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Research Article

Investigation of the Environmental Effects of Light Pollution which External Lighting Systems Caused

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ABSTRACT

Especially since the second half of the 20th century, important developments in the fields of science, industry and technology have emerged. In parallel with this development, the need to illuminate, especially to the artificial illumination, has increased. Artificial lighting systems have become almost imperative in interior spaces as well as in outdoor spaces such as parks, gardens, streets and city lighting. The most important factor that makes illuminating in outside areas a necessity is the sense of security that people feel safe. On the other side, from the ergonomic point of view, phenomenons such as selectivity and attention-grabbing have made external illumination compulsory. Nowadays, external lighting applications, which is an important part of city lighting, are not done correctly and in a planned way. The city lighting consists of parks, gardens, streets, roads, streets, sports facilities, tourist facilities, exterior lighting and security lighting systems. The problem of light pollution, which has become a big problem nowadays, has come into being when the above mentioned lighting systems are added to the lights that overflow from the internal volumes of the buildings. In the light of this information, the concepts of external lighting, correct lighting and light pollution are covered in detail. The factors that cause light pollution under the heading of outdoor lighting systems have been examined. Finally, the environmental effects of light pollution are determined by using the findings and solution proposal is presented.

Keywords: Light pollution, Environment, Outdoor lighting systems, Control of light pollution

Harici Aydınlatma Sistemlerinin Yol Açtığı Işık Kirliliğinin Çevresel Etkilerinin İncelenmesi

ÖZ

Özellikle 20. Yüzyılın ikinci yarısından itibaren bilim, sanayi ve teknoloji alanlarında önemli gelişmeler meydana gelmiştir. Bu gelişime paralel olarak aydınlatmaya, özellikle de yapay aydınlatmaya olan gereksinim artmıştır. Yapay aydınlatma sistemleri ise konut içi hacimlerde ihtiyaç olduğu kadar park, bahçe, sokak ve şehir aydınlatması gibi harici alanlarda da neredeyse zorunluluk haline gelmiştir. Harici alanlarda aydınlatmayı zorunluluk haline getiren en önemli faktör ise insanların kendilerini güvenli hissetmeleri duygusu yani güvenlik olgusudur. Diğer taraftan aydınlatmaya ergonomik açıdan bakıldığında seçicilik, dikkat çekicilik gibi olgular da harici aydınlatmayı zorunlu hale getirtmiştir. Günümüzde ise önemli bir kısmını şehir aydınlatmasının teşkil ettiği harici aydınlatma uygulamaları doğru ve planlı bir şekilde yapılmamaktadır. Şehir aydınlatması ise park, bahçe, sokak, yol, cadde, spor tesisi, turistik tesis, dış cephe aydınlatması ve güvenlik amaçlı aydınlatma istemlerinden oluşmaktadır. Söz konusu aydınlatma sistemlerine binaların iç hacimlerinden taşan ışıklar da eklenince günümüzde büyük bir sorun haline gelen ışık kirliliği problemi ortaya çıkmıştır. Bu bilgiler doğrultusunda

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çalışmada, harici aydınlatma kavramı, doğru aydınlatma ve ışık kirliliği kavramları ayrıntılı biçimde ele alınmıştır. Dış aydınlatma sistemleri başlığı altında ışık kirliliğini oluşturan faktörler incelenmiştir. Sonuç olarak elde edilen bulgulardan yararlanılarak ışık kirliliğinin çevresel etkileri belirlenmiş ve çözüm önerileri sunulmuştur.

Anahtar kelimeler:: Işık kirliliği, Çevre, Dış aydınlatma sistemleri, Işık kirliliğinin kontrolü

1. Introduction

Environmental problems due to rapid population growth, industrialization and increasing consumption of natural resources have reached levels that cannot be overlooked today. So;there is not any living that is not affected from these problems (Aydın and Özyürek, 2014). One of these environmental problems is the light pollution. Nowadays the light used to make people's lives easier affects the lives of people and other living things in a negative way because of being used in the wrong place,at the wrong time and at the wrong quantity. Light pollution makes astronomical studies difficult, harms natural life, causes unnecessary energy loss and thus harms to the natural resources and economy (Velioğlu and Nazife, 2008). These problems are getting bigger with the increasing usage of light. Especially in large cities and industrial areas incorrect enlightenment is causing pollution (Aksay, Ketenoğlu, and Kurt, 2007). In Figure 1, a light pollution ATLAS of the World is given.Light reflected from houses and bridges, vehicles and ship lights, and lightingsystems which usedat lightingofthe

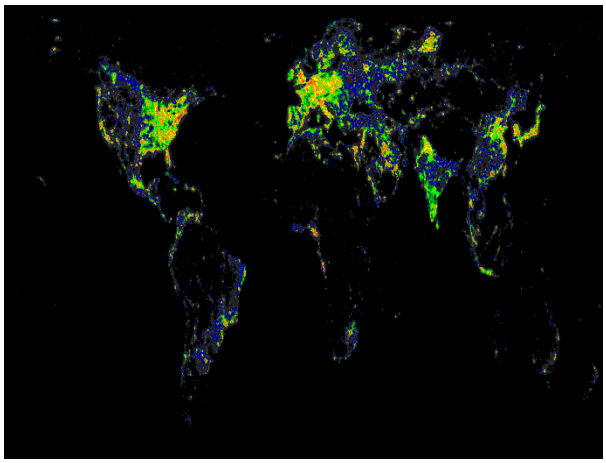


Figure 1. Light pollution atlas of the World (Lorenz, 2006)

streets also cause light pollution (Aslan and Onaygil, 1999). Poorly or incorrectly designed lighting systems are among the main reasons for these problems (Cinzano, Falchiandand Elvidge, 2001). Light pollution not only affects people but also affects many living things. Light differences between day and night have an important place in the life cycle of animals and plants. It affects nutrition, sleep, migration and reproduction cycles. Artificial light sources affect these cycles, which are determined by natural light sources such as Sun, Moon, and Stars. The migratory birds use constellations at night. However they can move to the wrong directions by following the dense city lights and die because of bumping to the buildings (Ülger, 2013).

Here are a few of the purposes of illuminating:

- Thinking in a safer environment,
- Providing better visibility,
- Create a better working environment,
- Making the environment more attractive and attracting customer interest (URL-1).

This study focuses on the environmental impacts of light used for different purposes and it is examined that how the artificial light sources affected animals and humans by giving examples.

2. Negative Effects of Light Pollution

Light, one of the reflectors of the modern world, is used almost everywhere in our daily lives. Almost every field uses different forms of light such as attention for children, triggers for perception of advertisers, lighting for city planning. Light sources, especially used for night lighting, have a big impact on world energy consumption. 19% of the total worldwide consumption of electricity constitutes energy utilized for the purpose of lighting. Approximately20% of the electricity consumed in Turkey is through components used for the purpose of lighting. (Şahin at all, 2016; Küçükdoğu, 2003). It is very worrying for future to waste energy generated by using natural resources in this way. The excessive light which is used to show the cities more modern causes sky glow especially at cloudy and dusty weathers. Sky glow is the biggest obstacle to astronomical studies (Dawson, 1984). The effect of asterisks in starlight is given in Figure 2 below.

Figure 2. Influence of sky glow on star display (IDA, 2017)

Unnecessary and intense light sources also have psychological and physiological effects on humans. Particularly in city centers (Figure 3), there is a lot of glitter in the eyes due to over-lighting, vertical light, flashing light and irregular light stacks. During the dazzling, the amount of light falling to the retina decreases, the pupil narrows. In this situation the eye cannot fulfill its seeing ability until the dazzling comes to an end. In addition to physiological effects, psychologically, excessive intensity of light is caused by stress (Ansarı, 2013).It is known that night and day differences of natural light are an important part of life processes of most animals and plants. Findings in the investigations and observations approves that the light is "attractive" to all living things. For example, in Figure 4, the picture drawn by William J Long (1901) shows how

much interest the frogs have on a small light source.

Figure 3. City view. Dense light, flashing lights, vertical light (Falchi at all, 2011).

Figure 4. Influence of a burning candle on frogs. A picture drawn by William J Long (1901) is an indication of how interested animals are in the light sources (Longcore, 2004).

It has been seen that such intensive and unnecessary artificial lighting in the environment, that is, the rate of light pollution is increasing and the life processes are adversely affected. The best known example of this is sea turtles breeding on the beach. After sea turtles lay their eggs on the beach, they leave the beach. (They protect their eggs in this way). The babies come out from the egg at night and try to reach the sea quickly. Because this migration is often performed at night, they use the wave sound and the reflection of the moon light in the water (Lutz at all, 2002). However, nowadays, unconscious construction and vehicle lights cause these creatures to be directed to different places instead of sea. For example, in figure 5 it is seen that the tortoises that have to turn to the sea are gathered around an artificial light. Turtles that cannot reach the sea in the required time are either destroyed by wild animals or because of their unsuitable life characteristics. So the sea turtles are about to become extinct.

Another example of the adverse effects of artificial light on animals is migratory birds. The migratory birds who benefit from the stars and the Moon to detect the night direction lose their way because of the sky glow and many of them are destroyed by turning around high buildings, searchlights (Poot at all, 2008).

3. Methods of Disposal of Light Pollution

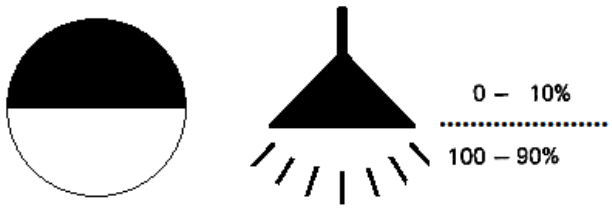
The main factor in the light pollution is the deviation of the direction of light from the desired direction.Therefore, the types of lighting are of great importance in terms of light pollution.

Figure 5. Sea turtle's tendency to light (URL-2)

In terms of light source, types of lighting are classified under two main headings as natural lighting and artificial lighting. Lighting made with the help of daylight and spaces like windows and doors is defined as natural lighting (Yener, 2007). It is called artificial lighting in case of providing illumination function with the aid of various lighting elements besides daylight (Özlü, 2008). Lighting is separated into five groups depending on how light comes to the surface, in other words, to distribution of lighting levels (Gordon, 2003; Şahin at all, 2014).

a) Direct Lighting

It is a lighting type that sends 90%-100% of light emerging from lighting tools directly to the plane to be illuminated. Figure 6 shows the symbol and basic principle diagram of direct illumination.



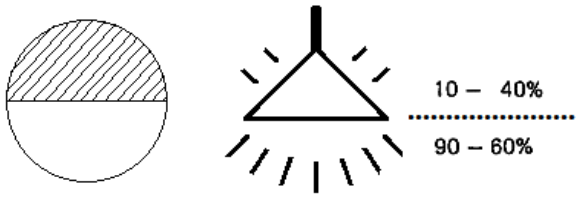
(a)symbol (b) Basic principle diagram

Figure 6. Direct lighting indication

Indirect lighting, sharp limits and shadows are obtained. The spotlight is the most important example of a direct lighting. Especially, in light of sizeable artworks, this lighting type must be used. For instance, volumes and shadows in sculpture exhibitions will be apparent with this lighting. However, spot applications should not be used in pictures and posters (Şahin at all, 2014).

b) *Semi Direct Lighting*

It is a lighting Type that sends 60%-90% of light directly to the plane to be illuminated. Ceiling lightings can be given as an example for this lighting type. Figure 7 shows the symbol and basic principle diagram of semi-direct illumination (Gordon, 2003; Şahin at all, 2014).



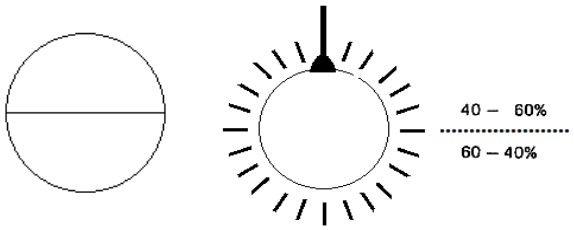
(a)symbol (b) Basic principle diagram

Figure 7. Semi Direct lighting indication

c) Diffused Lighting

It is a lighting Type that sends 40%- 60% of light directly to the plane to be illuminated. Ceiling and wall reflectors are the examples

of this lighting type. Figure 8 shows the symbol and basic principle diagram of the diffused lighting (Şahin, 2014).

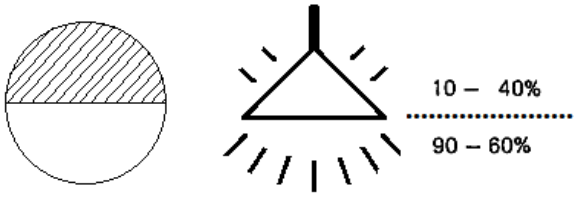


(a) Symbol (b) Basic principle diagram

Figure 8. Diffused lighting indication

d) Semi Indirect Lighting

It is a lighting Type made with armatures that sends 10%-40% of light downwards and remaining part of it to upwards. Here, it is aimed to ensure a dim and restful environment for users. Figure 9 shows the symbol of the semi-indirect illumination and its basic principle (Şahin, 2014).



a) symbol(b) Basic principle diagram

Figure 9. Semi Indirect lighting indication

e) Indirect lighting

It is a lighting type made with armatures that sends 0%-10% of light indirectly downwards and remaining part of it towards the ceiling and upwards. Figure 10 shows the symbol of the indirect lighting type and the basic principle diagram.

(a) Symbol (b) Basic principle diagram

Figure 10. Semi Indirect lighting indication

Indirect lighting is preferred in places with high reflection factor. Colors of ceiling and wall have an important effect (Yapar, 2007).

In the following Figure 11; Direct Lighting, Semi Direct Lighting, Diffused Lighting, Semi Indirect Lighting and Indirect Lighting are respectively given in (a), (b), (c), (d) and (e) respectively (Dursun, 2005).

External lighting:

External lighting is to illuminate outdoor areas. The surface to be illuminated is usually illuminated by direct light from light sources. Illumination of roads, airports, squares, tunnels, exterior surfaces of buildings and surroundings, sports fields, garages, docks etc. are included in this classification. As it is understood from the above definitions, the light pollution is a related concept of the light arrival angle to the surface, that is, the distribution of the light level. Figure 12 shows a parking area illuminated by diffused lighting.In order to remove the light pollution caused by the illumination made in this area, the following measure shown in Fig. 13 should be taken. Namely, the light is directed by using the reflector on the lighting element, and in this way the non-working light is prevented. That is, 90-100% of the light is directed to the

field to be illuminated by using direct illumination instead of mixed illumination.

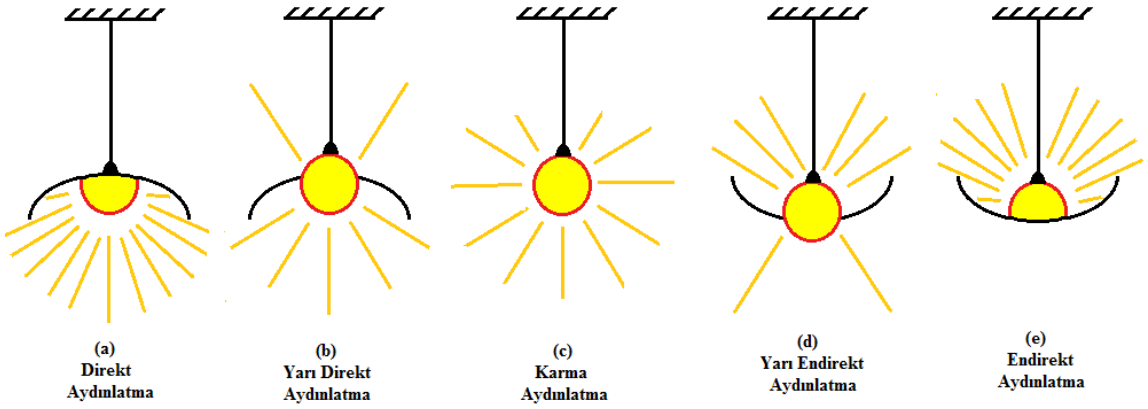


Figure 11. Types of interior lighting

Figure 12.A parking area illuminated by diffused lighting type (URL-3)

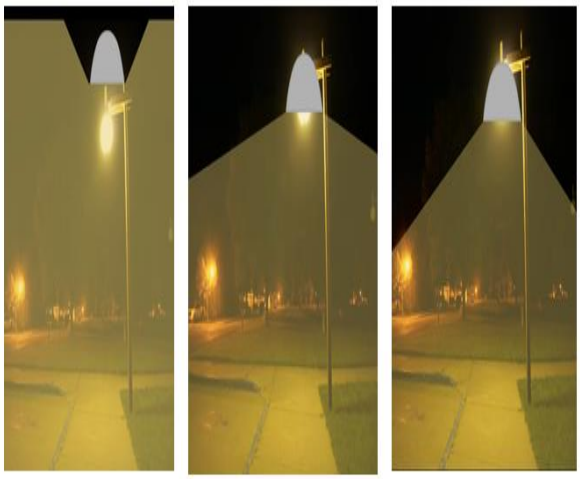


Figure 13. Blocking the ineffective light by using a reflector on the lighting element (URL-3)

4. Conclusion and Recommendation

As we have seen in our research, the use of wrong light has many negative effects on species.Some measures can be taken to reduce these effects. We can make serious savings on economy and consumption of natural resources, especially by minimizing the use of individual lights. Light pollution can be eliminated by supporting the projects of urban planning.The municipalities should monitor all light sources used at night and restrict the use of unnecessary and intense light in business firms.For the luminaires used in street lighting, suitable reflector and appropriate light color should be chosen and street lighting systems with automatic control should be used.The buildings of the tourism centers should be constructed away

from the beaches so as not to attract the attention of the sea creatures. Precautions against light pollution should be taken in the areas where our observatories are located. For these regions, stricter laws and regulations must be applied. Also, the type of lighting should be carefully selected, in safety lighting made in parks and gardens.

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