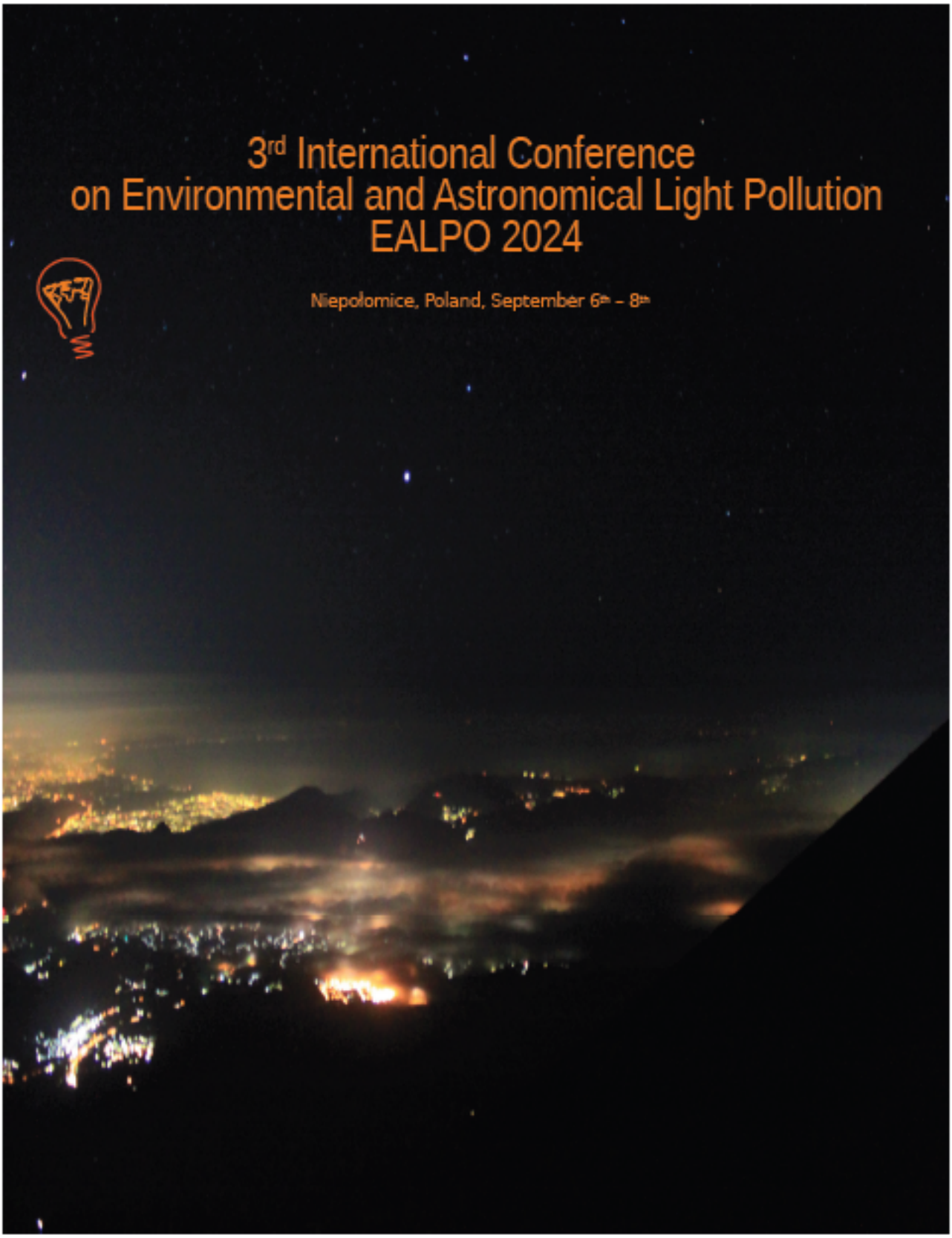
3rd International Conference on Environmental and Astronomical Light Pollution EALPO 2024

Niepołomice, Poland, September 6th – 8th



Cracow University of Technology
Faculty of Environmental Engineering and Energy

3rd International Conference on Environmental and Astronomical Light Pollution

EALPO 2024

Niepołomice, Poland, September 6-8, 2024

Polish Amateur Astronomical Society Publishing
Cracow 2024

SCIENTIFIC EDITOR
Tomasz Ściężor
Cracow University of Technology

REVIEWER
Krystyna Skwarło-Sońta
University of Warsaw

Tomasz Ściężor
Cracow University of Technology

PUBLISHER
Polish Amateur Astronomical Society
Miodowa 13a/35, 31-055 Kraków
Tel. 12 422 38 92
E-mail: sekretariat@ptma.pl

EDITORIAL OFFICE ADDRESS
Cracow University of Technology
Department of Water Supply, Sewerage and Environmental Monitoring
Warszawska 24, 31-155 Kraków
Tel. 12 628 28 30
E-mail: s-3@pk.edu.pl

Printed in Poland
Cracow 2024

ISBN 978-83-955493-4-2

Polish Amateur Astronomical Society Publishing

HONORARY COMMITTE

Mieczysław Janusz Jagła	President of the Polish Amateur Astronomical Society
Dominik Pasternak	President of the Youth Astronomical Observatory in Niepołomice
Stanisław M. Rybicki	Dean of the Faculty of Environmental Engineering and Energy, Cracow University of Technology

SCIENTIFIC COMMITTEE

Chairman:

Krystyna Skwarło-Sońta	Faculty of Biology, University of Warsaw *(Poland)*

Members:

Andreas Jechow	Department of Engineering, Brandenburg University of Applied Science *(Germany)*
Miroslav Kocifaj	Slovak Academy of Sciences *(Slovakia)*
Andrzej Kotarba	Space Research Centre, Polish Academy of Sciences *(Poland)*
Jerzy M. Kreiner	Astronomy Department, University of the National Education Commission *(Poland)*
Mieczysław Kunz	Faculty of Earth Sciences and Spatial Management, Nicolaus Copernicus University in Toruń *(Poland)*
Vladyslava I. Marsakova	Odessa National University *(Ukraine)*
Katarzyna Piotrowicz	Faculty of Geography and Geology, Jagiellonian University *(Poland)*
Marek Sarna	Polish Astronomical Society *(Poland)*
Katarzyna Szlachetko	Faculty of Law and Administration, University of Gdańsk *(Poland)*
Tomasz Ściężor	Faculty of Environmental Engineering and Energy, Cracow University of Technology *(Poland)*
Przemysław Tabaka	Faculty of Electrical, Electronic, Computer and Control Engineering, Lodz University of Technology *(Poland)*
Agata Zachariasz	Faculty of Architecture, Cracow University of Technology *(Poland)*
Karolina M. Zielińska--Dąbkowska	Faculty of Architecture, Gdańsk University of Technology *(Poland)*
Stanisław Zoła	Astronomical Observatory of the Jagiellonian University *(Poland)*

ORGANIZING COMMITTEE

Chairman:

Tomasz Ściężor	Cracow University of Technology

Secretary:

Anna Czaplicka	Cracow University of Technology
Anna Młyńska	Cracow University of Technology

Technical secretary:

Małgorzata Wojdak	Cracow University of Technology

Members:

Marcin Filipek	Polish Amateur Astronomical Society
Marek Kubala	Cracow University of Technology
Janusz Nicewicz	Youth Astronomical Observatory in Niepołomice
Agnieszka Nowak	Polish Amateur Astronomical Society

5th session (Civic activity in the dark sky protection)

Miroslav Kocifaj[1,2*], Peter Markoš[2], František Kundracik[2], John Barentine[3], Stefan Wallner[1]

[1]ICA, Slovak Academy of Sciences, Dúbravská cesta 9, 845 03 Bratislava, Slovakia

[2]FMPH, Comenius University, Mlynská dolina, 842 48 Bratislava, Slovakia

[3]Dark Sky Consulting, LLC, PMB 237, 9420 E Golf Links Rd, Ste 108, Tucson, AZ 85730-1317, USA

[*]e-mail: *kocifaj@savba.sk*

Night-sky polarization: Model vs. experiment

By way of brief background, our contribution concerns an aspect of measuring the brightness of the night sky that has been, until recently, overlooked by practitioners: the polarization state of the light. This is of particular value so as to completely characterize the light field, in particular given the increasing light pollution of even otherwise protected astronomical observatory sites. Interest in this matter is rising as advances in the sensing technology have permitted accurate field measurements of night-sky polarization that were difficult even a few years ago.

To date there is no successful, published model of night-sky polarization. We have constructed and tested such a model, which is the subject of our contribution. It shows excellent agreement with measurements, even in the context of a complex, real-world situation. Because it is the first realistic model of night-sky polarization that holds up well to experimental tests, we believe this represents an important advance in our understanding night-sky light as it tends to affect the astronomical observations.

Salvador Bará[1*]

[1]Independent scholar. Former profesor titular at Universidade de Santiago de Compostela (retired), 15782 Santiago de Compostela, Galicia, Spain

[*]e-mail: *salva.bara@usc.gal*

Trust, but verify: Reducing artificial light emissions and monitoring compliance

To reduce light pollution, we have to reduce the overall amount of artificial light emissions. This is a necessary consequence of the basic rules governing the propagation of light in the terrestrial atmosphere. In this talk we revisit the physical laws causing that (i) "all" artificial light emitted outdoors becomes lost or pollutant, (ii) the negative effects of light pollution depend monotonically on the local concentration of photons of anthropogenic origin, and (iii) this concentration depends linearly on the total emissions, weighted by the light pollution propagation functions.

Setting total emission limits becomes necessary in order to ensure that the negative effects of light pollution do not surpass red-lines of unacceptable degradation of the natural night. Once these red-lines are socially agreed, monitoring compliance becomes a relevant task. Several complementary methods for assessing total light emissions are being used nowadays, including public inventories of installed lights, direct radiance measurements from ground or satellites, and scattered radiance measurements using groundbased detectors (night sky brightness monitoring). While updated administrative inventories could in principle be trusted, independent verification is a must. The required measurements pose in turn significant challenges: we discuss here how the variability of the terrestrial atmosphere sets a lower limit on the minimum emission changes that can be reliably detected by measurements, and propose some ways to improve this performance.

František Kundracik[1*], Miroslav Kocifaj[1,2]

[1]Comenius University, Faculty of Mathematics, Physics and Informatics, Department of Experimental Physics, Mlynska dolina F1, 842 48 Bratislava, Slovakia

[2]ICA, Slovak Academy of Sciences, Dúbravská cesta 9, 845 03 Bratislava, Slovakia

[*]e-mail: *frantisek.kundracik@fmph.uniba.sk*

Identification of main light pollution sources by light pollution spectrometer

Main task, before any steps in lowering the light pollution can be entered, is to identify, which light sources in a city are mainly responsible for the light pollution in its suburban area. A night-sky spectrometer can help in solving this problem. Our simple but effective self-made light pollution spectrometer is based on Shelyak Aply-600 spectrometer and cooled Atik 414EX mono CCD camera was specially designed for such tasks. The measured spectrum of the light dome over a city can be decomposed into typical groups of light sources (high pressure sodium lamps, LED streetlamps, fluorescent lamps etc.). For the decomposition of spectra our SpectrumAnalyser program can be used. We have already demonstrated the effectiveness of such method in some case studies of night spectra over various places around Bratislava city.

Tomasz Ściężor[1*]

[1]Cracow University of Technology, Faculty of Environmental Engineering and Energy, Warszawska 24, 31-155 Kraków, Poland

[*]e-mail: *tsciezor@pk.edu.pl*

Light pollution measurement network of the Light Pollution Monitoring Laboratory of the Cracow University of Technology

The measurement network of the Light Pollution Monitoring Laboratory of the Krakow University of Technology (LPML) was established ten years ago, in 2014. They were preceded by a series of manual measurements of the brightness of the night sky conducted since 2010 in several points in Małopolska region using Unihedron manual Sky Quality Meters (SQM-L). In 2014, the first stationary meter of the SQM-LE type (connected to a computer), later changed to SQM-LU-DL (autonomous), was installed near the Dobczyce Reservoir, which is the drinking water intake for Kraków. Just a year later, an analogous SQM-LE meter was installed in the astronomical observatory of the Pedagogical University of Kraków (currently the University of the National Education Commission) on Mount Suhora in the Gorce Mountains. Both of these measuring stations operate continuously to this day. In the following years, SQM-LE or SQM-LU-DL meters were installed in many places in Małopolska. The installation locations were selected to enable studies of artificial sky glow impact in various environmental conditions, both in large cities and smaller towns and in protected areas, such as national parks. To date, fourteen measuring stations have been established in this way, thirteen of which are still operational today. Of these, nine have SQM-LU-DL type meters installed, and the rest have SQM-LE type meters. In the latter group, at three stations the meteorological parameters were additionally measured and images of the night sky were recorded using an all-sky camera. Such monitoring enabled numerous discoveries, including linking the brightness of the night sky with the concentration of particulate matter in the atmosphere or with the cloud cover. The results obtained from measurement stations allowed us to detect seasonal and long-term variability of the brightness of the night sky, mainly related to the increase in urbanisation and industry. Measurements made with public lighting turned off during the lockdown period due to the COVID-19 pandemic or currently for economic reasons allowed us to estimate the impact of this type of lighting on the brightness of the night sky. Continuous, uninterrupted measurements of the brightness of the night sky, carried out near the Dobczyce Reservoir, allow an attempt to verify the hypothesis about the influence of light pollution on the eutrophication of water in the reservoir.

It should be emphasised that in terms of spatial scale and temporal scope, the LPML network is unique not only in the country but also throughout Europe.

Natalia Konderak[1*], Waldemar Ogłoza[2]

[1]University of the National Education Commission, Institute of Biology and Earth Sciences, Podchorążych 15, 33-333 Kraków, Poland

[2]University of the National Education Commission, Institute of Technical Sciences, Podchorążych 15, 33-333 Kraków, Poland

[*]e-mail: *natalia.konderak@student.up.krakow.pl*

Measurements of light pollution with instruments

There are various kinds of instruments to measure light pollution, one of examples of such a device is sqm meter. It is a portable device that allows to evaluate the sky brightness at the location you are currently in. The purpose of this study was to present the preliminary results of light pollution measurements with the mobile sensor. Measurements of the change in the level of light pollution as a function of distance from the strict center of Krakow were carried out along several selected locations on moonless nights under different cloud cover conditions. These measurements were used to create and to present cross sections which showed how light pollution levels in Krakow change as one moves away from the city center. Similar measurements will also be carried out around other locations in the future.

Larysa Kudashkina[1*]

[1]Odessa National Maritime University, Department of Mathematics, Physics and Astronomy, Mechnikova 34, 65029, Odesa, Ukraine

[*]e-mail: *bogemakuda@gmail.com*

Development of an educational program for 'Astrotourism' in modern conditions of light pollution

A dark sky, free from light pollution, represents a unique natural resource that is becoming increasingly rare in the modern world. Dark sky tourism, based on the observation of stars and astronomical phenomena, not only contributes to the economic development of regions but also raises public awareness about the issue of light pollution. This work focuses on the development of an educational program aimed at popularizing astronomical observations under dark skies and visiting tourist sites under conditions of light pollution. The aim of the educational course is a comprehensive understanding of astronomy and skills in organizing astronomical excursions, including observations of astronomical objects and visits to places (structures) associated with astronomical activities.

The course includes the basics of astronomy, the history of astronomy, and the modern popularization of astronomical knowledge, as well as the ability to recognize and explain major astronomical phenomena and organize astronomical events and excursions. The course also includes analysis of the negative impact of light pollution on the quality of the night sky and an overview of modern methods and technologies for reducing light pollution. The main components of the program include lectures, practical exercises, observation sessions, and participation in the dark sky protection events. The program can be incorporated into educational institutions, tourist organizations, and local communities.

Ladislav Kómar[1*], Jaromír Petržala[1], Aleš Nečas[1]

[1]ICA, Slovak Academy of Sciences, Dúbravská cesta 9, 845 03 Bratislava, Slovakia

[*]e-mail: *usarlako@savba.sk*

Uplight fraction of selected European cities estimated from surrounding scattered radiation

The uplight fraction refers to the amount of light emitted upward from city light sources. Quantifying the uplight fraction is important for assessing light pollution levels in the city surroundings as well as rural areas and implementing effective lighting regulations to protect the environment and human health. Monitoring the uplight fraction changes can help identify areas where lighting improvements are needed to minimize negative impacts on the night sky. Measuring the city uplight is based on the knowledge of the lighting inventories containing complete information on lamp types, wattage, and shielding of the fixtures at all city-owned facilities However, compiling data on municipal lighting from cities world-wide is a challenging task. Not to mention additional vertical or inclined light sources that need to be taken into account in the overall city uplight calculation. Thus, the development of indirect methods for measuring city uplight is essential, particularly when comprehensive lighting inventories are not easily accessible.

Satellite observations of scattered radiation in the area surrounding the city can be used to estimate the city uplight fraction. Using a simple physical model based on light propagation in the atmosphere that uses nighttime satellite data from the Day-Night Band of the Visible Infrared Imaging Radiometer Suite (VIIRS-DNB) as input has demonstrated the potential for this task. This was done by looking at various statistical measures that check how well the computed and observed radiances of surrounding non-emitting pixels match up. We applied the model for several European cities to find the best Garstang parameter F, figuring out the overall percentage of uplight, while the ground albedo represented by the parameter G is acquired from conventional satellite measurements.

Monika Sitek[1*]

[1]University of Warsaw, Astronomical Observatory, Aleje Ujazdowskie 4, 00-478 Warszawa, Poland

[*]e-mail: *m.sitek4@uw.edu.pl*

The situation in the North Station of Astronomical Observatory of the University of Warsaw – light pollution in Ostrowik

The northern observatory station of the Warsaw University Astronomical Observatory was founded in 1948. The main Cassegrein telescope was launched in 1973 and is still used for science and teaching until now. Since 2020, the station has undergone extensive modernisation, with numerous components replaced with more modern ones. The changes will allow scientists to work more efficiently and will enable high-quality research to be conducted at national and international levels. Unfortunately, currently, the biggest problem of the station is not its equipment, but the quality of the night sky. Thanks to the station's measurements and those of the ALPS station (All-sky Light Pollution Survey), a progressive brightening of the sky has been observed. Negotiations to include the area around the station into a clear sky zone have been ongoing for years, but the municipal authorities are not favourable to this solution. The main problem is an expanding residential area that lights up the sky and the planned installation of street lighting. Interestingly, this is an area of the Mazowiecki Landscape Park, which attracts new residents. The station is located next to a newly built expressway which provides access to Warsaw in just 30 minutes. Up to now, the forests surrounding the station have been an ideal place for astronomical research, which was also the reason for choosing this place 76 years ago for an observatory station.

The situation of the station is becoming more and more dramatic – large expenditures have been made to modernize equipment that may soon cease to serve Polish astronomy.

A scheme of proposals for a protection zone and a document outlining the problem of widespread light pollution in the area of the Municipality of Celestynów, where the facility is located, and the Municipality of Kołbiel, which borders the station, have now been drawn up.

Dominika Daab[1*], Mieczysław Kunz[1]

[1]Nicolaus Copernicus University in Toruń, Faculty of Earth Sciences and Spatial Management, Department of Geomatics and Cartography, Gagarina 11, 87-100 Toruń, Poland

[*]e-mail: *ddaab@umk.pl*

Do snowy winters increase the brightness of the sky over Poland?

Light pollution of the night sky has been measured for several decades by researchers from all over the world in areas with different levels of anthropopressure. Due to its causes and, most importantly, its consequences, it is now an interdisciplinary issue with an increasingly noticeable negative impact of light pollution on the human life and surrounding natural environment. According to the published results of observations, significantly higher brightness of the night sky is observed in the centers of urban areas and in their vicinity, where there is a direct influence of external light on the surroundings. Several atmospheric factors, including cloud cover and particulate matter, affect the brightness of the night sky. The relationships between the measured surface brightness of the night sky and the occurrence of cloud cover is noticeable to numerous researchers. Another factor that can also enhance the intensity of this phenomenon is the presence of snow, which, through the multidirectional reflections from the white surface, further amplifies the light emitted by street infrastructure. In Toruń, multifaceted measurements of light pollution have been conducted since 2017. This work presents an analysis of the relationships between the observed brightness of the night sky and selected weather parameters using available analytical tools. The analysis includes the results of several years of observations collected at selected measurement sites located in the city center and outside its boundaries using factory-made SQM photometers.

Paweł Tysiąc[1*], Michael D. Wood[2], Karolina Zielińska-Dąbkowska[3], Katarzyna Bobkowska[1]

[1]Gdańsk University of Technology, Faculty of Civil and Environmental Engineering, Gabriela Narutowicza 11/12, 80-233 Gdańsk, Poland

[2]Environmental Research & Innovation Centre, School of Environment and Life Sciences, University of Salford, Salford, UK

[3]Gdańsk University of Technology, Faculty of Architecture, Gabriela Narutowicza 11/12, 80-233 Gdańsk, Poland

[*]e-mail: *pawel.tysiac@pg.edu.pl*

The path towards addressing adverse impacts of light and noise pollution on terrestrial biodiversity and ecosystems – Horizon EU project overview

The increasing presence of light and noise pollution shows significant challenges to biodiversity. The Horizon EU project titled "The Path Towards Addressing Adverse Impacts of Light and Noise Pollution on Terrestrial Biodiversity and Ecosystems (Plan-B)" addresses these issues through an approach, which integrates urban planning, and ecological, technological and social sciences. This presentation will detail the project's comprehensive strategy for mitigating the impacts of light and noise pollution, with a particular focus on terrestrial biodiversity and ecosystem services.

Key topics within the project include the ecological impacts of light and noise pollution, such as disruptions in wildlife behaviors, migration patterns, and changes in predator-prey dynamics. Therefore, the project explores how these pollutants contribute to habitat fragmentation and biodiversity loss, including protected areas like Natura 2000 sites. By its interdisciplinary approach, which includes integrating data from satellite imagery, field measurements, and citizen science, PLAN-B project aims to create a detailed understanding of the spatiotemporal distribution of light and noise pollution and their combined effects on ecosystems.

The results will discuss practical solutions, such as the implementation of policies or the use of technological solution systems. These measures are designed to minimize the ecological footprint of outdoor lighting, and enhance public awareness of the importance of preserving natural nightscapes. By engaging a broad range of stakeholders, including policymakers, environmentalists, urban planners, and the general public, the PLAN-B Project seeks to foster a cultural shift towards responsible lighting practices. What is important, this initiative is aligned with the EU Biodiversity Strategy for 2030 and other international frameworks, aiming to mitigate the negative impacts of light and noise pollution and support the restoration of biodiversity. The presentation invites conference attendees to engage in a multidisciplinary dialogue on implementing these innovative solutions.

Przemysław Tabaka[1,×], Tomasz Ściężor[2,×*], Anna Czaplicka[2], Natalia Słaboń[2], Aleksandra Tarnowska[2], Justyna Zając[2]

[1]Lodz University of Technology, Faculty of Electrical, Electronic, Computer and Control Engineering, Bohdana Stefanowskiego 18, 90-924 Łódź, Poland

[2]Cracow University of Technology, Faculty of Environmental Engineering and Energy, Warszawska 24, 31-155 Kraków, Poland

[×]Light Pollution Think Tank

[*]e-mail: *tsciezor@pk.edu.pl*

Illumination of the campus of the AGH University of Science and Technology in Krakow in the context of light pollution

Light pollution is a serious problem affecting human health, ecosystems and quality of life.

The aim of presented research was to identify sources of excessive lighting causing light pollution and to assess its regularity on the campus of the AGH University of Science and Technology in Krakow.

Light intensity measurements were made taking into account various categories of areas, such as sidewalks, roads, parking lots, building facades and vegetation. Numerous violations of lighting standards were demonstrated along with excessive. The excessive lighting of vegetation and building facades has also been observed. The 529 lighting fixtures were identified, more than half of which were defective, which led to uneven distribution of lighting intensity.

Spectral analysis of the light emitted by the lighting fixtures showed the variety of light sources installed in them, such as LEDs, high-pressure metal halide and sodium lamps, and low-pressure fluorescent lamps. The use of the equidensitometric method to measure the luminance distribution allowed us to identify the excessive lighting of vegetation and facades, which may cause ecosystem disturbance.

Research has shown that despite the reduction in radiance over ten years, the AGH campus remains an area with high lighting intensity, requiring further optimization. One of the main reasons for this situation is a significant number of milky ball lighting fixtures in which, approximately 40% of the light is sent into the upper half-space. The recommendations include the repair and maintenance of lighting fixtures, and in the case of lighting modernization, replacing opal ball fixtures with LED emitting light flux into the lower half-space merely. Such treatments will improve the uniformity of lighting and minimize its negative impact on the environment.

Przemysław Tabaka[1,×], Tomasz Ściężor[2,×*]

[1]Lodz University of Technology, Faculty of Electrical, Electronic, Computer and Control Engineering, Bohdana Stefanowskiego 18, 90-924 Łódź, Poland

[2]Cracow University of Technology, Faculty of Environmental Engineering and Energy, Warszawska 24, 31-155 Kraków, Poland

[×]Light Pollution Think Tank

[*]e-mail: tsciezor@pk.edu.pl

Colour filters as a tool for reducing blue light emission from LED sources in the context of light pollution

The energy efficiency of outdoor lighting can be improved, among others, by using more energy-efficient light sources. An essential criterion when designing new and modernizing existing outdoor lighting installations is energy efficiency with a clear environmental emphasis. It results from a belief that one of the contributors to alarming climate changes on Earth is excessively expansive human activity. One way to improve energy efficiency, which significantly contributes to reducing greenhouse gas emissions, is to reduce the demand for electricity. It should be emphasized that outdoor lighting constitutes a very significant and dynamically growing electricity consumer. The energy efficiency of outdoor lighting can be improved, among others, by using more energy-efficient light sources. LED sources offer substantial potential in this area. Outdoor LED lighting fixtures are produced in a wide range of correlated colour temperatures, from very low (e.g., 1800 K, 2700 K) to high (exceeding 6000 K). The most popular colour temperature values are 3000 K, 4000 K, and 5000 K. Spectral characteristics of LED sources emitting white light include a significant blue light component. This radiation has a significant peak in the blue light range (typically around 450 nm), which distinguishes them from traditional light sources such as high-pressure sodium lamps, less invasive to the environment.

In recent years, blue light emitted by LED sources has become the subject of numerous studies due to its impact on human health, the environment, and potential increase in night sky brightness.

This study presents the use of colour filters as a tool to limit the blue light emission from LED sources. The analysis focuses on several colour filters and their effectiveness in reducing blue light emission, as well as their impact on photometric and colourimetric parameters. Spectral transmittance coefficients were measured using a spectrometer. To assess the impact of individual filters on the spectral characteristics of LED sources, computer modelling was performed.

The results indicate that proper selection of filters can effectively reduce blue light emission, thereby limiting light pollution. However, it should be noted that this process is not without losses. Applying a filter to an LED source will reduce the emitted luminous flux resulting in a decrease in luminous efficacy, one of the measures of energy efficiency.

Anat Barnea[1*], Stan Moaraf[1,2], Monika Okuliarová[3], Rachel Heiblum[1], Abraham Hefetz[2], Inon Scharf[2], Michal Zeman[3]

[1]The Open University of Israel, Department of Natural Sciences, Raanana 43710, Israel

[2]Tel Aviv University, Faculty of Life Sciences, School of Zoology, Tel-Aviv 6997801, Israel

[3]Comenius University, Faculty of Natural Sciences, Department of Animal Physiology and Ethology, 84215 Bratislava, Slovakia

[*]e-mail: *anatba@openu.ac.il*

How are brain plasticity, behavior, and melatonin in birds influenced by light pollution?

We study the effects of artificial light at night (ALAN) on brain plasticity (BP) in the songbird zebra finch (*Taeniopygia guttata*). ALAN increases brain cell proliferation, which is the first stage of BP, when birds are exposed to low but ecologically relevant intensities, compared to controls that are kept under dark nights. The increase is intensity-dependent, as does a concomitant decrease of melatonin levels, indicating that ALAN causes perturbation of the circadian rhythm. These changes occur in both sexes, but to a lesser degree in males. We then studied the second stage of BP, which is migration of the new neurons to their target destinations and their recruitment in functional circuits in brain regions with different functions: Nidopallium caudale (NC), Medial striatum (MSt), and Hippocampus (HC), which process auditory, visual, and spatial information, respectively. In females, ALAN increases the recruitment of new neurons in all these regions, whereas in males, recruitment increased only in the MSt, and to a lesser extent, further indicating that males are more resilient to ALAN.

The increase in cell proliferation and neuronal recruitment under ALAN conditions could be a compensation for increased neuronal death (apoptosis) that is caused by ALAN. Under normal conditions neuronal densities are kept constant by neuronal replacement, where new neurons replace older ones that die, which is the third stage of BP. We found that ALAN causes higher neuronal death in MSt and NC and that it affects neuronal densities in a region- and sex-dependent manner. In males, ALAN did not affect neuronal densities, whereas in females we observed mixed effects, depending on ALAN duration (short-/long-term exposure). These findings suggest that ALAN causes apoptosis that is sex-specific and varies by region.

The indications that males are more resilient than females led us to study the song system in the brain, because it is male-specific. We chose two nuclei in this system, HVC (controls vocal behavior) and Area X (critical for song acquisition). Although ALAN causes an increase in neuronal recruitment in both regions, it decreases neuronal densities only in Area X, an additional indication for the differential and region-dependent effect of ALAN. The effects of ALAN on the song system might have ecological implications, because it could cause impaired or mistimed singing, which in turn might affect the males' fitness and survival, by decreasing their ability to attract females and defend territories.

Our recent findings support the suggestions that melatonin mediate the effect of ALAN on BP, and that the effect of ALAN on BP is related to behavior. We will also present ongoing studies, which investigate whether the effects of ALAN on BP and behavior are reversible, and whether they are general across behaviors and species, including wild ones. Finally, we will discuss the relevant, yet completely unknown, ecological aspects of life-long exposure to ALAN on BP.

Przemysław Tabaka[1,×], Krystyna Skwarło-Sońta[2,×*]

[1]Lodz University of Technology, Faculty of Electrical, Electronic, Computer and Control Engineering, Bohdana Stefanowskiego 18, 90-924 Łódź, Poland

[2]University of Warsaw, Faculty of Biology, Miecznikowa 1, 02-096 Warszawa, Poland

[×]Light Pollution Think Tank

[*]e-mail: *k.skwarlo-sont@uw.edu.pl*

ALAN and smartphone – two contemporary factors disturbing human well-being

Excessive use of artificial light at night (ALAN) is one of the fastest growing anthropogenic pollutants in developed countries. The recent introduction of energy-saving, and therefore cheaper, various types of light sources significantly contributes to the increase in outdoor light pollution. The negative effects of light pollution include its significant impact on living organisms, including humans. It has been well documented that the presence of ALAN disrupts the circadian organization of human physiological processes and behavior coordinated by the biological clock. Biological clock is a molecular mechanism present throughout the body, the main structure of which is a master clock located in the brain and synchronized with external light conditions by melatonin, the hormone of darkness. Melatonin is produced in the pineal gland in the darkness and immediately released into the blood, and its main role is to adjust the intensity of biological processes, which allows the body to function in harmony with environmental conditions. The adverse effect of ALAN on the biological clock results primarily from the inhibition of melatonin synthesis not only by various types of light sources but also by numerous electronic devices, e.g. smartphones willingly used at night. Inhibition of nocturnal melatonin synthesis, resulting mainly from the ubiquitous presence of light pollution, seems to be one of the main causes of the global increase in the incidence of the so-called civilization diseases.

Aim of present study was: 1) to assess the dependence of calculated melatonin inhibition on the color temperature of light (CCT) emitted by various types of light sources, both traditional and energy-saving, and 2) to assess the extent of reduction of blue light emitted by various models of smartphones operating in night mode.

It was found that high CCT light sources enriched with blue light (>2900 K) significantly inhibited melatonin synthesis, while the inhibition was negligible when CCT was lower. This effect was visible regardless of whether the sources were traditional or LED.

On the other hand, since a smartphone operating in night mode can regulate the emitted CCT, blue light emission was found to be reduced by 1.5% to 40%, depending on the smartphone model used. Therefore, in the case of individual regulation of the light color by the smartphone user, there is a risk of improper CCT control leading to the excessive inhibition of melatonin and, consequently, disruption of the proper functioning of the biological clock.

To sum up, it is necessary to emphasize the need to disseminate knowledge about the health risks resulting from the use of light enriched with blue waves in the evening/night. Moreover, modern electronic devices can substantially contribute to global light pollution, leading to a significant inhibition of melatonin synthesis and circadian rhythm disorders that are dangerous to health.

Anna Kołton[1*], Monika Czaja[2]

[1]University of Agriculture in Krakow, Faculty of Biotechnology and Horticulture, Department of Botany, Physiology and Plant Protection, 29 Listopada 54, 31-425, Kraków, Poland

[2]University of Agriculture in Krakow, Faculty of Biotechnology and Horticulture, Department of Ornamental Plants and Garden Art, 29 Listopada 54, 31-425, Kraków, Poland

[*]e-mail: *anna.kolton@urk.edu.pl*

Light pollution as stress factor for *Tagetes erecta* plants

Light is an important source of energy for plants but also is a factor regulating its growth and development. Insufficient or excessive amount of light is considered a stress factor for plants. Disturbed photoperiod as consequence of light pollution should also be recognized as stress for plants. To evaluate plant response to light pollution African marigold (*Tagetes erecta*) was used in the presented experiment. One part of plants was treated by light at night during cultivation in controlled environment chamber, second one was cultivated with photoperiod with light and dark phases (control). We observed that plants affected by light at night set flower buds nearly one month later. Also, its potential to conduct light phase of photosynthesis was disturbed. Chlorophyll a fluorescence phenomenon is widely used for plant stress detection and analysis. According to the results from chlorophyll a fluorescence measurements, potential for energy conversion in a photosynthetic electron transport chain was lower in plants with disturbed photoperiod and more energy was lost (dissipated). The content of assimilation pigments in the leaves was also reduced. This indicates the induction of a stress response in *Tagetes erecta* plants by a light at night.

Agnieszka Chechelska[1*]

[1]Cracow University of Technology, CUT Doctoral School, Faculty of Environmental Engineering and Energy, Warszawska 24, 31-155 Kraków, Poland

[*]e-mail: *a.chechelska@doktorant.pk.edu.pl*

Light pollution and eutrophication: current insights and implications

Eutrophication is a process by which water becomes excessively enriched with nutrients, particularly nitrogen and phosphorus, resulting in the rapid growth of algae and other aquatic plants. This growth disrupts biochemical balance of the water, leading to a deterioration in water quality. Recent studies have highlighted that light pollution, i.e. the excessive and misdirected artificial light, can exacerbate eutrophication by affecting the behavior and physiology of aquatic organisms and altering biogeochemical cycles.

This study aims to explore the intricate relationship between light pollution and eutrophication, highlighting recent research findings, mechanisms involved, and the broader implications for aquatic ecosystem health and water quality management. A comprehensive literature review synthesizes findings from various interdisciplinary studies, examining the effects of artificial lighting on nutrient cycles, algal growth, and zooplankton behavior.

Emerging evidence suggests that light pollution disrupts nocturnal behavior of zooplankton, reducing its vertical migration and subsequent grazing on algae, leading to increased algal biomass (Moore et al., 2001). Light pollution also induces nocturnal photosynthesis in algae, accelerating eutrophication (Bennie et al., 2016). Studies have shown significant alterations in chlorophyll-a concentrations under different light conditions, highlighting the complex relationship between light and algal growth (Mullineaux, 2001; Poulin et al., 2013).

Addressing light pollution is crucial for managing eutrophication and preserving aquatic ecosystems. Mitigation strategies should include policy interventions, technological innovations, and public awareness campaigns. By understanding and managing the impacts of light pollution, we can improve water quality and protect biodiversity.

Literature:

Moore, M., Pierce, S. M., Walsh, H. M., Kvalvik, K. K., & Lim, J. D. (2001). *Urban light pollution alters the diel vertical migration of* Daphnia. Verhandlungen Internationale Vereinigung für Theoretische und Angewandte Limnologie, 27. https://doi.org/10.1002/9780470694961.ch1

Bennie, J., Davies, T. W., Cruse, D., & Gaston, K. J. (2016). *Ecological effects of artificial light at night on wild plants*. Journal of Ecology, 104 (3), 611-620. https://doi.org/10.1111/1365-2745.12551

Mullineaux, C. W. (2001). *How do cyanobacteria sense and respond to light?* Molecular Microbiology, 41, 965-971. https://doi.org/10.1046/j.1365-2958.2001.02569.x

Poulin, C., Bruyant, F., Laprise, M., Cockshutt, A. M., Vanderhecke, J. M., & Huot, Y. (2013). *The impact of light pollution on diel changes in the photophysiology of Microcystis aeruginosa*. Journal of Plankton Research, 0 (0), 1–6. https://doi.org/10.1093/plankt/fbt088

Sicco Bauer[1], Christopher C. M. Kyba[2,3*] for the Nachtlichter Team

[1]Citizen scientist, Sternwarte Dresden-Goennsdorf e.V., Dresden, Germany

[2]GFZ German Research Centre for Geosciences, Telegrafenberg, 14467 Potsdam, Germany

[3]Ruhr-Universität Bochum, Universitätsstraße 150, 44801, Bochum, Germany

[*]e-mail: *kyba@gfz-potsdam.de*

Nachtlicht-BüHNE: a German citizen science project to create large area lighting surveys

Nachtlicht-BüHNE is a co-designed citizen science project, which investigates the proportion of different types of outdoor lighting. We developed an app that allows citizen scientists to easily and efficiently conduct lighting surveys.

Background: At the moment, the relative light emissions from different source types (e.g. streetlights, advertising, façade lighting, and light escaping from windows) is not known. Several researcher groups have examined the relative fraction due to street lighting, and have come up with values ranging from 12-100% (Kyba et al. 2020). This uncertainty complicates the interpretation of nighttime images for several research fields. For example, the relationship between energy consumption and light emissions observed from space is not proportional, because the identical light source appears brighter if it has emissions directly towards space than if the light is reflected from a partially observing surface like the grounds ground. It is also a problem for skyglow simulation, because light reflected from the ground propagates in different directions compared to light emitted by horizontal surfaces such as signs.

We categorized outdoor lightings by type and properties, including shielding, colour and size. During our 2021 campaign, citizen scientists were then asked to categorize and count all of the light sources visible from public spaces in a predefined area.

Results: This talk presents results from the campaigns using the Nachtlichter (night lights) app. These campaigns took place in 36 regions (in 10 countries) during fall of 2021, covering a total area of about 22 km2. We also present the results of comparisons between the counted number of lights and over 100 fully sampled VIIRS Day-Night Band pixels (based on the 15" grid of the Earth Observation Group).

Finally, we show the results of a comparison between our observed numbers of lights and different land cover areas. We find that private windows are the most common light type reported, and further, that illuminated streetlights and shop windows outnumber streetlights by 2 to 1 in urban areas of Germany. We also find that the number of lights observed per square kilometer in Germany corresponds to approximately 220 times the radiance observed by satellite instruments carrying the Visible Infrared Imaging Radiometer Suite Day Night Band (in nW/cm^{2}sr). Outside of Germany, the typical relationship is 120 times the observed radiance.

Wojciech Noga[1*], Jakub Konior[1], Krystyna Skwarło-Sońta[1], Piotr Nawalkowski[1]

[1]Polaris-OPP Association, Sopotnia Wielka 174, 34-340 Jeleśnia, Poland

[*]e-mail: *wojtekn1@gmail.com*

Sopotnia Wielka – International Dark Sky Community

Sopotnia Wielka, in Jeleśnia Commune, Poland, has been officially designated as an International Dark Sky Community by DarkSky International on November 11th 2023. This achievement marks the culmination of a grassroots initiative started in the late 1990s when local activists successfully negotiated with the local authorities to switch off some street lighting late at night. Since then, numerous activities have been undertaken by POLARIS-OPP Association members, dark sky experts and residents to preserve nighttime ecology. Sopotnia Wielka is one of nine villages in Jeleśnia Commune, located in the southern part of Silesian Voivodeship, approximately 35 kilometres from the nearest city and about 100 kilometres from the Katowice metropolitan area.

Sopotnia Wielka is situated in a valley of the same name in the area of the Żywiec Beskids mountain range (Pilsko massif). It is a typical woodcutters' village founded by Wallachian settlers and is associated with logging and slash-and-burn agriculture. Its first historical mentions are associated with the Polish king Jan Kazimierz (1609-1672), who, according to legend, drew excellent water from this area on his way to Vienna. In 2001, with the participation of young people and the local authorities, an information campaign began showing the positive economic and social effects of dark sky protection. As a result, an agreement to deactivate part of the street lighting system and reduce overall operational hours, starting in 2002, was reached. Thanks to these efforts, Sopotnia Wielka became a popular astro-tourism place. In the following years, both public and private lighting infrastructure continued to improve. Educational campaigns and meetings were conducted regularly to help residents understand the negative impacts of artificial light. The efforts of Polish dark-sky activists were crowned with the greatest success in 2011, when all 150 sodium street lamps were replaced with new lighting fixtures, fully shielded (upward light output ratio ULOR = 0%), with a correlated colour temperature not exceeding 3000 K. Apart from replacing street lighting, improvements to several home lighting systems have been completed. POLARIS-OPP association advises people on lighting policies, encourages residents to use proper lighting on private properties, and conducts educational activities directed primarily toward the local youth and tourists. Since 2013, the annual Dark-sky Festival has been organized in Sopotnia Wielka, near the period of Perseids maximum. While the event initially targeted Polish enthusiasts of astronomy and related fields, the Festival successfully marked its eleventh instalment as Poland's biggest dark-sky event. Over 30 years of efforts they resulted in Sopotnia Wielka being a community where dark skies are well protected. One of the latest steps was to adapt the newly formulated Rational Lighting Policy, which was created due to numerous consultations with DarkSky International and discussions with the local government. The policy's provisions have been included in the new Strategy for Development of Jeleśnia Commune for 2023-2030, approved by Jeleśnia's Council. Sopotnia Wielka now joins more than 200 places that have demonstrated robust community support for dark sky advocacy and strive to protect the night from light pollution.

Patrons

Cracow University of Technology

Partner Universities

Uniwersytet Wrocławski

UNIVERSITY OF AGRICULTURE IN KRAKOW

Media Partners

ISBN 978-83-955493-4-2