: Lubnya, Knyahynya, Uzhok and Vyshka. For comparison, we also conducted measurements in Uzhhorod and in village Nyzhne Solotvino. Measurements was carried out by Sky Quality Meter (SQM-LU-DL), this device was purchased for the "Carpathian Starry Sky" project which was implemented and co-financed under the Cross-Border Cooperation Program Poland-Belarus-Ukraine 2014-2020, on the basis of the grant contract (project №PLBU.01.02-00-UA-0809/19-00) between the Ministry of Funds and Regional Policy of the Republic of Poland and the NGO "Institute of Development of the Carpathian Region".

In all places of the Transcarpathian Dark-Sky Park where we carried out measurements the average value of a background of the night sky was equal or more than 21.50 mag/arcsec^2. Continuous monitoring of the brightness of the night sky allows to record specific light pollution in each place, taking into account differences in weather conditions, climate and different phases of the moon, as well as the ability to study long-term trends. The modal value of the brightness of the night sky ranged from 19.73 to 21.92 mag/arcsec^2, which confirms the high variability of light pollution depending on the location of the site, in particular, the height of the site, its distance from major sources of pollution, and various climate changes, playing an important role.

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Urban lighting policies in practice: sustainability, light pollution and a night in the city. A comparative case study

Attempts at shaping or limiting an artificial lighting situation in urban planning are not a new topic of interest, but certainly not common. In particular, the overall control of light pollution has not yet covered large urban areas. The proper methods of lighting regulation are still not popularized, and the social awareness of the issue is described as low. At present, development of lighting policy that balances the brightness in city space after dark and the conditions of relative darkness, in the zones that require it, makes a great challenge. Given the yearly global increase in brightness and the current state of art in light pollution, regulation of this area appears to be inevitable, although still delayed.

The paper contains the study of five cases of lighting policy, preceded by the process of initial selection and comparative parameters determination. The following were selected for the research: Sopotnia Wielka in Poland, Flagstaff in Arizona, US, Austrian Vienna, the Canadian Capital Region – Ottawa and the case of Croatia. The aim of the paper is to enhance the practical knowledge of light pollution, as perceived from an urban perspective. The research focuses on the recognition of multi-threaded activities and regulations aiming at improving the quality of city lighting environment. Important part of the work is to indicate the methods of mitigating light pollution related phenomena, currently applied on urban areas through legislative instruments, urban planning and management.

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Science, legislation, regulatory initiatives and guidelines on the control of light pollution in México

In the path towards the economic growth and development of Mexico, the government has created a series of new regulatory guidelines on the atmosphere, besides its adherence to international treaties and agreements, thus ensuring a healthy environment. The Secretariat of Environment and Natural Resources has determined the need for federal light pollution (LP) regulations in the country. For this reason, the government convened a group of scientists and lighting technicians to establish a scientific protocol for a new normative. The protocol will follow a deep study of LP and will include recommendations to establish levels of radiance and irradiance, the spectral composition of light sources, their photometric characteristics, and the energy consumption in public and private spaces. This study will include three main points: 1 the development of a sky scanner and an experimental method for the retrieval of LP, 2 a theoretical characterization of LP in Mexico City, 3 a method for LP legislation in Mexican cities.

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A few reasons why people are increasingly photophilous and how this affects light pollution

For hundreds of thousands of years, the ancestors of modern humans lived in harmony with the natural rhythm and cycles of day and night, i.e., with the presence and absence of sunlight. The first breakthrough of this natural state was the conscious use of fire, which contributed to the lengthening of the time of 'day'. First, everyone would gather around the fire, next wooden fire torches were used to illuminate the roads and spaces, subsequently oil lamps were used, then – candles. However, a small single flame, emitting a dozen or so lux, would not provide adequate lighting: it was difficult to perform various activities in such conditions. Therefore, the power of the luminous flux was increased – by increasing the number of light points and the use of reflectors. Finally, in the 18th century people started looking for some kind of lighting improvement and until the mid-19th century all new solutions were based on an open flame (e.g., gas and kerosene lamps). The breakthrough came with the use of electric current, initially used in arc lamps and then to illuminate the first light bulb. Still, at that time, the process of burning (or rather incandescence) was at the source of light being emitted. Subsequent discoveries, ranging from the discharge lamp to luminescence, unlocked this correlation. The entire development of lighting has always had one basic goal – to create a light source with the best parameters: similar to sunlight, energy-saving and emitting as much light as possible.

This paper lists and compares some of the necessary levels of illuminance to perform specific activities as outlined in the norms. The author demonstrates that the required levels of illuminance have been increasing over the last 100 years and are likely to continue rising. The illuminance levels given in the guidelines take into account visual efficiency only, whilst the ease and comfort of vision and the so-called 'light environment' become parameters that the user has to provide for himself. It should be emphasized that the legal norms regarding the illuminance were defined at a time when the light sources were only incandescent and fluorescent lamps. An analysis will also be made of the change in behaviours and habits of dwellers depending on the change of light sources in their environment.

Nowadays, we are dealing with two new phenomena – the gradual withdrawal of light bulbs from everyday use and daily access to computer and smartphone screens. In 2029, 150 years will have passed since Edison introduced the light bulb, and in such a long time people have become used to its warm tone and good colour rendering parameters. The necessity to give up this kind of lighting brought on the replacement of light sources, with LED sources becoming the most common substitute, and forced a change of habits. Despite numerous works and improvements, LED light differs from an incandescent lamp light and has a relatively weaker colour rendering index. The way interiors are being lit is also changing from main general lighting to point task lighting. The human environment becomes an arena of interplay between many different light sources, complemented by the lights emitted by screens, and there are more and more of them, as it seems we – humans – have become very photophilous. We simply like bright interiors, ideally with large windows. These desires were picked up by architects, but instead of raising the windows as close to the ceilings as possible, the sash walls were lowered or eliminated, proposing French windows instead. This solution of portes-fenêtres does not provide more daylight, but limits the possibilities of space planning of apartments and contributes to a greater expansion of the evening light outside. This evening light in turn intensifies the light noise in the city, contributing to an increase in the overall luminance of city spaces.

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The boundless heritage of mankind. About the legal model for the protection of dark skies

The legal protection of dark skies is concerned not only with the right to a clean and sustainable environment (due to the problem of light pollution), but also with the right to the common heritage of humanity. The dark skies is a problematic object of protection from a normative perspective. Despite its unquestionable natural values, as well as its cultural attributes, it cannot be the subject of separate legal protection inscribed on the UNESCO World Heritage List.

The main obstacle is the impossibility of defining its borders and territoriality. On the other hand, the possibility to observe naturally dark and starry skies should be considered in terms of third-generation human rights. The aim of this paper is to present a model for universal dark skies protection that is feasible to implement in the relatively short term. The model indicated is based on providing legal protection for astronomical observatories with their buffer zones, which is acceptable in both common (international) and national legal orders.

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Light pollution in the area of the planned construction of a nuclear power plant in the Pomeranian Voivodship in Poland

Nuclear energy, despite many controversies related to it, is undoubtedly one of the ways to mitigate the effects of the energy crisis. So far, no power plant of this type has been operating in Poland. Starting from 2017, location and environmental research have been conducted in two locations: "Lubiatowo-Kopalino" and "Żarnowiec" in the areas of Choczewo, Gniewino and Krokowa communes in the Pomeranian Voivodship. Undoubtedly, this type of investment will also affect the level of light pollution in the area, in particular in the category of sky glow. Therefore, in October 2019, as part of the research carried out by the Light Pollution Monitoring Laboratory at the Cracow University of Technology, environmental studies were undertaken on the current state of this phenomenon in these two locations. The research covered an area of over 200 km^2. Measurements were made during the astronomical night, at designated measuring points evenly distributed along the 200 km detour route.

Measurements were made over two moonless nights. SQM meters and a sensitive luxmeter were used as the measuring apparatus. During the first night the sky was overcast, during the second night it was completely cloudless. The obtained results were compared both with existing model maps of light pollution and also with satellite maps of radiance distribution. By comparing the results of measurements of the sky glow brightness with the satellite photos, the main sources of light pollution were identified.

It was found that for all measuring points the cloudless sky is significantly brighter than the model predictions. In the overcast conditions, the impact of ground-based light sources on the brightness of the sky was assessed. It has also been found that in most cases the ground illuminance is in the range of 0.010 to 0.018 lux, which is comparable to that of the quarter Moon, but significantly lower than that of the full Moon.

Based on the research, it was assessed that the level of light pollution is significantly lower in the western part of the study area ("Lubiatowo-Kopalino") compared to the eastern part ("Żarnowiec"), which is related to the proximity of large urban centres in the first case, primarily city of Wejherowo, and with a dense network of brightly lit roads as well as small but brightly lit villages.

As is already known, the first Polish nuclear power plant will be built in the western area with a low level of light pollution ("Lubiatowo-Kopalino"). The performed measurements will be the basis for the future assessment of environmental changes after the power plant is commissioned in 2033.

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Education and lighting management as the key to protecting the dark sky. Narusa case study

The proper functioning of living organisms is closely related to the daily and seasonal rhythm of changes in the amount of natural light. The dynamic development of cities and the new buildings along with the accompanying infrastructure are the main source of light pollution of the night sky. Many organizations and governments around the world are now taking steps to protect the night sky from light. There are known model Dark Sky Reserves, the Dark Sky Communities program, good practices in the field of lighting that eliminates problems with bright nights, and multi-criteria certifications in sustainable construction. The common denominator of all these activities is minimizing light pollution. Often, activities are undertaken by representatives of various industries and scientific fields: astronomers, naturalists, experts in ecological construction, engineers and designers.

Eco-Masuria, in cooperation with committed naturalists, astronomers and local authorities, took steps to protect the dark skies over Narusa and Frombork City.

As part of the construction of the holiday complex, the investor obtained LEED pre-certification at the GOLD level for his aparthotel, meeting the certification requirements and guidelines of the specialists involved in the field of external and internal lighting, which must be friendly to the sky and birds.

As a part of promoting knowledge among clients and the local community, Eco-Masuria undertook educational activities. For less than a year, open field ornithological education has been organized regularly, introducing the subject of bird biology and ecology, with particular emphasis on the dangers of bright nights.

Regular astronomical meetings were also started, combined with night observations of the sky through the telescope, recognition of stars visible to the naked eye and the structures of the Milky Way.

In 2015, by the decision of the local government, Frombork and Narus were included in the area of health resort protection. A number of activities have been defined to ensure the integrity of the natural landscape of the spa, which fits well with the concept of protecting the dark sky. In favor of the subject of dark skies, the commune authorities made a decision regarding the recommended type of lighting for new investments. Work is currently underway on an agreement in this area.

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Complex neuroendocrine disturbances caused by light pollution – much more than melatonin

Circadian rhythms evolved in response to 24-h rotation of the Earth and help organisms to cope with environmental cycles. They are endogenous, enable time measurement and predict regular changes in environment to prepare in advance to periodic challenges. The endocrine system maintains a complex homeostasis in response to internal or external conditions. Thus, both circadian and endocrine systems help organisms to adapt and are mutually interconnected. The circadian system in mammals is hierarchically organized with the central oscillator localized in the suprachiasmatic nucleus (SCN) of the hypothalamus and peripheral oscillators present in all cells of the body. The main output pathways from the SCN to peripheral tissues lead via nuclei in the anterior and medial hypothalamus and are mediated by the neuroendocrine system, mainly circadian rhythm of melatonin, and other hormones, which are much less studied. The SCN is entrained via the light/dark cycle, which used to be the most reliable environmental signal for the whole evolution. However, during last decades this signal has been compromised by artificial light at night (ALAN), which is recently ubiquitous. The subsequent circadian disruption can affect functioning of the endocrine system, that controls the key biological processes, and their disruption can contribute to development of lifestyle (civilization) diseases.

In our studies, we exposed Wistar rats to ALAN (2 lx) for two weeks and measured 24-h rhythms of selected clock and clock-controlled genes, metabolites and hormones. By *in situ* hybridisation in the SCN we found strongly attenuated molecular clockwork, as indicated by the damped and lost daily rhythmicity in the clock genes *Per1* and *Per2*, respectively. Moreover, ALAN damped rhythmic expression of *Nr1d1* and arginine vasopressin (*Avp*) in the SCN and disturbed rhythmic clock gene expression in the paraventricular and dorsomedial hypothalamic nuclei that convey the circadian signals from the SCN to endocrine and behavioural rhythms. Disruption of these output pathways resulted in lost daily variations in plasma melatonin, testosterone and AVP concentrations and phase-advanced plasma corticosterone rhythm. Observed changes in corticosterone and AVP rhythmicity suggest a disturbed circadian control of stress response with a negative impact on the control of metabolism. Moreover, attenuated central *Avp* rhythmicity was related to disrupted daily rhythms in drinking behaviour. Lost circadian rhythm of the dominant androgen testosterone indicates that a part of reproductive problems in humans can be at least partially related to extensive ALAN exposure. Thus, our results illustrate a disruption of multiple circadian output pathways by ALAN and this mechanism can mediate a negative impact of light pollution on health.

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Somnambulism and blue light

Activity of humans exhibits a circadian rhythm, generated by endogenous biological clock. Periodic variations in ambient light intensity are the most important external cues (Zeitgeber) that synchronize diurnal rhythmical functions with the environmental conditions. Among the most basic circadian rhythms there is a sequence of sleep and wakefulness, which can easily be disturbed by adverse environmental factors including the presence of artificial light at night. In the two-process model of sleep regulation, first described by Borbély in 1982, the circadian process related to the changes in lighting (day and night), together with the homeostatic process (dependent on prior wakefulness) consist the basic mechanism ensuring the consolidated sleep at night and maximal alertness during the day.

Somnambulism involve getting up and walking around while in a state of sleep. Sleep walking episodes typically occur during the first hours of sleep, in patients whose brain is over stimulated. Movements in sleep may be limited to speaking or sitting in bed. The next levels of severity of symptoms can be getting out of bed and walking around the room, going out into other rooms, or walking around the neighborhood or even further. Accidents during these episodes can cause injuries, and sleepwalking is associated with worse sleep and subsequent day time drowsiness. While somnambulism episodes affect up to 15% of children, in most cases it recedes around puberty.

Growing usage of the electronic devices (mobile phones, laptops) and/or watching TV around bedtime increases an exposure to the blue component of light spectrum and contribute to the sleep disorders. In the Sleep Disorder Center of the Institute of Psychiatry and Neurology in Warsaw, only 3 adult patients were diagnosed with somnambulism between 2000 and 2012. Between 2013 and April of 2022 the number of such adults has reached 96.

Hypothesis: Refraining from using devices emitting blue light will help to recede or significantly reduce the severity of sleepwalking episodes.

Methods: All patients were asked not to watch TV and to stop using mobile devices minimum one hour prior to entrance to bed. After six weeks of treatment the patients who did not report the improvement were additionally prescribed with low dose of SSRI (selective serotonin reuptake inhibitor).

Results: Change in the pre-bedtime behavior eliminated episodes of somnambulism in 41 of 96 patients (42.72%) while 42 others (43.75%) achieved a marked improvement after the introduction of the mild antidepressant pharmacotherapy. The therapy was not effective in 4 patients (4.16%) and 9 persons did not attend the follow-up visit.

Conclusions: The growing number of episodes of somnambulism in adults may originate from an excessive exposure to the blue light around bedtime. Successful treatment comprises mainly the change in sleep hygiene supplemented in some cases with an antidepressant given in a low dose.

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Light pollution and chronodisruption of immune functions

Many aspects of immune functions oscillate in a circadian manner, thereby allowing temporal alignment of defense mechanisms with external environmental cycles as well as internal physiological processes. Disruption of circadian clocks has been shown to deregulate inflammatory response, consequently representing a driving force for development of chronic diseases. In our previous studies, we demonstrated that rats exposed to artificial light at night (ALAN) display attenuated circadian organization, including rhythms in the brain and periphery. Here, we aimed to examine the effects of low-intensity ALAN (~2 lx) on changes of leukocyte populations in the blood, and their infiltration into the kidney during acute inflammation. To evaluate time-of-day-dependent variability in inflammatory response, rats were administrated with lipopolysaccharide (LPS) either during the day or night phase. Endotoxin injection induced peripheral neutrophilia and recruitment of neutrophils into the kidney in both control and ALAN-exposed rats. In controls, a rise of blood neutrophils was more pronounced when LPS was applied at the beginning of the dark phase than during the daytime, whereas an inverted day-night differences were observed in renal neutrophil infiltration. Interestingly, the time-dependent response in peripheral neutrophilia was eliminated under the ALAN regime. Moreover, ALAN also disturbed the time-of-day-dependent capacity of blood neutrophils to produce the oxidative burst under the inflammatory conditions. In response to endotoxin, blood monocytes and T cells decreased, and an extent of this decline was dependent on time of LPS administration in control animals. On the other hand, day-night differences in monocyte and T cell inflammatory response were abolished in ALAN-exposed rats. Animals exposed to ALAN also exhibited higher renal neutrophil counts and higher renal expression of macrophage marker Cd68 compared to controls, specifically during the light phase, indicating disturbed steady-state daily rhythm of leukocyte trafficking between the blood and the kidney. Together, our data demonstrate that ALAN impairs time-of-day-dependent kinetics of leukocytes under both homeostatic and inflammatory conditions, pointing out an important linkage between light pollution and negative health issues.

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Light pollution as a possible factor disturbing balanced bat-virus relationships

Bats are a unique mammalian species due to their ability to fly. Moreover, they are extraordinarily long living without visible traits of morbidity and senescence suggesting their exceptional pathogen tolerance or resistance to infections. Being nocturnal, they also present a very promising model to study the effects of light pollution on animal physiology and behavior. The evening emergency of bats is influenced by the sunset time while the presence of Artificial Light At Night (ALAN) might dramatically modify the timing of bat activity. Majority of bat species is considered as "threatened" or "endangered" mainly because of their natural habitat destruction by various anthropogenic factors, light pollution being one the most detrimental. European bats are insectivorous and their response to ALAN seems to depend on the foraging strategy and flight technique with or without using of echolocation, and therefore they are divided into two groups, differently responding to the presence of light, i.e., light-tolerant vs light-intolerant. However, recently it has been shown that even in apparently light-tolerant bats the dynamics of population could be negatively influenced by the presence of ALAN. Thereby, research leading to a better understanding the consequences of light pollution on bat ecology progresses importantly, and the necessity to restore dark sky areas appears to be of the greatest urgency. On the other hand, knowledge about the functioning of the bat immune system is much less advanced, mainly due to the lack of many species-specific immunological tools, although recently a lot of fundamental data has been obtained. Namely, exceptional anti-viral resistance of bats has been shown to be based on the innate immune response with the most important role of the interferon system. As a significant light pollution has been observed in the region of China where the COVID-19 pandemics outbreak has happened, ALAN-mediated deterioration of the bat circadian system was taken into consideration as one of factors responsible for the spill-over of corona viruses, normally hosted in bats without any pathological symptoms. Above mentioned problems will be presented and discussed in the lecture with particular emphasis on the role of light pollution in disrupting the normal functioning of anti-viral immunity in bats. By ceasing to give bats a chance to live in harmony with nature, i.e., to enjoy the dark nights, we will probably jeopardize our chance to live a healthy life unless we learn from bats how to outsmart killer viruses.

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