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Effects of Light Pollution on Macroscopic Living System: A Concise Review

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Abstract: The growing worldwide population has increased the demand for housing development in cities, suburbs, and rural locations. This tendency, combined with the slow but steady march of urbanization and globalization, has given rise to a distinct "night lifestyle" in which people engage in various recreational activities late at night and early in the morning. While much research and intervention has focused on air, water, soil, and noise pollution, light pollution has yet to get much attention. Light pollution has an impact on various physiological, behavioural, psychological, and ecological processes in both land and marine environments. This review will investigate the numerous forms and sources of light pollution, and its wide-ranging consequences on plants, animals, and human health. By doing so, this review paper hopes to raise awareness of the seriousness of light pollution issues and their influence on daily life.

Keywords: Ecosystem, Light pollution, Living organisms, Physiological activities

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Introduction

Outdoor lighting has an unexpected side effect known as light pollution, which happens when artificial light is used excessively and inappropriately. Sky glow, trespass, glare, uplight, and clutter from city lights are the five overlapping elements of light pollution (Kaushik *et al.*, 2022). Light pollution is defined by Rich and Longcore (2006) as artificial light that interferes with natural light cycles (such as the day and night

cycle and seasons), changes the nocturnal component of the environment, or illuminates the environment, and thus affects behaviour, biological rhythms, physiological processes, and ecosystems. Ecologists use the phrase "ecological light pollution" to emphasise the negative impact of excessive unwanted artificial light on natural biodiversity, which leads to an unbalanced ecosystem (Longcore and Rich, 2004).

The term "urban sky glow" refers to the illumination of the night sky over densely populated places. The phrase "light trespass" refers to the falling of light in an area where it is neither desired nor required (Rajkhowa, 2014; Mishra, 2018). Glare is a result of excessive brightness in the light, which impairs vision and is uncomfortable (Rajkhowa, 2014). A pointed up light generates a particularly conspicuous, localized form of light pollution. Clutter is an excessive cluster of lights that is commonly found in overly lit areas (Mishra, 2018; Hufnagel and Mics, 2022).

Poor signage and streetlight placement, as well as excessive and inappropriate light use, have a substantial impact on light pollution in densely populated areas with more roads and vehicles. Environmental factors like smog, fog, and high suspended particle levels can make light pollution worse (Anand and Madhav, 2021).

Sources of light pollution include illuminated structures and buildings, street and public illumination, emergency lights and vehicle lighting. These types of pollution alter the natural period of photo cycles, degrade the night sky's quality, and alter the night-time environment. A single noble aim is served by an artificial light source (Rich and Longcore, 2006). In practise, however, it results in an unending flow of light directed toward the sky and diluted by water vapor and air particles. The dispersion of artificial light produces a "halo of light" at the luminaire scale. At the scale of an agglomeration, the sum of the luminous halos produces a "agglomeration halo" (Rich and Longcore, 2006).

As a result, any artificial structure with artificial lighting is likely to cause light pollution. Light pollution is further magnified when illumination is of poor technical quality, lights are turned on unnecessarily late at night, they are poorly maintained, or they are not maintained at all (Kaushik *et al.*, 2022).

Finally, weather can influence the intensity of light pollution by increasing the dispersion of light

in the atmosphere. For example, dense cloud covers can tenfold the quantity of light pollution in urban areas. Under the same conditions, the amount of light reflected toward the sky will vary depending on how reflective the illuminated surfaces are (Kaushik *et al.*, 2022).

This review focuses on the negative consequences of light pollution on biodiversity, particularly in plants, animals, and humans. The timing of biological activity is altered by light pollution rather than the biological activities themselves. The daily cycle of light and darkness on Earth is critical in determining various activities of the living world, including reproduction, sleeping patterns, and migration. Night-time artificial lighting has a negative impact on these practises.

Effect of Light pollution on Plant kingdom:

The quantity of light refers to the entire concentration or intensity of light. The wavelength of light defines light quality, whereas duration denotes the overall time that light is present. All three components of light play a distinct function in influencing many physiological activities of the plant kingdom, such as photosynthesis, germination, flowering, and so on. Light pollution may modify one or more of these characteristics (Kaushik *et al.*, 2022). Light pollution, in general, affects plants by interfering with photoperiodism. Long-day plants, short-day plants, and day-neutral plants are the three varieties of plants depending on their light sensitivity. Outside natural light hours, the presence of artificial light can alter these plants' photoperiods (Anand and Madhav, 2021).

The photoperiod controls many biological processes in plants, including pigment formation, leaf shedding, and the onset and termination of bud dormancy. Artificial night lighting impairs plant development by changing the regular photoperiod (Anand and Madhav, 2021). Many plant species (for example, night-blooming cacti like Queen of the Night- *Epiphyllum oxypetalum*) only bloom at night and are pollinated by

nocturnal pollinators. Increased sunshine can limit flowering, pollination, and reproduction in these plants (Anand and Madhav, 2021). Artificial light sources also have an adverse effect on nocturnal pollination networks, which pose a serious threat to terrestrial ecosystems. This has an effect on the reproductive process of plants (Knop *et al.*, 2017).

Effect of Light pollution on Animal kingdom:

Light pollution has an effect on animals as well. Artificial light has a wide range of effects on fish, amphibians, coral reefs, reptiles, birds, mammals and all other animal species (Bennie *et al.*, 2015). To understand the impacts of artificial light, we must first distinguish between diurnal and nocturnal animals. Diurnal species are those that are active during the day and sleep at night. Bees, squirrels, songbirds and even people are among them. Nocturnal animals sleep during the day and move around at night. Moths, bats, frogs and cats are examples of these animals. Both groups are impacted by artificial light, but in different ways. Artificial light has several effects on wildlife (Anand and Madhav, 2021).

Artificial light at night is one of the key reasons for global insect decline. Crepuscular (only active at dusk and dawn) and nocturnal (only active at night) animals rely on the length of the day (light) to begin and stop their daily activity. Artificial light interferes with these activities, decreasing their chances of finding food and mates and exposing them to predators. Although many different organisms are negatively impacted by light pollution, it is most severe in insects, amphibians, sea turtles, and migratory birds (Anand and Madhav, 2021).

Amphibians are light sensitive and can perceive light intensities far below those of humans. At night, amphibians emit mating calls. Long-term artificial light exposure can interfere with this process and diminish reproductive success (Perry *et al.*, 2008).

Sea turtles lay their eggs on beaches. When the eggs hatch, the hatchlings find their way to the water by following the dazzling horizon over the

ocean. Artificial lights, on the other hand, pull them away from the water and in the wrong direction (Anand and Madhav, 2021). Artificial excess light near coastal areas harms coral reefs, and sea turtle hatchlings suffer a significant drop near beaches (Behera and Mohanta, 2018; Rosenberg *et al.*, 2019). This process exposes them to various dangers.

Nocturnal birds rely on moonlight and stars for navigation and hunting, they become disoriented when exposed to too much artificial light. Birds are killed when they collide with high-rise buildings, lighthouses, wind turbines, and sea-based drilling platforms, which are common in many cities (Anand and Madhav, 2021).

The impact of light pollution on the biological rhythms and physiological processes of wildlife is still poorly understood. The majority of the current data is derived from avian studies. Day birds exposed to light pollution start moving and chirping earlier as a result. Seasonal rhythms also change since light pollution causes birds to breed earlier in the year (Dominoni *et al.*, 2013). Light pollution disrupts biological cycles in laboratory mice. Furthermore, in these animals, light pollution has been associated with metabolic problems (glucose intolerance, body weight increase), the development of apathetic and sad behaviour, altered thermoregulation, and reduced immune response (Le Tallec *et al.*, 2016).

Impact of light pollution on human beings:

In humans, artificial light significantly interferes with sleep. A 24-h cycle of day and night known as the circadian clock affects physiologic processes in almost all animals. These include things like hormone production, cell regulation, brain wave patterns, and other biological processes. Human health issues like depression, insomnia, cardiovascular illness, metabolic disturbances, renal ailments, type II diabetes, and cancer have all been connected to disruptions of the circadian clock (Erren and Lewis, 2019, Kumar *et al.*, 2019, Anand and Madhav, 2021).

The disruption of the day-night cycle by light pollution puts human health at risk, in accordance with clinical and epidemiological studies on humans conducted in urban settings and on night work (Haim and Portnov, 2013). Three methods have been proposed to explain how light pollution can harm human health:

- *Circadian disruption hypothesis*: Light pollution causes the primary internal clock to desynchronize with the day and night cycles.
- *Melatonin hypothesis*: Melatonin generation and secretion are both reduced by light pollution. Melatonin deficiency, on the other hand, disrupts biological cycles and results in loss of anti-inflammatory, antioxidant, immunostimulant, neuroprotective, cardioprotective and anti-oncotic properties.
- *Sleep disruption hypothesis*: Light pollution may disrupt sleep patterns or limit its duration by desynchronizing the major internal clock. On the other hand, both the quality and amount of sleep have been related to the preservation of internal balance and are a guarantee of good health.

These three mechanisms are not mutually exclusive. They are, on the contrary, most certainly linked and, in the long term, may lead to the onset of illnesses in people by upsetting the body's equilibrium. Wildlife is most likely using the same methods (Haim and Portnov, 2013, Erren and Lewis, 2019).

Light pollution leads towards unbalance ecosystem:

Light pollution can cause various ecosystem problems. It can affect inter- or intraspecies competitions, prey-predator balances and the organization of species communities. By modifying the lighting environment, light pollution creates a new ecological niche. However, the strong illumination that characterizes this niche attracts some nocturnal species while deterring others. As a result, swift flying bats can take advantage of nocturnal insect gathering near lighting (Rich and Longcore, 2006). Furthermore, this ecological

niche improves diurnal animals' vision, helping them to orient themselves, move around, and find food. These species "colonise" artificially lit nocturnal environments, competing with nocturnal predators and affecting the prey-predator balance. Such behaviour has been observed in spiders, day reptiles and day birds hunting nocturnal insects clustered around lighting as well as the departure of some nocturnal animals to fill a vacant environment (Le Tallec *et al.*, 2016).

Light pollution may play a role in habitat fragmentation. The example of nocturnal insects perfectly shows this. In cities, however, streetlights are just 30 to 50 yards apart (Erren and Lewis, 2019). Illuminated traffic lanes are thus actual artificial barriers in people's journeys. Given the appeal of artificial light for nocturnal insects, these impediments limit their migration and fragment their habitat (Rich and Longcore, 2006). Light pollution may threaten photosensitive species or individuals, such as those with low light tolerance. As a result, light pollution may act as a selection factor affecting the variety of natural populations. Finally, light pollution endangers aquatic life and plants, which are light sensitive like mammals (Hölker *et al.*, 2010).

Conclusion

Light pollution is a real, albeit little known, phenomenon with a growing impact. However, by disturbing the regular cycles of light and illumination of the environment, this pollution is likely to influence the behaviour, physiological processes, and biological rhythms of living organisms. Individually, light pollution can alter people's communication behaviours and the way they exercise and eat. At the population and ecological levels, light pollution affects interspecies competition, prey-predator balances, and habitat fragmentation. As a result, it has a significant impact on ecological communities. It is also vital to limit and reduce light pollution to protect the night sky and wildlife.

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