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## ILUMINATION OF ARCHITECTURE. THE PROBLEM OF LIGHT POLLUTION

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## ILUMINACJA ZABYTKÓW. PROBLEM ZANIECZYSZCZENIA ŚWIATŁEM

### Abstract

This paper is an attempt to briefly present the problem of light pollution, concerning the illumination of both historical and architectural objects and its influence on environment. According to the measurements conducted in Kraków and Frankfurt am Main, the comparison and the analysis of the problem will be provided.

*Keywords: light pollution, illumination of architecture, Unified Glare Rating*

### Streszczenie

Niniejsza praca jest szkicową próbą przedstawienia problemu zanieczyszczenia światłem związanym z iluminacją obiektów zabytkowych na przykładzie analizy porównawczej natężenia światła na rynku głównym we Frankfurcie nad Menem oraz w Krakowie.

*Słowa kluczowe: zanieczyszczenie światłem, iluminacja zabytków, wskaźnik UGR*

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## 1. Introduction

Light in its form is a flexible and simple to manipulate matter, that allows achieving the desired goals easily. These days – thanks to the technical development – people are able to operate with light’s intensity, color, or play with the ways of its propagation. The field, which involves light waves is called illumination and is defined as “applying light, in order to show objects and their surroundings”.

Designing illumination requires insightful analysis of its influence on perception and artistic values (Fig. 1). Subjects of illumination may differ – they may include buildings, details of the building, streets, signs, monuments, as well as any structure and video mapping subject. Main purpose of illumination is to improve security of an object, or its attractiveness, understood as distinction from its surroundings.



Fig. 1. Light illumination of the historic objects in Kraków and Frankfurt

Excessive light has negative health effects on human body. Mainly, it can cause an effect called “glare”, which results in a feeling of discomfort, reduced ability to recognize objects or simply problems with sleep. Lights also confuse animals, especially birds, which can be light-blinded and hit the walls of the buildings. While light remains an essential part of historical spots of old towns, we have to bear in mind, that proper design and application is required in every stage of illumination, in order to avoid the negative outcomes of what we call the “light pollution”. In the paper [11] – are presented examined the effect of night shift work on breast cancer. In the paper [1] – are presented problems with astronomical survey of the sky.

## 2. The problem of light pollution

Putting esthetic values aside, it is worth to notice a problem of high emission of artificial light. “Light pollution” is defined as an excessive presence of artificial light in comparison to the natural luminosity of the night. Light scattered in atmosphere is perceived as “sky glow” – or so called “light fog”. This fog is related to the overall air pollution. Air pollution enhances light pollution trough increasing the amount of scattered light. It is easy to notice that nowadays the problem of photo-pollution increases – even if it is not as well known as air pollution and not such easily detectable. Light pollution can be determined as emission

of disturbing light. Disturbing light is an undesired light, that can cause irritation, interrupted vision, distraction or reduction of vision. The light pollution causes unnecessary escape of light to the areas, which are not supposed to be illuminated or are not the subject of the given illumination (ex. street lamps on the side of the buildings). Another side effect results in excessive light – the presence of lights, which are actually not needed; too bright, too numerous and without any particular purpose. The third side effect is the so-called light chaos, caused by a badly designed illumination, consisting of lights, which are poorly shielded or not shielded at all, badly installed, poorly directed or situated. Finally, the urban glow, often caused by street lighting and commercial premises lighting, which is usually pointed upwards and thus contributes to the phenomenon called “light fog” [2–10].

In our paper we would like to prove, that what looks pretty is not necessary good. As far as sound goes, people are aware of the term “noise pollution” but they are not aware of light pollution.

### 3. Method of measurements

The analysis features the illumination of historic urban areas; two European markets, which differ in surface and surroundings (Fig. 2).

The measurements were conducted during summer (no snow) on the main squares of Frankfurt am Main and Cracow. The sky was clean and relatively dark. The following results were obtained, according to the eyesight level values. All measurements were taken with use of photometer (Mastech MS6612 37450 – 0). The difference in the number of analysis points (positions at which the measurement was held) is caused by the difference of the area’s surface – Cracow’s area (0.03 km<sup>2</sup>) is about 3 times bigger than Frankfurt am Main (0.01 km<sup>2</sup>).

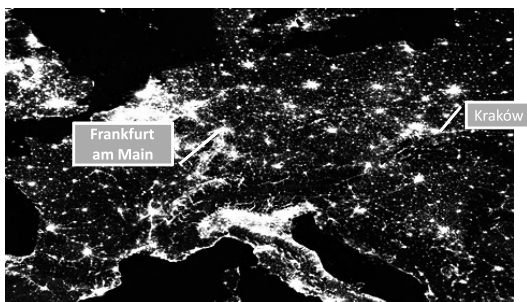


Fig. 2. Location of the examined objects on the light pollution map

### 4. Results

Firstly, it is very important to remember, that not only the areas vary, but so does the significance of those two places. The main square in Kraków is the city center, not only full of restaurants, but also of significant, internationally known monuments. In comparison, the main square in Frankfurt am Main is of lesser importance. This difference is easy to notice

during analyzing the diagrams above. In case of Kraków, the biggest amplitude is observed near the lanterns, the main sources of light needed in order to illuminate the monuments (e.g. Saint Mary's Basilica), as well as the openings of the main streets (Szewska, Floriańska). According to the results from Frankfurt am Main, the highest values were obtained in front of two spotlights illuminating the Church of Saint Nicolaus.

Diagrams no 3 and no 4 reveal the difference of luminous flux on the walls of squares.

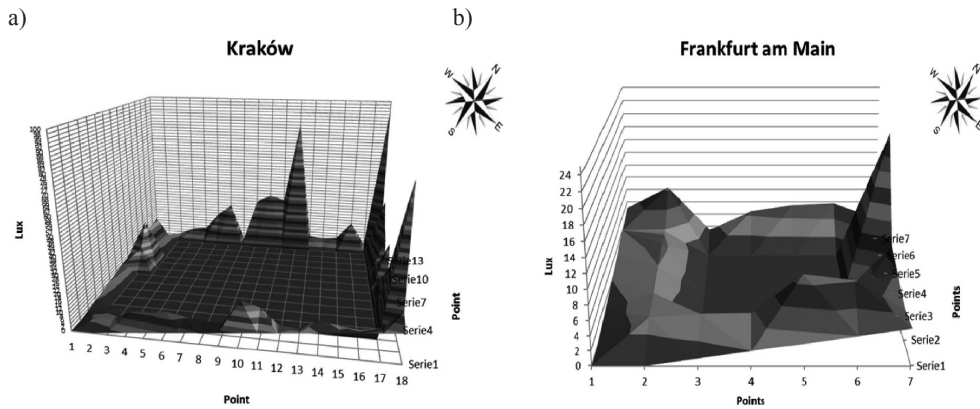


Fig. 3. Distribution of luminous flux on the Main Square, measured on the eyesight level:  
a) in Kraków, b) in Frankfurt am Main



Fig. 4. Glare effect on the Main Square in Frankfurt am Main (left side) (author: B. Rudnik)

In order to better understand the problem, we were also measuring the luminous flux on one side of the Main Square in Kraków – the NE wall. Moreover, the research was carried out in six different positions – from the base to the eyesight level, as shown on the Fig. 4. The highest amplitude – as mentioned above – is observed near lanterns located at the openings of the streets. What was noticed during the measurements is that the value of the luminous flux decreased as the street movement increased. Additionally, on the main market square in Frankfurt am Main, the glare effect was observed, which dimmed the surrounding area. This

effect was caused by a point light located in the southern part of the market. In Cracow, the main market square lighting is evenly distributed (Fig. 5 and 6).

Luminaries: the market in Frankfurt am Main and Cracow luminaries does not cause light scattering upwards. The shape of luminaries affects the scattering of light on the sides (Frankfurt) or concentrates the light downwards without scattering it sideways Cracow (Fig. 6).

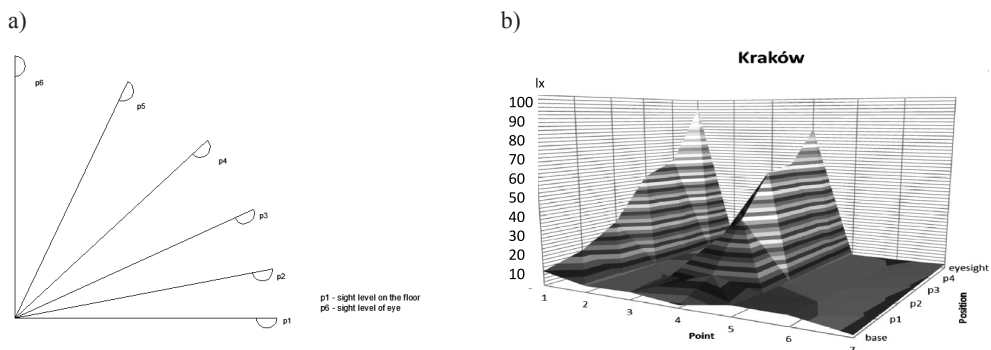


Fig. 5a) The position of photometer, b) The distribution of the luminous flux on the Main Square in Kraków at six different positions of the photometer for NE wall

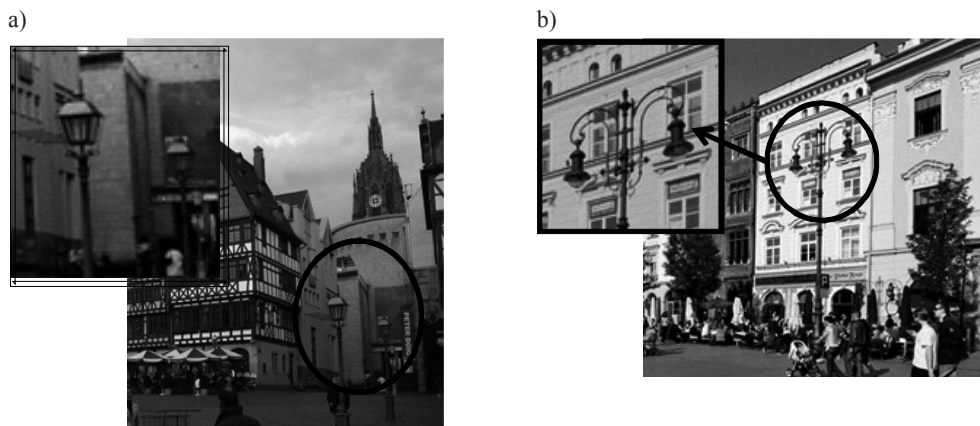


Fig. 6. Luminaries: a) in Frankfurt am Main, b) in Cracow

## 5. Conclusions

In this paper we demonstrated, that the choice of the shape of the light fittings for the historic sites can not be accidental, and even small differences in their shape are affecting the environment significantly. However, the lighting of historic areas is important for aesthetic

perception of the historic monuments. Selection of lighting fixtures because of their shape referring to the historical location, is not a sufficient criterion, as there may still cause various disturbing effects, such as glare. In order to properly evaluate the lighting in public open spaces, a Unified Glare Rating – similar to the one used in evaluation of the closed spaces – should be used as the basic parameter. Further direction of research should address the impact of night lighting on the health of both residents and nocturnal animals, as well as astronomical observations carried out in the historical areas.

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