
DECLARATION ON THE USE OF BLUE-RICH WHITE LIGHT SOURCES FOR NIGHTTIME LIGHTING

Light pollution, defined as the introduction of artificial light into the environment at night, has received increasing attention during the last decades, due to its impact on science, biodiversity, economy and human health. The impact of light pollution on astronomy is obvious, but artificial light at night also affects wildlife, since ecosystems have evolved and adapted to the darkness of night. The same is true for the human species: modern generations have grown up under streetlights, and often forget that light at night is, in biological terms, a very recent invention. We are learning that artificial light at night may pose huge risks for our health. Many solutions have been proposed to deal with the different aspects of light pollution from the point of view of light engineering. But there is growing evidence that most detrimental effects of light at night increase when the light is white or, more specifically, rich in blue (short) wavelengths. For this reason, and given that recent trends in outdoor and indoor lighting are promoting this kind of light, mainly in the form of white light emitting diodes (LEDs), this declaration is being made to warn about the disadvantages of blue-rich artificial light at night. Its contents should also be taken into account in the wider context of light pollution in general.

The scattering of light in the atmosphere is responsible for artificial skyglow at night, the diffused light surrounding towns and cities. It happens when light coming from outdoor and indoor lighting systems interacts with the molecules of the air and with the particles suspended in it (aerosols). The ratio of useful light to skyglow depends on fixture design and on the kind of lamps used; on clear nights, blue light produces more skyglow than red light. The physical processes (mainly Rayleigh scattering) are strongly colour dependent, and explain the blue hue of the sky during the day: the blue part of the light coming from the Sun is more strongly scattered than the yellow, orange or red light. As a result of these fundamental physical laws, a key technique to reduce the impact of light at night on astronomy and on the natural landscape is to use light as yellow-red coloured as possible, avoiding blue-rich sources. Use of blue-rich white light in the open air at night is harmful for the observation of the night sky. Cool white LEDs are particularly strong light polluters, due to their strong blue emission peak.

The light halos are visible from cities far away and may affect adjacent sensitive species and ecosystems. Many species near the base of the trophic chain, such as nocturnal insects, are most sensitive to blue-rich light. The effect of lights, whether localized or diffuse, may be fatal, such as for sea turtles or petrels that use natural darkness and starry skies to navigate from their breeding grounds back to the ocean. Marine organisms are attracted by strong and localized lights, and many fish or cephalopods are captured by commercial fleets taking advantage of this fact. More subtle effects have also been reported, such as disorientation of animals. Many behavioral activities are synchronized with lunar cycles. The increase of skyglow from blue-emitting lamps may impair lunar light cycles and affect mating, migration, foraging and other essential activities of organisms in unpredictable ways.

Most natural preserves were not designed or placed to ensure maintenance of ecological processes without disturbance from artificial lights or skyglow from distant cities. There are few safe havens on the planet where continuing evolution of organisms occurs in non-altered conditions. The ecology of night should be urgently considered in relationship to artificial light in the existing network of protected areas, and dark sky reserves are also sorely needed.

Since life formed on our planet, it has developed with a predictable rhythmic environment. Every life form has evolved in coordination with the day-night cycle, developing the circadian system. The circadian system of mammals is synchronised by a deep part of the brain (the suprachiasmatic nucleus of the hypothalamus) and several peripheral clocks, passing its temporal signal to the organism via melatonin, a hormone produced by the pineal gland that peaks at night, with low levels during the day. Light reaches this master clock through a nonvisual pathway consisting of specialised cells in the retina (melanopsin ganglionar cells), that are sensitive primarily to blue light. Their stimulation suppresses

melatonin secretion during the day, and at night if light is present. A growing and increasingly convincing body of scientific evidence suggests that excessive exposure to bright light at night generates circadian disruption or chrono-disruption: impairments in the healthy internal temporal order. Evidence points to melatonin inhibition as the main culprit. Blue light is most effective in melatonin suppression. Longer exposures are required with warmer (yellow or redder) light. Epidemiological studies show that chrono-disruption is associated with increased incidence of metabolic syndrome, cardiovascular diseases, cognitive and affective impairments, premature aging and some cancers such as breast, prostate and colorectal, and with the worsening of pre-existing pathologies. Light cannot be considered harmless. More specifically, blue light should be avoided during the night in order to preserve our circadian physiology.

In relation to human vision and artificial lighting, it is noteworthy that the eye's lens transmits less blue light as people age, while the transmission of yellow light remains almost constant across all age groups. Although the dark-adapted human eye is more sensitive to blue light, recommended lighting levels now bring vision into the day-time (photopic) regime and, thus, a frequent argument favouring light with high blue content fails, unless recommended lighting levels are much reduced. Also, at low lighting levels, warm light is normally perceived as more comfortable than cool light, which produces an aseptic and spectral look in urban places.

Light pollution poses a major challenge to modern societies. Its effects worsen with the use of blue-rich light for lighting at night, both indoors and outdoors. Many aspects converge to make of blue-rich light a resource that must be carefully and sparingly used, and very carefully controlled. Wildlife and ecosystems, human health, and the natural nocturnal landscape are all threatened by blue-rich light. For these reasons we warn against the recent trends favouring widespread use of white light (unless coupled with a simultaneous great reduction of lighting levels). We recommend restricting blue light at night, and using warm, yellow-hued light whenever possible. Spectral criteria should be introduced into outdoor lighting regulations, restricting the use of blue-rich light. Although some blue-rich sources offer efficacies that make them attractive from an energy standpoint, warmer light sources now have very similar efficacies, and much lower environmental impact. The design of modern lighting systems should not rely only on engineering or energy-saving considerations; environmental considerations must also be addressed, adapting not only lighting direction and intensity to the use of the areas, but also the spectral distribution of the light. Lamps that emit more energy in the blue than standard high-pressure sodium lamps should not be installed outdoors. Technological solutions, both classical (sodium) and solid-state (amber LED, filtered white LED), provide warm, less harmful light with excellent energy efficiency. These products, should be required by authorities, and specified by engineers and designers, to preserve a nighttime environment that is friendly to the sky, to nature and to ourselves.

On the basis of the above, the following minimum prescriptions should be used together to limit light pollution:

- Do not allow luminaires to send any light directly at and above the horizontal.
- Do not waste downward light flux outside the area to be lit.
- Avoid over lighting and redefine the lighting levels for road lighting, lowering them substantially.
- Shut off lights when the area is not in use.
- Aim for a decrease of the total installed flux (in the same manner as other pollutants are being reduced).
- Strongly limit the short wavelength blue light.

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