Light Pollution and energy efficiency: a case study of the village of Vialonga

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Introduction

Since industrialization and the formation of large urban centers in the nineteenth century, pollution of the environment was always present in daily life in various ways, namely in the form of light (Sazaki et al, 2009).
Light pollution can cause various consequences, both for humans and for their ecosystem, producing effects on environmental, social, economic and scientific level (Gargaglioni, 2007). In Portugal, the lighting is responsible for 3% of total electricity consumption, energy costs are in some cases more than 50% towards the costs incurred by municipalities with energy, checking-in recent years a trend similar to that improvement of illumination levels in the region (about 4 to 5% per year) (Agência para a Energia, 2011).
Proper use of lighting brings many benefits both to the citizen and environment, since greater energy efficiency can contribute to reducing CO_2 emissions, energy costs, as well as to decrease the use of resources not-renewable and/or contamination of renewable resources, which can occurs in the process of obtaining electricity.
The present study has as main goal to analyze the illuminance levels associated to the public lighting of the village of Vialonga, Vila Franca de Xira (Portugal), to verify if it is efficient. The aim is also to relate the efficiency of street lighting with the existence of light pollution.

Material and Methods

In Vialonga there are 2929 luminaires equipped with a total of 3025 lamps with a total output of 408581W.
For this study, in 2011, were selected twelve tracks, three of typology "Avenue" and nine of typology "Street", constituting a sample of 209 lighting masts, equipped with lamps of high pressure sodium vapour of 150W. Sampling was non-probability by rational selection.
The data collected consisted in the illuminance levels and the distances between poles, their height and width of the roads. In order to prevent that the moon had any effect on the values collected, measurements were made in the new moon phase and without any cloudiness, at every twenty meters in the track, at a distance of one meter of the floor. For the collection of data on the distance between posts, commensurate with the masts and the width of the road, was used a laser distance meter, model PD 32 (Hilti®) and to collect data relating to illuminance was used the luximeter GOSSEN MAVOLUX 5032®, identification number 4D10081, with calibration certificate ' OUST YEMENI REBELS ' number 126/April 8, 2008. The calculation of the percentage of wasted luminance was calculated with software Roadpollution®, version 1.6.1 Beta.

Results and Discussion

In the Table 1 are represented the average values of the variables under study, as well as the percentage of wasted luminance by typology of road.

Typology of Road	Track width (m) $\bar{X}$	Distance between luminaires (m) $\bar{X}$	Luminaire height (m) $\bar{X}$	Measured illuminance (lux) $\bar{X}$	Wasted Illuminance (%) $\bar{X}$
Streets	6,71	25,60	7,71	19,17	40,11
Avenues	8,52	22,01	8,94	25,62	41,94

Table 1: Descriptive statistics by typology of road

The standard EN 13201 establishes the reference values for the illuminance in lux, by typology of road. For the typology "Street" is considered an illuminance of 15 lux, while for the typology "Avenue" is considered an illuminance of 20 lux. The streets and avenues present analytical values of illuminance higher than those recommended by the standard EN 13201.

The "Streets" have average luminance values and percentage of illuminance wasted lower than the "Avenues".
At both typologies there was a percentage of wasted luminance in the order of 40%, considering that there is a high amount of energy wasted in Vialonga. This waste can be fixed by replacing the existing equipment by other more efficient. The results of this will be immediate, making sure to note on the economy and on light pollution. Currently there is a wide range of luminaires that, in addition to being effective for practically in all kinds of situations or areas to illuminate complies with the standards in force, are easy to maintain and have a longer lifetime (Silva, 2007).

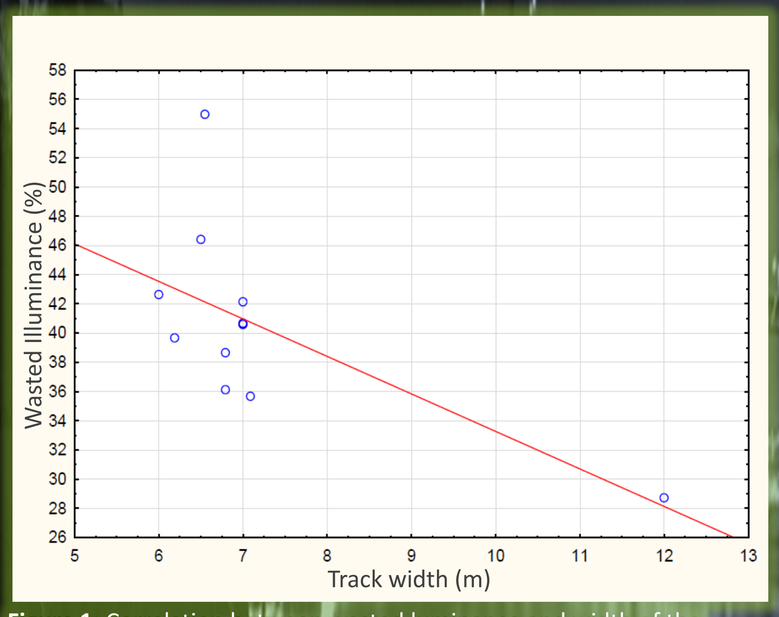

Figure 1: Correlation between wasted luminance and width of the road. r = -0,6370; p value = 0,026 < 0,05

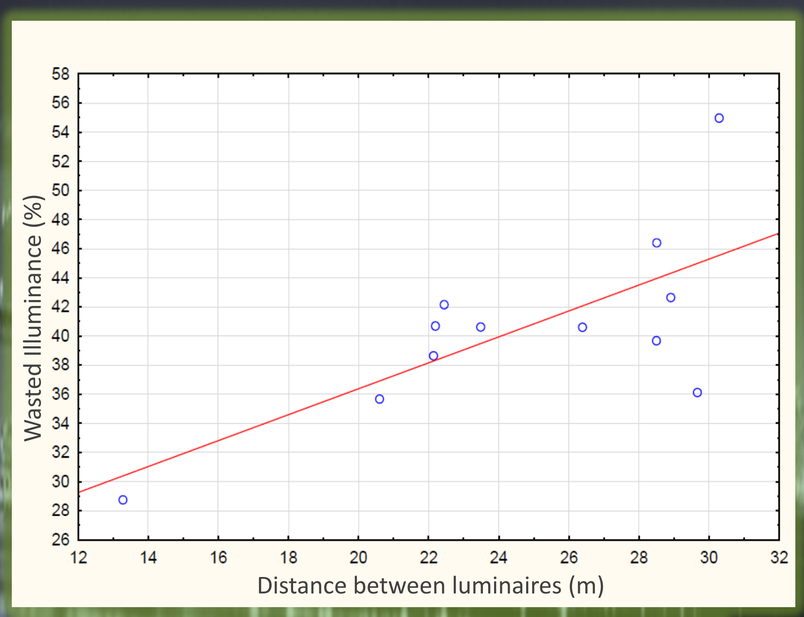

Figure 2: Correlation between illuminance wasted and the distance between luminaires. r = 0,7031; p value = 0,011 < 0,05

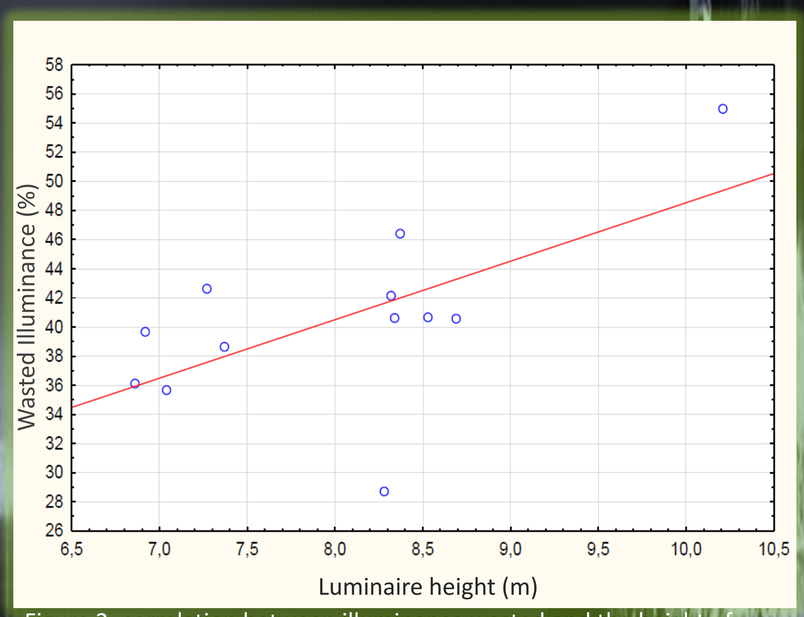

Figure 3: correlation between illuminance wasted and the height of luminaires. r = 0,6192; p value = 0,032 < 0,05

It was found that there is a statistically significant correlation (p value < 0.05) between the illuminance wasted and the width of the road. This finding is supported by other authors, in a study carried out in the districts of Coimbra and Aveiro, which qualified this correlation as statistically significant and negative (Cravo et. al, 2012). The greater the distance between the lights larger is the percentage of wasted luminance. On the other hand, the higher the height of luminaires is, higher is the percentage of wasted illuminance, which may be minimized if the height of those luminaires decrease (Barghini & Medeiros, 2005).

Conclusions

An inefficient lighting system can contribute to the energy wastage and hence to light pollution.
The benefits of an efficient public lighting are reflected in various aspects. The efficient use of public lighting system will be an added value economic and environmental as well as social.
With the results of this study it is possible to conclude that, apart from the average illuminance values are above the stipulated in EN 13201, there is a waste of about 40% of the luminance of lighting system. This waste contributes to light pollution and will have an economic impact, since there is energy consumption without useful lighting.

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