

Implications of light pollution on human health and the environment: insights for the Indian medical and scientific community

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Light pollution is a type of environmental pollution resulting from excessive and improper artificial lighting. This article provides a brief overview of the detrimental effects of light pollution on the environment, human health and wildlife. It aims to raise awareness about light pollution, and encourage adoption of responsible and sustainable lighting methods to offset the detrimental impacts arising from erroneous lighting. It also emphasizes on the importance of collaboration between health professionals, legislators and the public to preserve the natural equilibrium of the environment, safeguarding human and animal health.

Keywords: Climate change, ecosystems, environment, human health, light pollution, wildlife.

UNABATED human activity has polluted the five basic elements of our environment, namely space, air, water, fire and earth, causing negative impacts on human health. These elements are known as 'pancha bhutha's in ancient Indian literature. One form of environmental pollution that has gained attention in recent years is light pollution, caused by excessive and inappropriate artificial lighting. Despite its detrimental effects on human health and the environment, awareness among health professionals regarding light pollution is still limited, making it relevant to propagate this new development in the field of pollution and implement mitigation measures.

The circadian rhythm of the human body has evolved over millions of years guided by natural light sources such as the Sun, the Moon and the stars. However, since late 1880s, humans have been increasingly exposed to artificial lighting, which has become pervasive worldwide. The normal circadian rhythm of the human body functions like a clock, regulating the day and night cycles, primarily controlled by the hormone melatonin secreted by the pineal gland, also known as the third eye. However, use of artificial lighting disrupts this natural process, causing negative impacts on human health such as sleep disturbance, depression and even cancer¹.

Thus, it is crucial to address the issue of light pollution through responsible and sustainable lighting practices to

preserve the natural balance of the environment and protect human health. By reducing excessive artificial lighting, we can help minimize the negative impacts of light pollution on both the environment and our health.

Impact on human health

Light pollution has a significant impact on human health. Exposure to artificial light at night disrupts the natural circadian rhythm of the human body, which regulates the sleep-wake cycle, metabolism and hormone secretion. As a result, it can lead to sleep disturbance, insomnia, fatigue and reduced productivity. A study found that even low levels of light pollution can affect the timing and quality of sleep in humans².

Light pollution has also been linked to increased risk of various health problems, including obesity, diabetes, cardiovascular diseases and cancer. A study has linked night artificial light exposure to increased risk of developing type-2 diabetes³. Similarly, women who were exposed to high levels of light at night were identified as being more likely to develop breast cancer³. Furthermore, light pollution has been linked to depression, anxiety and other mood disorders. Blue light from electronic devices before bedtime can inhibit melatonin secretion, causing sleep disruption and an increased risk of depression⁴. Blue light signals wakefulness, while red and yellow light indicate the need to sleep.

To mitigate the negative impacts of light, it is necessary to reduce exposure to artificial light at night, and adopt responsible and sustainable lighting practices that preserve the natural darkness of the night sky. In addition, artificial light causes eye strain resulting in headaches and migraine in the long run. Exposure to artificial light at night can disrupt the circadian rhythm in children, leading to sleep problems, mood disorders and other health problems^{5,6}. Also, exposure to bright light at night can interfere with the development of visual systems in infants and young children, leading to visual impairments later in life⁷. Furthermore, disruptions in the sleep pattern and circadian rhythm are known to have a negative impact on growth and development, including cognitive development⁸.

It is pivotal to adopt responsible lighting practices and promote awareness on the impacts of light pollution to

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minimize the negative effects of artificial light on the health and development of children. By doing so, we can help ensure that children, infants and newborns can sleep well and are healthy.

Impact on wildlife and the environment

Light pollution not only affects human health, but also has a significant impact on wildlife and the environment. It alters natural light cycles, disrupts ecosystems, and affects the behaviour and physiology of animals.

Studies have consistently shown that artificial light can disorient migrating birds and contribute to collisions with buildings⁹. It can cause birds to fly off-course and even change their migration routes¹⁰. Sea turtles are known to become disoriented by artificial light on beaches. This makes them lose their way or get stranded. Researchers discovered that sea-turtle hatchlings exposed to artificial light at night had poor survival rates and were more prone to become confused¹¹. Light pollution can affect the behaviour of nocturnal animals, such as bats and insects, by disrupting their feeding and mating patterns. For example, female glow worms use bioluminescent light to attract males (even 150 ft away) for mating. However, presence of artificial light can result in visual competition or obscure the light of the glow worms making it difficult for the males to locate the females. This can disrupt their mating behaviour and reproductive success¹². Artificial light at night was found to affect the foraging behaviour of bats, leading to reduced food availability and population decline¹³. Similarly, artificial light can disrupt pollination by moths, beetles, bees, and bats, leading to reduced plant reproduction and biodiversity.

Sources of light pollution

The sources of light pollution can be office lights, streetlights, garden lights and traffic lights. All of them contribute towards light pollution, and have a significant impact on the environment by wasting energy, increasing carbon emissions and contributing to climate change.

Artificial light, particularly in indoor environments, can have a significant impact on the human visual system. The intensity of artificial light, measured in lumens, determines the brightness perceived by our eyes. Higher light intensity can lead to visual discomfort, glare, and even potential damage to eyes. The American Optometric Association recommends that indoor lighting should be set at an appropriate level to ensure comfortable and safe visual conditions¹⁴. The specific appropriate levels may vary depending on the task and the visual needs of individuals. Factors such as age and visual acuity of the individual, nature of the task being performed and the surrounding ambient lighting conditions should be taken into consideration when determining the appropriate lighting levels. It is recommended to consult with an eyecare professional or lighting

specialist to ensure that the lighting is set at levels that promote comfortable and safe visual conditions for the specific environment and individuals involved.

Types of light

There are various types of light. Natural light includes sunlight and moonlight, and artificial light includes light from incandescent bulbs, fluorescent lights, and light-emitting diodes (LEDs). Table 1 shows the types of light and the differences between them. Lights differ in their wavelength, intensity and spectral composition, which can have an impact on human health and the environment. The usage of LED has increased by 875% between 2016 and 2023 (refs 15, 16). LED is more efficient because it uses 70% less energy, has longer lifetime, higher lumen, produces less heat, is cost-effective, and emits no UV radiation, but emits blue light.

One of the major contributors to light pollution is artificial light, which is extensively used in urban areas for lighting buildings, streets and public spaces. The intensity and spectral composition of artificial light can have a significant impact on the environment and wildlife, particularly when it is used at night. In urban areas, it has a significant impact on various wildlife species such as nocturnal birds, like owls and nightjars that could experience disorientation and changes in behaviour affecting their navigation and breeding pattern. Migratory birds can also be drawn off-course by brightly-lit urban areas, leading to collisions with buildings. Insects, including moths and beetles, are disrupted by artificial light, affecting their natural rhythm, pollination and feeding pattern. Amphibians, reptiles and even plants can be sensitive to artificial light, leading to changes in habitat use and growth pattern¹⁷. Understanding and mitigating these impacts is crucial for preserving urban biodiversity and ecosystem functioning.

Artificial light at night can be categorized into three main types: direct light, sky glow and light trespass. Direct light refers to the light emitted from a source that is visible to the observer, such as streetlight or security light. Sky glow is the result of light reflecting off particles in the atmosphere, creating a diffuse glow that can be seen from a distance. Light trespass refers to light that spills into areas where it is not intended or needed, such as into residential properties from streetlights or floodlights on building.

One of the major differences between natural and artificial light is the spectral composition. Natural light has a broad spectrum that includes all colours of the rainbow, whereas artificial light typically has a narrow spectrum that is dominated by blue and green wavelengths.

In addition to the differences in spectral composition, the intensity of artificial light is often much higher than that of natural light, particularly in urban areas. This can have a negative impact on wildlife, such as disorientating migrating birds and disrupting their navigation, as well as affecting the foraging and mating behaviour of nocturnal animals¹⁸.

Table 1. Types of light and the differences between them

Type of light	Energy efficiency	Health effects	Colour	Human eye lumen exposure	Renewable
Incandescent	Low	Heat emission, ultraviolet (UV) radiation (if no coating)	Warm (yellowish) light	High lumen exposure	No
Halogen	Moderate	Heat emission, UV radiation (if no coating)	Warm (white) light	High lumen exposure	No
Compact fluorescent lamp (CFL)	Moderate–high	Low levels of UV radiation (if no coating), flickering (older models)	Varies depending on the bulb	Moderate lumen exposure	No
Light-emitting diode (LED)	High	Low levels of UV radiation, minimal flickering	Varies depending on the bulb	Low lumen exposure	Yes
Natural sunlight	N/A	Beneficial to overall health, regulates sleep cycle	More of blue light Full spectrum	Varies depending on the intensity of sunlight	Yes

N/A, Not applicable.

Overall, the differences between natural and artificial light, particularly in their spectral composition and intensity, can have significant impact on human health and the environment, particularly when artificial light is used excessively and inappropriately. By understanding these differences, we can work to develop more sustainable and responsible lighting practices that minimize the negative impacts of light pollution.

Mitigation measures

There are several ways to mitigate the effects of light pollution on human health and the environment. Dark-sky lighting is used to reduce the quantity of light that is emitted into the sky and into places where it is not needed, such as into nearby properties. This may reduce trespass of light and sky glow¹⁷. Protecting light sources, like floodlights of buildings and streetlights, can assist in the focus of light where it is required and reduce light trespass. The usage of warm-colour lighting can be incorporated. Research has indicated that warm-colour lighting, like amber LEDs, has less of an influence on wildlife and people than cool-colour lighting, such as blue and green LEDs¹⁹. Technological innovations can be incorporated. For example, Kyba *et al.*²⁰ found that cloud cover acts as an amplifier for light pollution by reflecting and scattering artificial light, thereby increasing the overall brightness of the night sky. This amplifying effect intensifies the ecological disturbances caused by artificial lighting in urban areas. These researchers have also highlighted the importance of considering cloud cover when assessing the impacts of light pollution and developing mitigation strategies²⁰.

Studies should also focus on motion sensors for people. Policy and legal approaches like building codes and lighting ordinances, for example, can serve to control the use of artificial lighting and encourage appropriate lighting habits. Implementing behavioural modifications can effectively reduce the use of artificial light and minimize light pollution. Simple acts like shutting-off lights when they are not in use and implementing energy-saving practises can drastically

reduce light emissions. Shielding windows with drapes or blinds can help prevent light from escaping, thereby reducing light trespass. Using white-colour light for street lighting instead of stronger and harsher light sources in metropolitan areas helps reduce the negative impacts on animals and human health. Avoidance of focus lights on trees would help the other species which live on them, to safeguard our ecosystem. When paired with education and awareness initiatives, these behavioural changes can encourage appropriate lighting practices and contribute to the protection of natural darkness. We can establish a more sustainable and ecologically friendly approach to lighting by encouraging individuals and communities to adopt these adjustments.

Conclusion

Overall, mitigating the effects of light pollution requires a multifaceted approach that involves the cooperation of individuals, communities and governments. By adopting responsible lighting practices and promoting awareness of the impacts of light pollution, we can work to minimize the negative effects of artificial light on the overall well-being of humans, animals and the environment.

Conflict of interest: None.

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