

An inventory of selected sources of light pollution in Tarnów

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Abstract

This article deals with the problem of light pollution, which is associated with the use of incorrectly constructed and positioned lamps, lanterns and reflectors. This problem is common in Polish villages, towns and cities, one of which is Tarnów. External lighting was analysed and evaluated in some areas of this city. This lighting was classified into the following groups: street, stylish, park, architectural and parking. This analysis enables solutions to the problem of excessive night-time lighting to be proposed.

Keywords: light pollution, Tarnów, inventory of lighting, improper lighting

1. Introduction

In the urban space of modern cities, towns and villages, there is a lack of natural night-time darkness that is necessary for the proper functioning of living organisms, including humans. Instead of darkness, artificial light has appeared. This light is the result of excessive, improper use of night lighting, which is often incorrectly constructed and positioned. When introduced into the night-time environment, it causes significant disruption and has several adverse effects. Night lighting is burdensome for the environment. The brightening of the night sky caused by artificial light scattered by various forms of aerosols contained in the atmosphere is one of the definitions of light pollution (Ścieżor, 2015; Pracownia Monitoringu Zanieczyszczenia Światłnego, 2020).

Light pollution is a problem that was noticed as early as the end of the nineteenth century. At that time, the harmful effect of lighthouses on the night migration of birds was described. A decreasing number of insects, which are birds' food, was also found. This phenomenon was connected with the lighting of city streets in Great Britain. Over the following years, subsequent effects of using artificial light were observed. However, the problem was only defined in the nineteen-seventies when it was described by astronomers. They introduced the concept of light pollution defined as the brightening of the night sky due to artificial lighting. The biological aspect of light pollution was the subject of further intensive research, especially in terms of the impact of excessive lighting on biological clocks and the behaviour of nocturnal animals. In the nineteen-eighties, the importance of this problem came to public awareness. In 1988, astronomers founded the International Dark-Sky Association (IDA). Its creation is recognised as the beginning of the protection of the dark sky. In subsequent years, at several different meetings, conferences and congresses, further aspects and problems related to light pollution were raised. The topics of these meetings included such issues as preventing excessive lighting and educating the public in this regard. Knowledge of the described issue has also been made available in Poland. Among other initiatives, in 2004, the "Ciemne Niebo" (Dark Sky) program was established, one task of which is to cooperate with local authorities on ways to reduce light pollution. National and international conferences on light pollution have been hosted in Poland since 2013, gathering specialists from various fields of science (Ogólnopolskie Konferencje, 2020).

Why should light pollution be treated as a serious problem? First of all, light pollution has several effects which pose a serious threat to the environment, and thus also to man. Among other factors, the change of the natural day and night cycle is a problem. The lack of night darkness results in disturbances in the spatial orientation of animals and alters the interrelationships between species. Excessive lighting has an impact on animals obtaining food or on their reproduction, as is the case, for example, with Florida turtles. Artificial light, mistaken for moonlight, causes them to lose their orientation after hatching and head towards the land, not towards the water. An excess of artificial light, also affects plants as it can be harmful to their flowering or growth (Kołomański, 2015; Siedlecki & Czaplicka, 2017).

It should be emphasised that, in the long-term, artificial light at night harms human health. It disturbs the natural biological clock, which is responsible for circadian rhythm. Hormonal balance is also upset, primarily with regard to the production of melatonin. Excessive night-time brightness contributes to such ailments as fatigue, anxiety and stress (Skwarło-Sońta, 2015; Siedlecki & Czaplicka, 2017). It is worth mentioning that the use of improper light sources also affects people's safety. For example, glare is particularly dangerous in road traffic; this is a phenomenon including drivers being dazzled after leaving a less illuminated road and entering one in which light sources with a much higher intensity are used (Kołomański, 2015; Ścieżor, 2019).

A severe effect of light pollution is also a waste of electricity needed for the operation of artificial lighting and thus constitutes a waste of money. Such a loss

of energy occurs when a light source is located in an improper place or emits light of an unsuitable or excessive intensity.

2. Tarnów – inventory of artificial lighting sources in selected areas

The problem of light pollution is common in Polish cities nowadays. The aim of this research was to check the extent to which it affects Tarnów, one of the cities located in the eastern part of the Lesser Poland province. For this purpose, the lighting of two main areas of the city was selected for detailed analysis. These areas are shown on the attached maps (Figs. 1 and 2). The first research area is the very centre of the city – the Old Town with its medieval layout and adjacent streets (Fig. 1). The second research area is located on the northern outskirts of the city (Fig. 2). The grounds of this area are partially built-up, by supermarkets among other structures. However, this area has a much lower building density than the former.

3. Classification of analysed lighting

All analysed lamps were divided into five categories:

- ▶ Street lamps, the main task of which is to illuminate communication routes;
- ▶ Stylish lamps (lanterns), i.e. whose which are stylised as nineteenth-century street lamps, located mainly on the Market Square and adjacent streets;
- ▶ Park lamps, i.e. those illuminating green areas, like squares or parks, and which are often spherical lamps – lamps with spherical covers;
- ▶ Architectural lamps, designed to emphasise the historical and architectural value of buildings, which are often so-called pavement lamps taking the form reflectors mounted in the ground, or elevation lamps which are wall spotlights facing up (bottom-up elevation lamps) or facing down (top-down elevation lamps);
- ▶ Parking lamps, illuminating car parks.

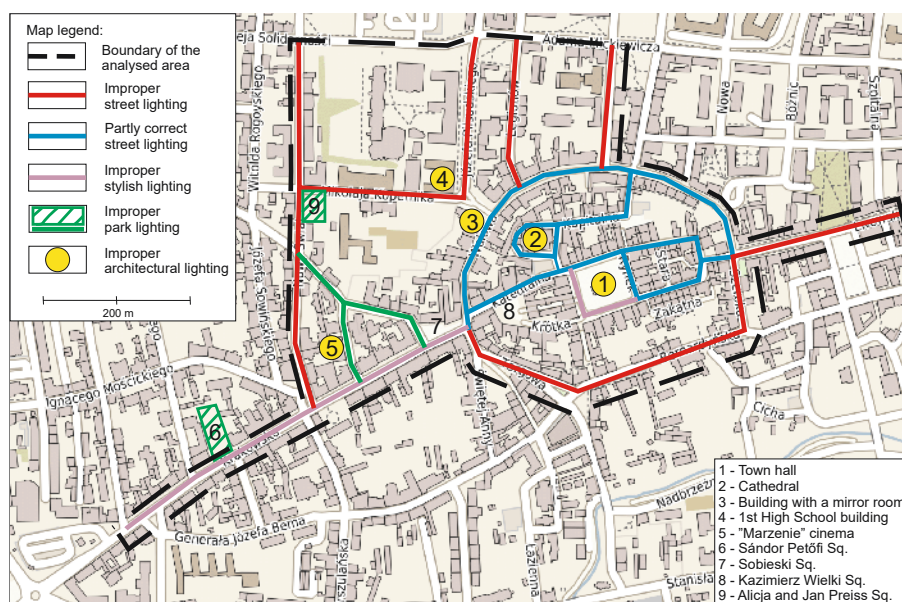


Fig. 1. Map of the centre of Tarnów with places marked where lighting analysis was undertaken (based on: polska.e-mapa.net)



Fig. 2. Map of the northern outskirts of Tarnów with places marked where lighting analysis was performed (based on: polska.e-mapa.net)

Due to frequent misunderstandings, it is worth explaining the technical terms used in the publication:

- ▶ Cover – the transparent part of the lamp holder;
- ▶ Shield – the opaque part of the lamp holder;
- ▶ Pole – the assembly upon which the lamp holder is mounted.

4. Street lighting

In the category of street lamps, the primary identified problems are with improperly constructed, convex covers upon which the light is dispersed. The second identified problem is the source of light being positioned too low in the shield. Such a difficulty is encountered in the case of the sodium lamp shown in Fig. 3. Sometimes, another harmful effect appears when the lamp cover is not mounted horizontally. As a consequence, most of the emitted light goes not to the streets or the pavements, but to the surroundings above. This causes, among other effects, light to permeate through the windows of residential buildings, where it disturbs people's sleep. Sometimes the lamps are located on poles that are too high and in effect, the pavement at the foot of the light source is poorly lit and a large amount of light is dispersed.

Figure 4 shows a situation in which an improperly shielded light propagates in all directions. Such propagation is an unfavourable phenomenon which is associated with wasting electricity and, consequently, is a waste of money. Furthermore, the permeation of light through windows by incorrectly directed light poses a problem. Such light disrupts the circadian rhythm of the inhabitants, causing problems with their sleep. Figure 4 presents this exact situation. The facade of the building is brightly lit and this includes the area above the lamp. The



Fig. 3. HPS lamp with an older type of shield, which are very common on Tarnów streets (photo by: I. Esmund)

Fig. 4. Street lamp with an older, inappropriate shield on Kopernika St. (photo by: I. Esmund)

light freely reaches the windows. External light permeating through the windows constitutes a problem for inhabitants of the residential building. Fortunately, in this case, this is just a school, so people do not stay there at night.

There is also another type of sodium lamp with a newer design on Tarnów streets, which contributes less to light pollution (Fig. 5). The filament is wholly hidden within the shield, but the lamp cover is still convex, so the light scatters on it.

Figure 6 shows the weaker upward emission of light from the newer lamps. Most of the light rays indeed illuminate the street, which is connected with the correct lamp setting. The factor that causes light pollution is, in this case, the convex cover upon which the light rays scatter. Insufficient lighting of the pavement on the street is another noticeable issue. Placing lamps between two lanes only makes the road well lit. However, the problem should not be solved by, for example, lifting the lamp shields. Such an action would increase the excessive lighting of the area, while at the same time deteriorating the illumination of the road.

Fig. 5. A lamp with a newer shield type but still with a convex cover (photo by: I. Esmund)

Fig. 6. The effect of using lamps with newer shields, Błonie St. (photo by: I. Esmund)



Tarnów also boasts examples of correct street lighting. These include LED lamps (Fig. 7), located on newly built or renovated street sections. These lamps have a flat shield, in which the LED panel is completely hidden. The construction used does not allow light to escape upwards. Furthermore, the lamps are positioned correctly, i.e. the lamp cover plane is parallel to the horizon.

Fig. 7. LED lamp of an appropriate construction (photo by: I. Esmund)

Fig. 8. Light directed in different ways on Błonie St. (photo by: I. Esmund)



Figure 8 shows LED lamps located on Błonie St. on the outskirts of Tarnów. This proves that the proper construction of artificial light sources, as described above, brings positive effects. The foggy weather demonstrates that the light is only slightly scattered below the line of the horizon. Incident light illuminates a specific space, only the street and pavement, nothing more. It should be noted that not all LED lamps are mounted in the right way. It may be even noticed that the orientation of each differs slightly from the orientation of the next. As a result, light is spreading at different angles. Lamps on the left side of the street are positioned more correctly.

Lamps with a sodium light source (HPS) (Fig. 9) located on the section of Jan Paweł II Ave. leading to the city borders can also be considered as examples of proper lighting. They are characterised by their correct shields, good positioning and an appropriate intensity of light, which does not dazzle drivers on busy traffic routes. The correctness of lighting is confirmed by the light shafts visible in Fig. 10, which fall mainly down on the street.



Fig. 9. A lamp with the correct construction on Jan Paweł II Ave. (photo by: I. Esmund)

Fig. 10. The use of lamps with the correct construction on Jan Paweł II Ave. (photo by: I. Esmund)

5. Stylish lighting

Stylish lamps are present in large numbers in the centre, within the Old Town, as well as on Krakowska St., from Wałowa St. to Krasińskiego St. Their shapes are adapted to the historical nature of these spaces and the existence of numerous pedestrian communication zones.

Within the Old Town, stylish lighting takes the form of lanterns with a sodium light source (HPS). Although they differ from each other, they are kept in the same style. These are either stand-alone lamps (Fig. 11) or they are attached to the walls of buildings (Fig. 12).



Fig. 11. A stylish free-standing lantern in the Market Square (photo by: I. Esmund)

Fig. 12. A stylish lamp attached to the building on Wałowa Str. (photo by: I. Esmund)

The stylish lamps are shielded from above with flat visors, so the upward escape of light rays is limited. However, it is difficult to say in which part of the shield the filament is placed because the opaque cover does not make this visible. The best solution would be with the filament located just below the visor. This would mean that the light would be directed towards the ground, where it is needed. The height of both the free-standing lamps and those attached to buildings is adequate. The environment is illuminated evenly, but the level of luminance is rather low. When the light reaches the ground, it no longer scatters too much in the atmosphere.

The night-time photos of these lanterns (Figs. 13 and 14) suggest that the filaments are placed too low in the shield. This is a disadvantage of this kind of light source. Figure 13 shows that the lantern illuminates the adjacent wall better than the ground. In Fig. 14, light is emitted in all directions. However, the use of such lanterns has also positive aspects. The wall lamps are mounted at the appropriate height, and the free-standing lamps are arranged with an appropriate frequency. The light intensity is correct, which contributes to both electricity savings and municipal finances. Numerous other examples of stylish lighting are sodium lamps located on Krakowska St. and the adjacent Sobieski Sq.

Lanterns, like the one in Fig. 15, are usually of an improper construction despite their striking appearance. They have round, transparent covers diffusing the light and shields in the form of a visor. However, the visors are too small and do not prevent the light from being directed upwards.

Fig. 13. A stylish lantern on the Market Square (photo by: I. Esmund)

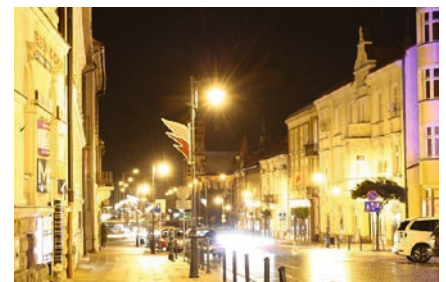
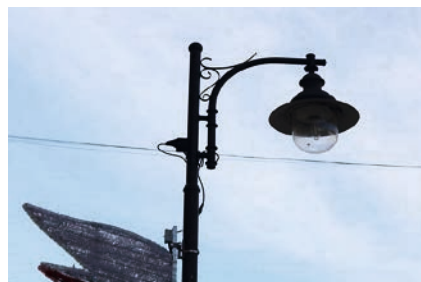
Fig. 14. A stylish lamp at night on Wałowa St. (photo by: I. Esmund)



The photo of these lamps at night (Fig. 16) shows that the shafts of light are distributed evenly in all directions, including upwards. This distribution confirms the incorrect construction of the lanterns. Furthermore, the intensity of their light is too high, which can dazzle drivers. Acting together with illuminated advertisements and illuminations of buildings, lighting chaos arises that distracts users of the space, not only drivers of cars but also pedestrians. Another problem worth noting is the brightly lit facades of buildings (Fig. 16), not only below the elevation of the described lamps. This phenomenon also indicates that the light rays are escaping upwards. This effect contributes to the light-trespass effect. This effect consists of lighting places that do not need to be illuminated, in this case, windows of buildings.

Fig. 15. A stylish lamp on Krakowska St. (photo by: I. Esmund)

Fig. 16. Stylish lamps on Krakowska St. at night. (photo by: I. Esmund)



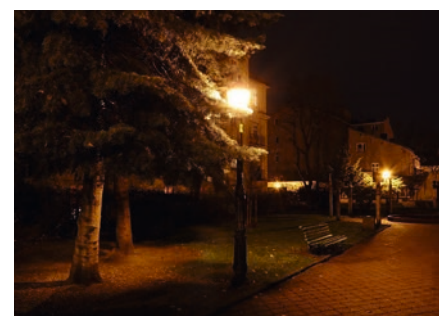
6. Park lighting

Park lighting is another group being discussed. In Tarnów, it can be found mostly in parks, as the name suggests. This kind of lamp also appears on squares (e.g. Sándor Petőfi Sq. and Kazimierz Wielki Sq.).

One of the inventoried examples of park lamps are those found on Sándor Petőfi Sq. on Krakowska St. (Fig. 17). In addition to the problems discussed earlier, Fig. 18 shows new issues worth addressing. First, grass and tree trunks are illuminated as strongly as the pavement. Even the shadow cast by one of the trees is visible. In this case, there is a phenomenon the light-trespass – light reaching places that it should not enter or where it is entirely unnecessary. However, the nearby pavement could be better illuminated. Worth noting is the darker area at the base of the lamp and the lighter area under the trees.

Fig. 17. A park lamp in Sándor Petőfi Sq., on Krakowska St. (photo by: I. Esmund)

Fig. 18. A park lamp in the square at night (photo by: I. Esmund)



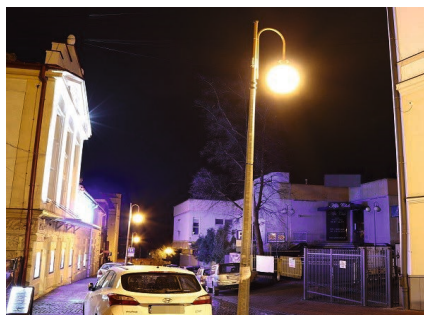


Fig. 19. Park lamp with spherical cover, Staszica St. (photo by: I. Esmund)

Fig. 20. Lamp with a spherical cover at night, Staszica St. (photo by: I. Esmund)

Another type of park lamp is the one with a spherical cover, without a top visor. An example of such a lamp can be found on Staszica St. (Fig. 19). The photograph of this lamp taken at night (Fig. 20) confirms that as a result of the lack of any cover, lighting causes the excessive emission of light into the environment and the pollution of the night sky with artificial light. As well as the ground, the lamp illuminates a fragment of the wall visible on the right. This is the most harmful and improper type of park lamp.

7. Architectural lighting

Architectural lighting is another type of lighting that has been considered when analysing light pollution sources. It is also referred to as architectural floodlighting. The purpose of architectural lighting is primarily to emphasise the historical and architectural values of buildings, increasing their attractiveness and beautifying the urban space in the evening and at night (Żagan & Krupiński, 2016).

Spotlights represent illumination lighting on the Tarnów Market Square. Their task is to outline the body of the Town Hall building and enable it to be admired after dusk, and maybe especially at night. The spotlights are located on the roofs of tenements surrounding the main city square (Figs. 21 and 22). They can also be found at the Town Hall itself.



Fig. 21. View of Tarnów Market Square with the spotlight marked (photo by: I. Esmund)

Fig. 22. The circled spotlight from Fig. 21 in close-up (photo by: I. Esmund)

The reflector presented in Fig. 22 is one of several that illuminate Tarnów Town Hall. Their construction is correct. Models with flat or even concave covers were used, as well as opaque shields; as a result of this, light is directed in only one direction. In this case, the light pollution is caused by the improper, practically vertical alignment of the reflectors. The light propagates horizontally instead of downwards. In this way, it is dispersed, and a large part of it is dispersed upwards.

Excessive lighting often enters the surroundings and becomes a component of light pollution (Fig. 23). The light is also directed through the windows of buildings, some of which are residential. Furthermore, high-intensity light is used, which may well illuminate the Town Hall but at the same time dazzles the users of the adjacent urban space. Instead of enhancing the architectural shape of the object, the light only illuminates its walls. The photo also shows frontage buildings with their illumination. This consists of bottom-up spotlights mounted

Fig. 23. View of the Market Square at night with a reflector illuminating the Town Hall (photo by: I. Esmund)

Fig. 24. Reflectors lighting from below to illuminate Tarnów Town Hall (photo by: I. Esmund)



on their walls, arranged so that the light spreads on the walls from the bottom up. As a consequence, it escapes into the environment and is dispersed.

Bottom-up reflectors are also mounted directly on the walls of the Town Hall (Fig. 24). They are directed straight up. Light travels a vertical path to the atmosphere above, where it disperses.

Reflectors of the same type are used to illuminate the Cathedral Basilica. As in the previous case, the lighting devices are mounted on the roofs of the neighbouring buildings (Fig. 25). They are directed towards the tower of the object. This arrangement is not completely vertical and light rays stop on the barrier, i.e. the walls of the cathedral tower. Moreover, part of the light is dispersed into the atmosphere before it reaches the illuminated object.

The conclusion is that the spotlights are too intense. It is true that, in effect, the walls are very clearly visible, but the architectural qualities of the building have not been emphasised in any way. It would be worth thinking about discrete lighting, highlighting the body of this building.

Fig. 25. The brightly lit tower of Tarnów Cathedral, shot from Wałowa St. (photo by: I. Esmund)

Fig. 26. Bottom-up lamps located on the building of Tarnów City Hall, Wałowa St. (photo by: I. Esmund)



Another example of improper illumination is lighting installed on the “building with a mirror room” at Wałowa St., where sessions of the City Council are held. Two types of architectural lighting illuminate it. The first are wall-mounted bottom-up floodlights (Fig. 26) in the form of elongated lamps situated on the walls of buildings and directed upwards. The second type represents lamps installed on the pavement, often called sidewalk lamps (Fig. 27). In Tarnów, they take the form of LED panels located on pedestrian routes, covered with tempered glass.

The presented reflectors (Fig. 27) are the worst example of architectural lighting. First of all, the streams of light are directed straight up; some of them are stopped, for example, by a ledge of the building. Lamps of both types significantly contribute to the formation of light pollution. By their arrangement, they dazzle users of public spaces. This remark applies mainly to sidewalk spotlights, which provide too much light. This situation is dangerous because they temporarily disturb visual perception. Additionally, these lamps should not be used at all to illuminate outdoor spaces. They do not conform to the requirements of paragraph 293, item 6 of the Regulation of the Minister of Infrastructure of April 12th, 2002 on the technical conditions to be met by buildings and their location. It says that external lighting devices cannot be the cause of a nuisance to space users. Sidewalk spotlights do not meet this condition. Both types of lamps emit light above the horizon, where it diffuses. The scattered light contributes to the formation of an artificial sky glow.



Fig. 27. Sidewalk spotlight at Tarnów City Hall, Wałowa St. (photo by: I. Esmund)

Fig. 28. Tarnów City Hall building at night (photo by: I. Esmund)

Figure 28 shows that too much light is emitted into the environment, especially from sidewalk lamps. The surface of the walls is illuminated, which does not serve to emphasise the body of the building or its architectural details. Lamps attached to the walls seem better in this respect. Their improper construction is associated with bottom-up lighting so that the light is directed upwards. It is worth noting that the top of the building is very brightly lit. The reason for this is the ledge blocking some of the light emitted both from wall reflectors and lamps in the pavement.

The buildings with illumination in the form of bottom-up and sidewalk lamps also include the one building of the First High School in Tarnów and the building of the “Marzenie” cinema on Staszica St.

8. Lighting accompanying large car parks

Large-scale service areas with car parks are present in modern cities, especially in their outskirts. Such spaces also require lighting.

Figure 29 shows an example of a newly created commercial space with an accompanying car park. It is located in the outskirts of the city, on Błonie St.

LED floodlights mounted on very high poles (Fig. 29) are used to illuminate the aforementioned car park. Such an installation allows the use of only a few sets of reflectors and the entire area is properly covered by light. However, this is not a valid method of lighting.



Fig. 29. Car park next to a large area store, Błonie St. (photo by: I. Esmund)

Fig. 30. Close-up of a set of floodlights illuminating the car park (photo by: I. Esmund)

The poles used are too high, which reduces the control over the distribution of light, leading to light of too high intensity. A large number of reflectors were used which emit very high intensity light; furthermore, the floodlights were misdirected. The planes of their covers are not parallel to the horizon, which makes the lighting dazzling for people (Fig. 30). The results of this design are such categories of light pollution as glare or intensification of the sky glow. Moreover, the light that leaks into space constitutes significant losses of electricity and, therefore, of money.

A view of the described car park at night is presented in Fig. 31. The applied light is so intense that it causes the phenomenon of glare. Our eyes are dazzled; a long time often passes before they adjust to the changing lighting conditions. This situation is hazardous, especially for drivers who suddenly reach this area from less-lit places. During the period while their eyes are adapting to the new light intensity, an accident or collision may occur. Additionally, a light-trespass

Fig. 31. View of the car park at night time (photo by: I. Esmund)

Fig. 32. Parking lighting effect visible from a greater distance (photo by: I. Esmund)



phenomenon occurs – the lighting of surfaces that should not be illuminated. This light illuminates the grassy roadsides and pavement by the main road, which is also lit by street lamps. These surfaces are therefore illuminated twice, which is entirely unnecessary. The floodlights used also contribute to an increase of the phenomenon of artificial sky glow, i.e. the light glow over the city. Therefore, all three categories of light pollution occur in the described area.

The effects of excessive and improper lighting, accompanied by autumn fog, are very clearly visible in Fig. 32. Moving away from the car park area allows one to notice the scale of the excessive lighting of this place. First of all, there is a glow from the parking space. It is also noticeable from more distant places than the point from which the above photograph was taken. Distinguishing each the lighting sources in it is not possible. The artificial glow comes from the entire parking space.

The phenomenon of artificial twilight occurs in the described area. Natural darkness, resulting from the season and the day, is disturbed by artificial external lighting. This phenomenon is harmful to the natural environment, including man. Brightness occurring at the time when it should be dark disturbs the circadian cycle of organisms. In humans, this causes problems with sleeping. When the body is exposed to night-time brightness for a long time, other health problems also arise. Such issues related to light pollution may arise in inhabitants of single-family houses surrounding the described area.

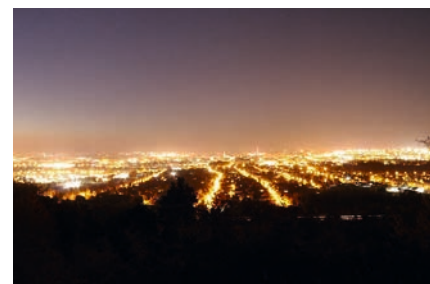
The Lasek Lipie (Lipie Grove) area extends just behind human settlements. This is a forest, one of the largest in Tarnów. It is inhabited by animals, such as birds, wild boars and deer. By the creation of a large, improperly lit shopping complex, they were also deprived of natural, much-needed night darkness.

In the close vicinity of this incorrect example of parking space lighting, there is another such square, also accompanying the commercial space.

Lamps used in the car park (Fig. 33) are correctly constructed. As can be seen in the photo, the light shafts are directed to the ground. There is no visible glare effect when looking at this area from a distance. The lamps used have the correct light intensity. They light up the car park sufficiently, without the effect of lighting the neighbouring city and significant energy (and thus financial) losses.

Fig. 33. View of the square near the shopping space at night, Błonie St. (photo by: I. Esmund)

Fig. 34. Panorama of Tarnów from St Martin's Mt at night time (photo by: I. Esmund)



All these analysed and evaluated light sources, as well as the others, not included in this paper, make up the panorama of night-time Tarnów (Fig. 34).

9. Suggestions for solutions

Knowing the problems caused by the use of the discussed examples of lamps, it was possible to propose several solutions that would reduce the phenomenon of light pollution.

First of all, street lamp covers should be replaced by flat covers which do not scatter the light. Their complete replacement with LED lamps should also be considered. However, for all types of lighting, including that used at the car park, care should be taken to position the enclosures correctly (i.e. parallel to the ground) so that the light is directed downwards, where it is needed. The height of each individual lamp pole is also important. It should be ensured that it is adapted to the place where the lighting is located. The presented actions will minimise, among other effects, light-trespass.

In some cases in the city, the street lamps do not provide adequate lighting for pavements along traffic routes. Therefore, it is proposed to use unique, low lamps with the appropriate setting, illuminating only pedestrian routes.

Another solution is the complete removal of architectural sidewalk lamps, illuminating buildings from below, because they do not comply with legal standards that are in force in Poland. They cause discomfort to space users who are dazzled by these reflectors. As for bottom-up lamps, it is proposed to change their setting to top-down so that the light travels from top to bottom. Thanks to this, the floodlights will neither contribute to the creation of artificial sky glow, nor will they cause glare.

Another solution is the use of opaque shields that will allow the light to stay below the horizon line, thus protecting the night sky. This solution applies to, among other types of lighting, park lamps with spherical covers. However, in the case of other examples of lighting, it is enough to slightly increase the size of their shields in relation to the location of the filament in order to stop excess light rays, e.g. in the case of stylish lamps.

10. Summary

After analysing the sources of artificial light in Tarnów, it was found that there are examples of both proper and improper lighting in the city. The proposed solutions are characterised by varying degrees of complexity and the amount of financial expenditure needed. However, it should be remembered that their use would result in a decrease of light pollution, and would thus reduce harmful effects on the natural environment. First of all, there would be significant financial savings. As a result of the correction of artificial light sources, part of the financial resources previously allocated to electricity can find other needed applications. Furthermore, lower energy consumption is a positive measure of environmental protection.

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Inwentaryzacja wybranych źródeł zanieczyszczenia świetlnego Tarnowa

Streszczenie

Publikacja podejmuje problem zanieczyszczenia świetlnego, który związany jest ze stosowaniem niewłaściwie skonstruowanych i ustawionych lamp, latarni i reflektorów. Problem ten występuje powszechnie w polskich miastach i miejscowościach. Zalicza się do nich Tarnów. Na części jego obszaru dokonano analizy oświetlenia zewnętrznego. Podzielono je na oświetlenie uliczne, stylowe, parkowe, architektoniczne i parkingowe. Wykonana analiza umożliwia zaproponowanie rozwiązania problemu nadmiernego nocnego oświetlania.

Słowa kluczowe: zanieczyszczenie świetlne, Tarnów, inwentaryzacja oświetlenia, niewłaściwe oświetlenie