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The Effect of Different Floor Coverings Elements on Landscape Ergonomics

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Abstract

Lighting can also cause negative impacts like light pollution and temperature on living and non-living elements. Aim of the study is that determination of the light reflectance values of the floor covering used in landscaping. Study area was analyzed, current lighting systems in the study area were determined, and the current illumination values were measured by using lux meter. The differences of the illumination values, between the ground (0m.) and reflection from the ground (1.60m.) were determined statistically. The highest level of reflectance of light was water. Following the water as a ground cover; it has been determined that the light reflecting ratios of the lawn plants are higher. Concrete and asphalt surfaces reflect less light than other ground covers. Stone and wood usage should be preferred instead of rubber, concrete and asphalt materials. Natural stone should be used, in order to minimize light loss on the roads where asphalt material is used.

Keywords: Lighting, Lighting Design, Campus, Sustainable Design, Ecology

Farklı Zemin Kaplama Elemanlarının Peyzaj Ergonomisine Etkileri

ÖZ

Aydınlatma, ışık kirliliği ve sıcaklık gibi canlı ve yaşam dışı unsurlar üzerinde olumsuz etkilere neden olabilir. Bu çalışmanın amacı, peyzajda kullanılan yer döşemelerinin ışık yansıma değerlerinin belirlenmesidir. Çalışma alanı analiz edilmiş, çalışma alanındaki mevcut aydınlatma sistemleri belirlenmiş ve mevcut aydınlatma değerleri lux metre kullanılarak ölçülmüştür. Aydınlatma değerlerinin zemin (0 m.) İle zeminden yansıması (1.60 m.) arasındaki farklar istatistiksel olarak belirlenmiştir. Işığın en yüksek yansıtma seviyesinin su yüzeylerinde olduğu tespit edildi. Suyun ardından; çim bitkilerinin ışık yansıtma oranlarının daha yüksek olduğu belirlenmiştir. Beton ve asfalt yüzeylerin, diğer zemin kaplamalarına oranla daha az ışık yansıttıkları tespit edilmiştir. Zemin kaplamlarında; kauçuk, beton ve asfalt malzemeler yerine taş ve ahşap malzeme kullanımı tercih edilmelidir. Asfalt malzemenin kullanıldığı yollarda ışık kaybını en aza indirmek için doğal taş kullanılmalıdır.

Anahtar Kelimeler: Aydınlatma, aydınlatma tasarımı, kampüs, sürdürülebilir tasarım.

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1. INTRODUCTION

'Landscape lighting', which is a major part of urban lighting, has been playing a major role in the 'City Beautification' process (Rea, 2007). It can add aesthetic beauty, expand the number of usable hours, improve safety, add security and develop a desired image for any projects (IESNA 2000). Landscape lighting includes a wide variety of outdoor areas including both natural and built environments, like plants, architectures and sculptures and a few indoor areas.

For outdoor landscape, it can mainly be classified as softscape and hardscape. Softscape refers to the elements of a landscape that comprise live horticultural elements, like flowers, plants, shrubs, trees, flower beds, etc. Hardscape refers to the built environment including paved areas like streets, sidewalks, structures, rocks, cliffs, plazas, benches, planters and other site furnishings. Generally, landscape lighting could be classified into two types, reproducing lighting and reshaping lighting (Yao 2015).

Floor lighting is the most important part of outdoor scenarios. Floors are completing objects in landscape designs (Moyer, 1992). Landscape designs that do not include any plants are lacking. People's perceptions of floor design are not solely limited to daylight conditions; night-time lighting emerges as another dimension of this issue. However, at night, floors may not be noticed without lighting. Additionally, when floors are left unlit, it has unexpected effects on humans such as restlessness, irritation, tension, etc. (Millerson, 1991). Floor lighting not only creates positive psychological effects on humans, such as feelings of attractiveness and pleasantness (Gorp, 2000), but also emphasizes the physical characteristics of floor materials such as the texture, colour, etc. (Wilson, 1984; Moyer, 1998). Flynn et al. (1973) suggest that lighting conditions affect moods.

In that study, a conference room that had various lighting systems was prepared. Rating scale judgements were obtained for each lighting arrangement; the results showed a significant difference under different lighting systems. Another study by Flynn (1992) showed that the same lighting can create identical impressions in different settings. These and similar studies were generally conducted in indoor spaces. The current study integrates these studies with outdoor spaces.

Campus sustainability has become an issue of global concern for policy makers and planners as result of the realization of the impacts the activities and operations of universities have on the environment. The issue has also been intensified by the pressure from government environmental protection agencies, sustainability movements, university stakeholders as well as the momentum of other forces including student activism and non-governmental organizations (Savely et al., 2007; Alshuwaikhat and Abubakar, 2008).

The need for environmental sustainability in university campuses has been stressed in many articles (Barnes and Jerman, 2002; Viebahn, 2002; Shriberg, 2002; Bernheim, 2003; Cortese, 2005). Urban environments such as cities, which can support significant biodiversity in the form of both resident and migratory species, can be called urban ecosystems. This may be surprising if ecosystems are considered to be strictly self-maintaining, homeostatic, and essentially closed entities (Cadenasso and Pickett, 2008; Longcore et al., 2016).

The term sustainable design for the built environment is used interchangeably with green design. However, there is a subtle difference. The Green Design Education Initiative states that green design often implies an interest in design that protects people's health and well-being, while sustainable design also protects the global environment and the world's ecosystems for future generations (Erdem, 2012). Sustainable landscaping is low impact, low maintenance, low resource use and frequently low- cost landscaping that fits each particular site and climate – virtually taking care of itself. The landscape is unique among the construction elements because it involves a living and therefore perishable finished product.

In the context of this study, effects of nine different floor covering materials (grass, concrete, andesite, rubber, water, stone, wood, ground cover and asphalt) on reflectance are determined. Three different landscape design projects covering with different floor materials are analyzed for outdoor lighting. During July in cloudless days, LUX values were measured by using MT-4017 lux meter between at 20:00 -23:59. In conclusion, design based suggestions related to the use of floor materials in urban areas are made for decreasing light loos and for designing comfortable places in hot climate cities.

Aim of the study is that determination of the light reflectance values of the floor covering used in landscaping. Another aim of the study is; developing recommendations for minimizing light loss after determining these values.

2. MATERIALS AND METHODS

Niğde Ömer Halisdemir University Campus was selected as the study area in order to determine the lighting problems in urban spaces, and to develop suggestions for increasing the quality of urban life by eliminating these problems.

The study area is an urban place where different activities such as housing, education, social and cultural centres, sports fields and green areas, are combined and used for 24 hours. Therefore, healthy night lighting is needed. The other reason to select Niğde Ömer Halisdemir University Campus for study area is; to provide energy efficient cost design proposals to reduce the expenses of the University for lighting and to offer ground cover suggestions for landscape designs considering outdoor lighting.

In the first phase of the study; Niğde Ömer Halisdemir University Campus has been defined and land-use data on the study area were determined by using Arc-GIS. Maps which were obtained from related units were transferred to Arc-GIS software and the campus map has been made. In this way, areas values of usage within the campus were determined. In the second phase of the study; the location and height of lighting elements is determined. The current lighting design map of Niğde Ömer Halisdemir University Campus was obtained from Niğde Ömer Halisdemir University Construction and Technical Department and digital maps have been created with ArcGIS 10.1 software. In this phase the amount and type of bulbs and the heights of poles of each lighting element is digitized.

As a result of these analyses, an illumination map of Niğde Ömer Halisdemir University Campus was created. After the inventory of the current lighting system on the campus was completed, a lux meter was used to measure the lighting systems on the campus. It is found that is the average height of the people living in Turkey is 1.70m (TÜİK 2018). Using this data for the measurement process, the eye level of 1.60m height is found suitable for lux meter. In addition, in order to determine the reflection of lighting intensity values of the ground cover, the measurement was made at the ground of the same points (0.00m high). MT-4017 lux meter is used for the measurement process. Unit of lux meter is "lux" (not lumen).

Measurement processes, during July in cloudless days between at 20:00 -23:59 have been made. Measurement was done once because the area is large. The illumination values were determined by measuring 1 meter spacing for 30m along each lighting pole for four directions. Thus, the front, back and cross points of the lighting pole were measured. Also the measurement model to be applied on the area is shown in Figure 1.

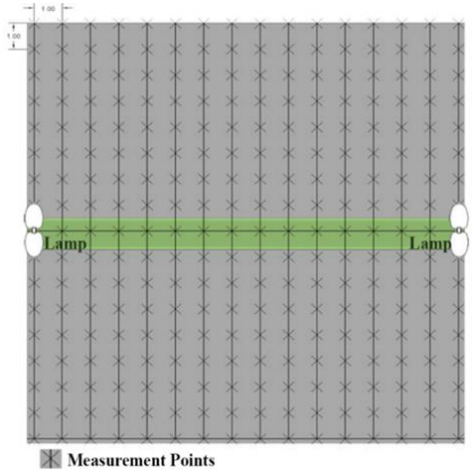

Figure 1. Measurement Model

After the measurement values were obtained, in order to determine the difference in lighting values for each ground cover (concrete, grass, soil, water, etc.), variance analysis in SPSS 20.0 software was used. And in order to determine the relationship between the ground covers, Tukey test was performed. In the final phase of the study; suggestions for outdoor sustainable lighting designs have been developed.

3. RESULTS AND DISCUSSION

The current area of land-uses at the Niğde Ömer Halisdemir University campus which have been calculated by using ArcGIS software, were determined that 64.30% of the settlements were covered with green areas, and the proportion of faculties, administrative buildings and classrooms within the campus was 5.16%. The area of land-uses within the campus is given in Table 1.

Table 1. Area and percentage of land-uses within the Campus

Land-use	Area (ha)	Percentage (%)	Land-use	Area (ha)	Percentage (%)
Main road	7.756	3.60	Heliport	0.025	0.01
Byroad	5.854	2.72	Court	0.110	0.05
Cycle lane	1.656	0.77	Car Parking	2.548	1,18
Patrol Road	2.153	1.00	Refuge	2.627	1.22
Educational Greenhouses	28.427	13.20	Sport Fields	0.509	0.24
Water	0.356	0.17	Assembly Area	0.528	0.25
Structures (Buildings)	11.107	5.16	Pedestrian Pathway.	13.208	6.16
Green Areas	138.430	64.30			
Total					215.294 ha

In accordance with the standards of CIE, the features of land-uses in the campus and the lighting poles in these areas have been stated. It is determined that LED lamp type is not used much in the campus, and sodium vapor lamps and energy saving lamps are preferred instead. Table 2 shows the features and numbers of the lighting poles preferred for use in the campus.

Table 2. Power of bulb, type, cap and numbers of units in land-uses

Land-use	Power of Bulb	Type	Cap	Units
Main Roads	250 Watt	Sodium Vapor Lamp	Double	107
Byroads	250 - 150 Watt	Sodium Vapor Lamp	Single	146
Patrol Roads	150 Watt	Sodium Vapor Lamp	Single	94
Car Parking Areas	150 Watt	Sodium Vapor Lamp	Single	63
Green Areas	23 Watt	Energy Saving Bulb	Double	260
	30 Watt	Energy Saving Bulb	Single-Double	13
	30 Watt	Ecotone Bulb	Double	250
Cycle Lanes	150 Watt	Sodium Vapor Lamp	Single	49
Sport Fields Areas	120 Watt	LED	3	21
Total				1,003

The length of the lighting poles used on the main roads in the campus was found to be between 11-12m. The lengths of the lighting poles used on the byroads were determined as 8m in some areas, and 11m in others. The use of different types of lighting elements within the campus was mostly in green areas. There are a total of 18 car-parking areas in the campus.

In order to illuminate these areas, a yellow light-emitting lighting element of 150-watt is connected to an 8m concrete pole within the campus. The projector type lighting elements are placed on the 8-10m poles are used for the lighting of the car park with a large vehicle capacity, located in the area which is considered as the center of the campus (beside the Rectorate Building). The use of different types of lighting elements within the campus was mostly in green areas. Most of these lighting elements are 3m long. In certain areas, lighting elements placed on 50-60 cm poles were used to lighten the areas covered with grass. Within the campus, lighting elements with a height of 1m were used to lighten the open - green areas next to the ornamental pond.On Niğde Ömer Halisdemir University Campus, lighting of green areas that is used extensively is provided by 23 watts of ecotone bulb placed on 3m high steel-galvanized poles.

In order to lighten the green areas near the ornamental pond in the campus, there are lighting elements of 30-60cm length and 30 watts. It is determined that there are 1 Olympic football stadium and 4x30m long artificial turf football fields in the campus. LED lamps are located in front of several specific areas of use, such as turf football pitches, and their numbers are quite small. In the campus, for the purpose of lighting the sculptures and ponds, projectors and surface lights placed on the ground were used. Lighting of outdoor sports areas is carried out by floodlights connected to high poles. The use of Niğde Ömer Halisdemir University Campus (main road, byroads, green areas, etc.) is classified according to ground covers. Generally, it has been determined that the asphalt is used on main road and byroads, concrete is used in car parks and squares, andesite ground cover is used on in pedestrian pathways and grass plants are used in green areas. In these areas, the measurements made on the ground and at the height of 1.60m were compared via statistical methods to determine the effect of ground covers on lighting. The averages and values of the differences are obtained, in accordance with the heights in each ground cover that are given in Table 3. The analyses were calculated with a 95% confidence interval.

Table 3. Differences between heights according to floor covers

Types	Min.	Max.	Std. Error	Std. Deviation	Average
Andesite	- 0.205 lux	6.531 lux	0.029	1.458	0.813 lux
Concrete	0.000 lux	22.463 lux	0.130	3.801	2.271 lux
Grass	0.362 lux	7.470 lux	0.007	1.130	0.274 lux
Asphalt	- 0.229 lux	7.155 lux	0.389	1.952	2.533 lux
Water	0.002 lux	0.000 lux	0.001	0.009	0.006 lux
Rubber	- 5.000 lux	44.000 lux	0.440	3.456	2.228 lux
Stone	-7.000 lux	30.000 lux	0.020	2.961	1.850 lux
Wood	- 16.000 lux	40.000 lux	0.532	1.933	2.205 lux
Ground Cover Vegetation	- 15.000 lux	58.000 lux	1.380	1.209	6.592 lux

According to Table 3, the highest level of reflectance of light was water. It was determined that the values of the lux measured on the ground, were higher than the values obtained at 1.60m. In this sense, it was concluded that water surfaces absorb light and reflect less upwards.

Following the water as a ground cover; it has been determined that the light reflecting ratios of the lawn plants are higher. The average of the differences between the measurements of lawn plants and andesite surfaces at 1.60m height was 0.274 and 0.813 lux, respectively. It has been determined that the surfaces with lawn plants reflect light more and consequently, so the light loss is minimized.

Andesite surfaces reflect more light following the surfaces with grass plants. According to the results of the measurements, concrete and asphalt surfaces reflect less light than other ground covers. When the results of the measurements made on the ground and the differences of the results at 1.60m height are taken into consideration, it was found that the light was most absorbed on the surfaces that were covered with plants, and as a result the loss of light was found to be at the highest level.

After the surfaces covered with plants, the highest light loss was found on the asphalt surfaces. One - Way ANOVA (one - way variance) analysis in SPSS 20.0 software was used to determine whether the differences between the ground covers were significant. The relationship between the differences in lighting according to ground covers is given in Table 4. According to the results of one-way analysis of variance found in SPSS 20.0 software, it was found that there was a significant difference between light reflectance rates of ground covers ($p < 0.05$).

According to the averages, concrete, asphalt, rubber and asphalt surfaces have been found to reflect less light to the ratios of grass, andesite and water, resulting in more light loss. Tukey test was processed to determine the inter-relationships among the groups. According to its results, water, grass plant and andesite formed a group among themselves whereas concrete, asphalt, rubber, stone and wood surfaces were found to form a separate group among themselves. It was determined that the surfaces where the ground is covered with plants emerged as a separate group from these groups.

Table 4. One-way analysis of variance of inter-group reflection rates

Ground Cover	Average	Std. Error	F	P
Andesite	0.813 lux [a]	0.029		
Concrete	2.271 lux [b]	0.130		
Grass	0.274 lux [a]	0.007		
Asphalt	2.533 lux [b]	0.389		
Water	-0.006 lux [a]	0.001	159.40	0.001
Rubber	2.228 lux [b]	0.440		
Stone	1.850 lux [b]	0.020		
Wood	2.205 lux [b]	0.532		
Ground Cover Vegetation	6.592 lux [c]	0.380		

[a b c] Groups formed according to Tukey test

In Niğde Ömer Halisdemir University Campus, grass was used instead of ground cover plants. It was determined that there was no difference between the measurements made from the ground and the measurements made at 1.60m in these areas. Besides, it has been determined that the lighting elements used to illuminate the green areas within the campus are used to lighten the ground, rather than the eye level.

Therefore, contrary to the ones mentioned in the sources; the amount of light which grass plant absorbs was determined to be low. In the walkways throughout the Niğde Ömer Halisdemir University Campus, it was found that generally andesite ground cover was used.

In these areas, it is determined that lighting elements are long, like the ones used for lighting of roads. Therefore, the reflectivity of light in these areas is high.

A significant difference was found between the groups formed ($p < 0.05$). As a result, it was found that the structural surfaces reflect more light compared to the vegetative and water surfaces, thus they lose less light values. In addition, Tukey test was applied to determine the differences between the groups and to determine the relationship of each ground cover to another. The results are given in Table 5.

It was found that there was a significant relationship between the measurement differences of ground covers ($p < 0.05$). Only there was no significant difference was found between the grass surfaces and the water surfaces in terms of reflecting the light ($p > 0.05$). According to Table 5, there was a significant negative correlation between grass plants and other covers.

Table 5. Distribution of Tukey test comparison on ground covers

	Ground Covers	Difference Between Averages	P
Andesite	Concrete	-1.457	0.001*
	Grass	0.539	0.001*
	Asphalt	-1.719	0.001*
	Water	0.819	0.001*
Concrete	Andesite	1.457	0.001*
	Grass	1.996	0.001*
	Asphalt	-0.261	0.001*
	Water	2.277	0.001*
Grass	Andesite	-0.539	0.001*
	Concrete	-1.996	0.001*
	Asphalt	-2.250	0.001*
	Water	0.280	0.486
Asphalt	Andesite	1.719	0.001*
	Concrete	0.261	0.001*
	Grass	2.258	0.001*
	Water	2.539	0.001*
Water	Andesite	-0.819	0.001*
	Concrete	-2.277	0.001*
	Grass	-0.280	0.486
	Asphalt	-2.539	0.001*

When the results of studies are compared in terms of the results obtained; it shows similarities in terms of the inadequacy of the current lighting system of the campus. However, differences were determined in terms of detecting the plant species that caused loss of lighting, in terms of ground cover. Examining the studies done so far, it is seen that the surfaces with grass plants have the least reflection rate in terms of lighting. But in the study, it was determined that the ground with the grass plant had the highest reflection rate. It is thought that the reason for this can be irrigation, the maintenance of the lawn, as well as the lighting elements used in this area. As a result of the study, it has been determined that andesite ground cover is the most suitable floor type in order to minimize light loss in places. Stone and wooden grounds can also be used as like andesite. In vegetative design, it is recommended that ground cover vegetation should be preferred instead of the surfaces with grass.

4. CONCLUSION

Landscape architecture works in ecological planning, field use planning, conservation of water, soil and visual values, nature restoration, creating usage areas in urban and rural environments, and in creating functional and aesthetic living spaces with living and non-living elements that is sensitive to environment, by examining the specifications the characteristics of the natural factors that make up the landscape and structure.

As a result of this, providing the correct use of colour and light while creating areas of usage, increases the importance given to human beings and provides the integration of the relationship between environment and people (Alper and Yılmaz, 2004).

In this period when we are experiencing the period of globalization and when even the slightest mistake to be made in the cities is difficult to compensate, instead of using random and incompatible lighting, master plans for lighting of the entire cities need to be created. Lighting with holistic approaches designed in line with these plans should be inevitable. Otherwise, like many current examples in today's world where ecology is too important to ignore, it can lead to cities which waste limited energy resources, which are extremely harmful to the environment, nature, inhabitants and the city itself, and create pollution of light (Brandi, 2006). Pollution of light in our country stands out between the environmental problems of urban spaces. Pollution of light is the use of light in the wrong place, at the wrong time and in the wrong amount. The overuse of light and using it in the wrong place, or the reflection of natural light, impacts human life and natural environment along with the pollution of air, water, and soil. It causes visual impairments because of the reflecting light, and creates uncomfortable and disturbing environments caused by excess light. In order to avoid light pollution, lighting should be correct and in-situ.

In sustainable lighting system design, planning should be made according to the usage. Lighting elements in green spaces should be designed separately. The lighting on the walkways and pedestrian walkways in the green areas should be different. In accordance with the result of analysis, it was determined that the poles that are 3m high, were suitable for walking paths in green areas. In order to lighten these areas, LED or energy saving bulbs should be used instead of eco-tone lamps. In this study, it is determined that the grass plants were the type of ground cover that causes the least light loss. If there is grass as ground cover on an area, shorter sized poles (0.60m) should be used. But in case of using high poles for lighting, ground cover vegetation should be preferred. Another reason for the choice of ground cover plants instead of grass is, the grass needs more maintenance and water, as well as causing more light loss in case of high lighting poles.

Apart from green areas, there are areas in the campus with hardscapes (roads, squares, playgrounds, water, etc.) As a result of analyses, it was determined that "andesite" is the least light loss ground cover. For this reason, andesite should be used in the ground cover of hardscapes in the Campus. Following the andesite, it was determined that the least light loss occurred on natural stones. That's why in green areas, usage of natural stone should be increased. Following the stone materials; wood materials can be preferred as they are one of the ground covers that cause the least light loss.

Analysis showed that; andesite, stone and wood usage should be preferred instead of rubber, concrete and asphalt materials. In particular, asphalt covers have been found to cause more light loss than other ground covers in lighting. Therefore, the use of asphalt in the Campus should be reduced. Natural stone should be used, in order to minimize light loss on the roads where asphalt material is used. In addition, terrace floorings should be used instead of rubber materials in playground areas.

Another important point to consider in the landscape design in the Campus, is the color of the ground coverings. Light colored materials should be preferred while designing. Thus, the degree of light absorption can be reduced and the light loss can be kept to a minimum.

As a result; in the context of landscape design in urban areas, the qualities of the lighting elements presented to the users should be determined according to the area and the function of that area that will be lighted, and also visual comfort of the users should be considered, and the aesthetically selected lighting elements must be in harmony with the lighted area.

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