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Light Pollution: Warning from Life for Life

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Introduction

The presence of unwanted, inappropriate, or excessive artificial lighting is referred to as light pollution. In a broad sense, light pollution refers to the effects of any poorly implemented lighting, whether during the day or at night. Light pollution can be understood not only as a phenomenon caused by a specific source or type of pollution, but also as a contributor to the broader, collective impact of various pollution sources.

Although this type of pollution can exist during the day, the contrast of darkness magnifies its effects at night. It is estimated that 83 percent of the world's population lives under light-polluted skies, and skyglow affects 23 percent of the world's land area. The area affected by artificial lighting is expanding. Light pollution, a major byproduct of urbanization, is blamed for compromising health, disrupting ecosystems, and degrading aesthetic environments. Globally, has increased by at least 49% between 1992 and 2017.

Light pollution solutions are frequently simple, such as adjusting light fixtures or using more appropriate light bulbs. However, because it is a man-made phenomenon, addressing its effects on humans and the Earth's larger ecological systems entails vast societal complexities that combine light pollution with political, social, and economic considerations.

Remediation

Proponents of energy efficiency argue that a solution to the problem of light pollution lies in modifying people's behaviour to make better use of available lighting resources and reduce the production of unnecessary or distracting light. Light pollution is a problem that has been acknowledged as such by a number of professional organisations. The Institution of Lighting Engineers in the UK, for instance, educates its members on light pollution and its effects. However, new studies show that the rebound effect means energy efficiency alone isn't enough to significantly cut down on light pollution. It is common for one person to consider as light pollution something that another finds desirable due to differences in opinion regarding whether or not a specific lighting source is annoying and the significance of its effects on non-human life. An advertiser is a good example of someone who wants something to stand out and be noticed, even if other people find it annoying. Fewer people seem to disagree that other forms of light pollution are problematic. Illumination that spills over onto neighbouring property, for example, is often seen as wasteful and polluting.

This is just one of the many factors that contribute to contentious debates when deciding how to regulate artificial lighting. Parties may need to negotiate when they have divergent views on what constitutes reasonable light and who should have authority and responsibility. Isophote maps or light contour maps are commonly used to display the results of field measurements or mathematical modelling of light levels when it is desired that such decisions be supported by objective data. Authorities have taken various approaches to combating light pollution, each informed by the values, priorities, and worldviews of the society at large. The spectrum of options includes doing nothing at all to enforcing stringent laws and regulations governing the placement and use of lighting.

Types of Light Pollution

1. **Over Illumination:** When there is too much light, we say that there is over-illumination.According to the Department of Energy (DOE), commercial building

lighting in the United States uses more than 81.68 terawatts of electricity annually (1999 data). There is a wide variety in lighting habits even among the developed nations. When compared to German cities, those in the United States send three- to five times as much light into space per inhabitant.

Causes of excessive light include

1. Standards or norms reached by consensus that are not grounded in eye-tracking research;
2. Lack of consideration for the visual demands of a given task in the design phase, resulting in excessively bright environments;
3. The use of inappropriate lighting, such as bulbs or fixtures that do not provide adequate illumination;
4. Selecting hardware that consumes more power than necessary to achieve the desired effect;
5. Insufficient instruction in the proper use of lighting systems by building administrators and occupants;
6. Improper lighting maintenance leading to higher stray light levels and energy usage;
7. "Daylight lighting," which residents have been clamoring for in an effort to cut crime and store owners have been using to entice customers;
8. Direct lighting, such as shining a light down from above, or up a vertical wall, or onto the floor, can save money and energy.

Most of these problems have simple solutions, and they can be fixed quickly with current, low-cost technology and the elimination of landlord/tenant practises that slow down the process of fixing these problems. The greatest benefit from reducing over-illumination would accrue in industrialised countries if citizens were better informed about the issue. It may be necessary to employ an over-illumination lighting method in specific circumstances. Direct lighting can be harsh and unflattering on some surfaces, like skin, so indirect lighting is often used to achieve a more pleasing effect. Indirect lighting creates a warmer ambiance and is ideal for homes and restaurants. Softening filters or other solutions can be used to block the direct lighting effect, though this will reduce the intensity.

Problems with Assessing Light Pollution

Sky glow measurements on a global scale are a complicated process. In spite of the lack of artificial light from the Moon, the natural atmosphere is not totally dark. The two most important contributors to this are airglow and scattered light.

1. Ionization is caused by the sun's ultraviolet radiation at very short wavelengths, which is most prevalent at high altitudes, primarily above the mesosphere. Airglow is produced when ions collide with electrically neutral particles and recombine, releasing photons in the process. Even when the upper atmosphere is in Earth's shadow at night due to the high degree of ionisation, radiation can continue to be constantly emitted. Sunlight with energies greater than the ionisation potential of N2 and O2 is absorbed by the upper atmosphere before it can reach the lower atmosphere, so there is no significant ionisation of these gases at lower altitudes.
2. The sky not only shines itself, but also reflects and re-emits sunlight that has been reflected and backscattered by interplanetary dust particles, known as zodiacal light.

Although the amount of airglow and zodiacal light varies widely (due to factors such as sunspot activity and the Solar cycle), the darkest possible sky has a brightness of about 22 magnitude/square arc second under ideal conditions. When a full moon is overhead, the sky can become as much as 40 times brighter than the darkest sky, with a brightness of about 18 magnitude/sq. arcsecond (depending on local atmospheric transparency). It is not unusual for the sky brightness to reach 17 magnitude/sq. an arcsecond in highly populated areas, which is as much as 100 times brighter than is natural. Measuring light pollution presents some challenges.

As you can imagine, it's not easy to get a global reading on the impact of sky glow. Even without the Moon to provide light, the natural atmosphere is not totally dark. The two most important contributors to this are airglow and scattered light.

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In addition to its own luminosity, the sky scatters the light of other sources, such as the stars and the Milky Way, as well as the sun's reflected and backscattered rays from interplanetary dust particles (known as zodiacal light).

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Measuring Satellite Images

To precisely measure how bright the sky gets, night time satellite imagery of the earth is used as raw input for the number and intensity of light sources. These are then used in a physical model of scattering by air molecules and aerosols to derive an estimate of the total sky brightness. Global maps depicting the brightened skies have been created.

The Bortle Index or Scale

To keep tabs on how much light pollution there is, scientists use the Bortle scale, which has nine distinct levels. A Bortle scale of five or less is required to see the Milky Way whilst one is "pristine", the darkest possible.

Impact of population health

Medical research on the effects of excessive light on the human body suggests that light pollution or excessive light exposure may cause a variety of adverse health effects, and some lighting design textbooks[50] use human health as an explicit criterion for proper interior lighting. Over-illumination or improper spectral composition of light can cause headaches, worker fatigue, medically defined stress, a decrease in sexual function, and an increase in anxiety. Similarly, animal models have been studied, demonstrating that unavoidable light

has a negative effect on mood and anxiety. Light at night has a strong effect on alertness and mood in those who need to be awake at night.

The World Health Organization's International Agency for Research on Cancer classified "shift work that involves circadian disruption" as a probable carcinogen in 2007. (IARC Press release No. 180). Several studies have found a link between night shift work and an increased risk of breast and prostate cancer. One study that looked at the relationship between exposure to artificial light at night (ALAN) and levels of breast cancer in South Korea discovered that areas with the highest levels of ALAN had the most cases of breast cancer. Seoul, which had the most light pollution, had 34.4% more cases of breast cancer than Ganwon-do, which had the least amount of light pollution. This indicated a strong link between ALAN and the prevalence of breast cancer. It was also discovered that there was no link between ALAN levels and other types of cancer, such as cervical or lung cancer.

A more recent discussion (2009), written by Harvard Medical School Professor Steven Lockley, can be found in the CfDS handbook "Blinded by the Light?" 4th Chapter "According to the article "Human health implications of light pollution," "... light intrusion, even if dim, is likely to have measurable effects on sleep disruption and melatonin suppression." Even if the effects are minor from night to night, chronic circadian, sleep, and hormonal disruption may pose long-term health risks ". In 2009, the New York Academy of Sciences hosted a conference on Circadian Disruption and Cancer. Melatonin is suppressed the least by red light.

The American Medical Association developed a policy in support of light pollution control in June 2009. The decision's coverage emphasised glare as a public health hazard that contributes to unsafe driving conditions. Glare causes contrast loss, which obstructs night vision, particularly in the elderly.

According to a new 2021 study published in the Southern Economic Journal, light pollution may increase by 13% in preterm births before 23 weeks of gestation.

The environmental impact

When artificial light harms organisms and ecosystems, this is referred to as ecological light pollution. While light at night can be beneficial, neutral, or harmful to individual species, its presence always disrupts ecosystems. Some spiders, for example, avoid lit areas, whereas others are content to build their spider web directly on a lamp post. Because lampposts

attract many flying insects, spiders that don't mind light have an advantage over spiders that do. This is a simple illustration of how the introduction of light at night can disrupt species frequencies and food webs.

Light pollution is a serious threat, particularly to nocturnal wildlife, and has a negative impact on plant and animal physiology. It can disrupt animal navigation, alter competitive interactions, alter predator-prey relationships, and cause physiological harm. The natural diurnal patterns of light and dark orchestrate the rhythm of life, so disruptions to these patterns have an impact on the ecological dynamics. Many marine plankton species, such as Calanus copepods, can detect light levels as low as 0.1 Wm2; using this as a threshold, a global atlas of marine Artificial Light at Night has been generated, demonstrating its global prevalence.

According to research, light pollution around lakes prevents zooplankton, such as Daphnia, from eating surface algae, resulting in algal blooms that can kill off lake plants and lower water quality.

Light pollution may also have an impact on ecosystems in other ways. Entomologists, for example, have discovered that nighttime light can interfere with the ability of moths and other nocturnal insects to navigate. It can also have a negative impact on insect development and reproduction. Night-blooming flowers that rely on moths for pollination may be affected by night lighting because there is no replacement pollinator that is not affected by the artificial light. This can result in the extinction of plants that are unable to reproduce, as well as changes to an area's long-term ecology. Fireflies (Coleoptera: Lampyridae, Phengodidae, and Elateridae) are particularly interesting study objects for light pollution because they rely on their own light to reproduce and are thus extremely sensitive to light levels in the environment. Fireflies are well known and interesting to the general public (unlike many other insects), and are easily spotted by non-experts. They are also good bioindicators for artificial night lighting due to their sensitivity and rapid response to environmental changes[citation needed]. Significant declines in some insect populations have been suggested to be at least partially mediated by artificial lights at night.

Pinwheel Galaxy Images

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Original shot: lower edge Alkaid, right of center the double star Mizar with Alcor and right edge Alioth; the Pinwheel Galaxy is a small diffuse dot in the center of the image.

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Black level compensation: the darkest point in the digital picture was set to zero luminance, in order to reduce the visible stray light. However, blue light caused by Rayleigh scattering is visible in the center of the image.

- 

50 percent of stray light removed: the darker half of the stray light was set to zero luminance. The darker part of the blue light caused by Rayleigh scattering is still visible in the center of the image.

Complete elimination of stray light: all pixels showing stray light have been set to zero luminance, the faint and two-dimensional Pinwheel Galaxy is no longer visible, too.

Some astronomers use narrow-band "nebula filters," which allow only specific wavelengths of light seen in nebulae, or broad-band "light pollution filters," which are designed to reduce (but not eliminate) the effects of light pollution by filtering out spectral lines commonly emitted by sodium- and mercury-vapor lamps, enhancing contrast and improving the view of dim objects like galaxies and nebulae. These light pollution reduction (LPR) filters, however, are not a cure for light pollution. LPR filters reduce the brightness of the object under study, making higher magnifications unnecessary. LPR filters work by blocking specific wavelengths of light, which alters the colour of the object, often resulting in a pronounced green cast. Furthermore, LPR filters only work on specific object types (primarily emission nebulae) and are ineffective on galaxies and stars. No filter can match the visual or photographic effectiveness of a dark sky.

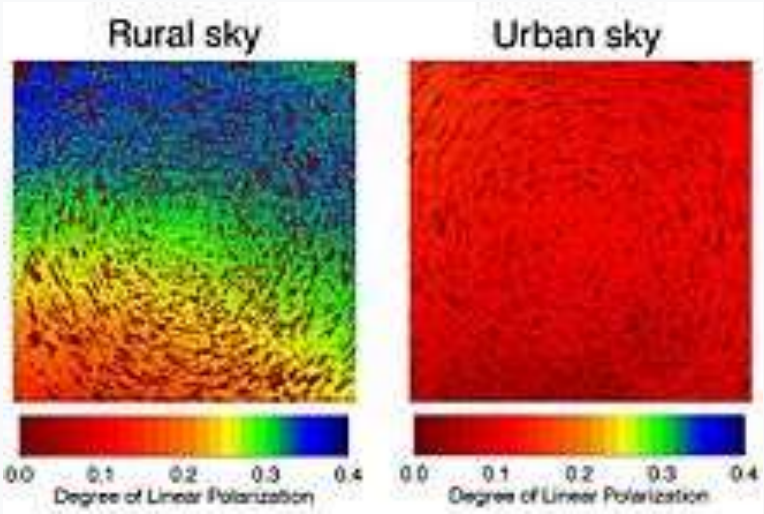
The Atacama Desert in northern Chile is remote, and the night sky is pitch-black. Photographer: José Francisco Salgado

Because of their low surface brightness, diffuse sky objects such as nebulae and galaxies are more affected by light pollution than stars. The majority of such objects become invisible in the heavily light-polluted skies above major cities. Looking for the Milky Way, which appears bright enough to cast a shadow from truly dark skies, is a simple method for estimating the darkness of a location.

In addition to skyglow, light trespass can have an effect on observations when artificial light enters the telescope tube and is reflected from non-optical surfaces until it reaches the eyepiece. This type of direct light pollution causes a glow across the field of view, reducing

contrast. Light trespass also makes it difficult for a visual observer to adapt to the dark. If reducing the light directly is not an option, the usual measures to reduce this glare include flocking the telescope tube and accessories to reduce reflection and putting a light shield (also usable as a dew shield) on the telescope to reduce light entering from angles other than those near the target. Some astronomers prefer to observe under a black cloth in these conditions to ensure maximum adaptation to the dark.

Reduction of Natural Sky polarization



Light pollution is mostly unpolarized, and its addition to moonlight results in a decreased polarization signal.

Economic Implications

Light pollution research focuses on the quality of lighting and how it affects our ability to see the sky clearly at night. However, light pollution has a wide range of root causes and consequences. Major changes in the way we live have occurred since the Industrial Revolution spread from England to the rest of the world. Technological innovation is accelerating. Gas stations, convenience stores, and pharmacies are examples of 24-hour businesses. Hospitals and other healthcare facilities must be staffed around the clock, seven days a week. With the rise of Amazon, many factories and shipping companies are now operating 24-hour shifts to meet the demands of the new global consumer. All of these industries require light, both inside and outside their facilities, to ensure the safety of their employees as they move about their jobs and enter and exit the facilities. As a result, "40% of

the US population and nearly 20% of the European Union population have lost the ability to view the night sky...it is as if they never truly experienced nighttime."

Researchers are investigating the impact of light pollution on this group of workers, with a focus on shift work and the continued need for 24-hour operations in specific sectors of the economy. The International Agency for Research on Cancer (IARC) sought to draw attention to the risk of developing cancer from shift work in 2007. This decision was made in response to numerous studies that found increased cancer risks in groups of shift workers. The 1998 Nurses Health Study discovered a link between breast cancer and nurses who had worked rotating night shifts for more than 30 years. However, in these industries, shift work cannot be stopped. Hospitals must be staffed 24 hours a day, seven days a week.

According to research, light pollution, like other environmental issues, is primarily the fault of industrialised nations.

Galloway et al. (2010) conducted research that looked at a variety of economic indicators to determine where light pollution was occurring around the world. Galloway's research discovered that countries with paved roads, a sign of a developed infrastructure, frequently had higher levels of light pollution (2010). Similarly, countries with high levels of resource extraction have high levels of light pollution. Finally, Galloway discovered that countries with the highest GDP and surface area classified as urban and suburban had the highest rates of light pollution. China is a rising industrial and economic powerhouse. A recent light pollution study using the Defense Meteorological Satellite Program Operational Linescan System (DMSL/OLS) discovered that light pollution is increasing over eastern coastal cities while decreasing over industrial and mineral extraction cities. Particularly vulnerable to light pollution are urban areas near the Yangtze River delta, the Pearl River delta, and the Beijing-Tianjin area. Jiang discovered that light pollution was much worse in the East and North of China than in the West. This is consistent with the location of major industrial factories in the East and North, while resource extraction dominates the West.

Following the United Nations declaration of 2010 as The Year of Astronomy, researchers advocated for a better understanding of artificial light and its role in social, economic, and environmental issues. According to the researchers, continued unrestricted use of artificial light in urban and rural areas would result in a global shift with unpredictable outcomes. Holker contended that focusing on the economic impact of increased energy consumption in light bulbs or the transition to energy-efficient lighting was insufficient. Rather, the emphasis should be on the socioeconomic, ecological, and physiologic consequences of light

pollution. In essence, receiving your Amazon package in less than 48 hours is not a compelling reason for increased light pollution.

Humans require some artificial night light for shift work, manufacturing, street safety, and nighttime driving, and studies have shown that artificial light disrupts animal lives. A recent article, however, suggests that we may be able to find a happy medium. A 2021 study looked at seasonal light changes and their impact on all animals, but especially mollusks. According to the authors, light research primarily focuses on the length of exposure to light. Based on their findings, they propose that future research should focus on quantifying the smallest amount of light, in terms of duration and intensity, that would allow both humans and animals to continue living safely. To collect as much data as possible, scientists are recruiting members of the public to act as citizen scientists from all over the world and enter their findings into apps and websites. Scientists gain access to volumes of data reflecting how light pollution affects the world around us by collecting and uploading sky images, star counts, agricultural data, and bird and butterfly statistics. Hopefully, scientists will be able to predict and recommend solutions to problems before they become permanent.

Reduction

Reducing light pollution entails many things, including reducing sky glow, glare, light trespass, and clutter. The best method for reducing light pollution thus depends on the nature of the problem in each case. Among the possible solutions are:

1. Using light sources with the least amount of intensity required to achieve the light's purpose.
2. When not in use, turn off lights with a timer, occupancy sensor, or manually.
3. Improving lighting fixtures so that they direct their light more accurately and with fewer side effects.
4. Changing the type of lights used so that the light waves emitted are less likely to cause severe light pollution problems.
5. Mercury, metal halide, and, above all, the first generation of blue-light LED road luminaires pollute the environment far more than sodium lamps: Blue light is better scattered and transmitted by the Earth's atmosphere than yellow or red light. It is common to see "glare" and "fog" around and below LED road luminaires as air

humidity rises, whereas orange sodium lamp luminaires are less prone to this phenomenon.

6. Evaluating existing lighting plans and redesigning some or all of them depending on whether existing light is still required.

Redesigning lighting schemes

In some cases, evaluation of existing plans has revealed the possibility of more efficient lighting plans. Light pollution, for example, can be reduced by turning off unnecessary outdoor lights and lighting stadiums only when there are people inside. Timers are particularly useful for this purpose. One of the world's first coordinated legislative efforts to reduce the negative environmental impact of this pollution began in Flagstaff, Arizona, in the United States. More than three decades of ordinance development have occurred there, with the full support of the population, frequently with government support, community advocates, and the assistance of major local observatories, including the United States Naval Observatory Flagstaff Station. Each component contributes to the education, protection, and enforcement of the imperatives to intelligently reduce harmful light pollution.

In the United Kingdom, one example of a lighting plan assessment can be found in a report commissioned by the Office of the Deputy Prime Minister and now available through the Department for Communities and Local Government. The report outlines a plan to be implemented throughout the UK for designing lighting schemes in the countryside, with a particular emphasis on environmental preservation.

In another case, the city of Calgary recently replaced most residential street lights with more energy-efficient models. The primary drivers are reduced operating costs and environmental protection. The installation costs are expected to be recouped in energy savings within six to seven years. The Swiss Agency for Energy Efficiency (SAFE) employs a concept known as "consommation électrique spécifique (CES)," which translates to "specific electric power consumption (SEC)" and promises to be very useful in the diagnosis and design of road lighting. Thus, SAFE has defined target values for electric power consumption per metre for roads of various categories based on observed lighting levels in a wide range of Swiss towns. For roads less than ten metres wide, SAFE currently recommends an SEC of two to three watts per metre (four to six for wider roads). Such a measure imposes a simple environmental protection constraint on conventional "norms," which are typically based on

the recommendations of lighting manufacturing interests, who may or may not consider environmental criteria. Given the ongoing advancements in lighting technology, target SEC values will need to be revised downwards on a regular basis.

Further the usage of light in daily life must be observed and requirement of the usage must be monitored as excessiveness of anything more than requirement lead to the problems and side effect on fauna and flora of the planet.

References

1. "Light Pollution". International Dark-Sky Association. Retrieved 2021-06-26.
2. "All You Need to Know About Light Pollution". Stanpro. 2018-10-18. Archived from the original on 2021-06-30. Retrieved 2021-06-26.
3. Argys, Laura M.; Averett, Susan L.; Yang, Muzhe (2021). "Light pollution, sleep deprivation, and infant health at birth". Southern Economic Journal. **87** (3): 849–888. doi:10.1002/soej.12477. hdl:10419/185163. S2CID 92984550. Retrieved 4 March 2021.
4. McMahon, Oak; Smyth, Tim; Davies, Thomas W. (2022-03-25). "Broad spectrum artificial light at night increases the conspicuousness of camouflaged prey". Journal of Applied Ecology. **59** (5): 1365–2664.14146. doi:10.1111/1365-2664.14146. ISSN 0021-8901. S2CID 247754178.
5. Smyth, T. J.; Wright, A. E.; McKee, D.; Tidau, S.; Tamir, R.; Dubinsky, Z.; Iluz, D.; Davies, T. W. (2021-12-13). "A global atlas of artificial light at night under the sea". Elementa: Science of the Anthropocene. **9** (1): 00049. doi:10.1525/elementa.2021.00049. ISSN 2325-1026. S2CID 245169968.
6. Yong, Ed (2022-06-13). "How Animals Perceive the World". The Atlantic. Retrieved 2022-06-14.
7. Light Nuisance. Institution of Light Engineers
8. Kyba, Christopher C. M.; Kuester, Theres; Sánchez de Miguel, Alejandro; Baugh, Kimberly; Jechow, Andreas; Hölker, Franz; Bennie, Jonathan; Elvidge, Christopher D.; Gaston, Kevin J.; Guanter, Luis (22 November 2017). "Artificially lit surface of Earth at night increasing in radiance and

extent". ScienceAdvances. **3** (11):e1701528. Bibcode:2017SciA 3E1528K doi:10.1126/sciadv.1701528. PMC 5699900. PMID 29181445.

9. www.google.com
10. www.wikipedia.co.in
11. www.nasa.usa.gov
12. Light pollution - Wikipedia
13. Light pollution - Wikipedia
14. Light pollution | Sustainable Community Action | Fandom
15. http://next.owlapps.net/owlapps_apps/articles?search=lubrizol,rouen,pollution&lang=en
16. https://www.ijsr.net/archive/v3i10/T0NUMTQyMTA=.pdf
17. Light Pollution and Impact of Light Pollution (ijsr.net)

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