



POPULAR SCIENCE ARTICLE

Light pollution and its cascading effects on global ecosystems

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Abstract

Light pollution is the excessive, misdirected, or unnecessary use of artificial light at night (ALAN). It is an increasingly pervasive but under-recognized form of environmental pollution. Beyond obscuring the night sky, ALAN disrupts circadian biology in humans, alters animal and plant behaviour, wastes energy resources, and contributes indirectly to greenhouse gas emissions. The present article highlights current evidences based on the sources, causes, multi-domain consequences of light pollution, outlines practical mitigation and policy measures. Curbing light pollution requires coordinated action across lighting design, urban planning, and regulation.

Keywords: Light pollution, artificial light at night (ALAN), sky glow, energy waste, smart lighting.

Introduction

Light pollution, also termed “photo-pollution” or “luminous pollution”, refers to the artificial brightening of the night sky and surrounding environment by sources whose light is scattered in the lower atmosphere (Hölker *et al.*, 2023). Unlike many pollutants, it is invisible in the conventional sense; its effects accumulate gradually, altering the natural light-dark cycle that has governed biological rhythms for millions of years. As urbanization and outdoor lighting infrastructure expand worldwide, night skies over most inhabited regions are now measurably brighter than a century ago, with direct consequences for astronomy, ecosystems, and human health.

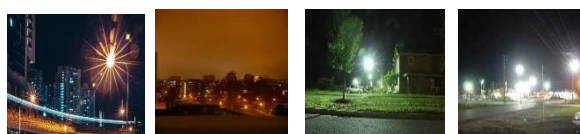
Types of light pollution

Four principal forms are recognised in the literature (Skandali *et al.*, 2024):

- **Glare-** Excessive contrast between bright and dark areas that impairs vision (Fig 1 a). Sub-types include:
 - Blinding Glare- Completely blinds (e.g., staring into the sun)
 - Disability Glare- Reduces visibility (e.g., oncoming headlights)
 - Discomfort Glare- Irritating but not dangerous
- **Sky Glow-** The brightening of the night sky over populated areas from light

scattered by the atmosphere, a major concern for astronomers (Fig 1 b).

- **Light Trespass-** Unwanted light spilling onto someone else’s property (e.g., a neighbour’s light shining through your window), causing issues like sleep disruption (Fig 1 c).
- **Clutter-** Excessive or confusing groupings of light that can distract and cause accidents (notable in road and aviation settings) (Fig 1 d).



(a) Glare

(b) Sky glow

(c) Light trespass

(d) Clutter

Fig. 1. Different types of light pollution

Causes

Light pollution is largely a side effect of industrialized, urbanized civilization. Its principal drivers are the excessive and often unnecessary use of artificial lighting, the absence of timers or occupancy sensors to switch off lights when not required, and the lack of defined optimum illumination standards for different premises. Poor shielding of fixtures compounds the problem by allowing light to escape upward and sideways rather than being directed onto the intended surface.

Measurement

Night-sky brightness and artificial-light exposure are quantified using instruments such as sky-quality meters, satellite radiance imagery (e.g., VIIRS Day/Night Band), and portable light meters placed at point sources such as bedroom windows, enabling both population-level and individual-exposure assessments (Susan *et al.*, 2023). Figure 2 illustrates a hierarchical classification of artificial light monitoring sensors, categorized by their operational platforms.

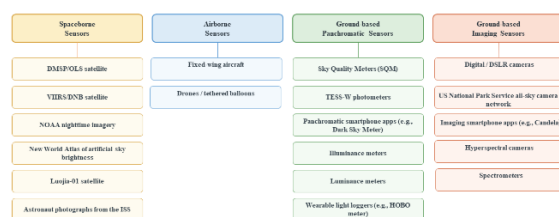


Fig. 2. Artificial light monitoring sensors

Effects of light pollution

Human health

Night-time light exposure suppresses melatonin, a hormone synthesised by the pineal gland only in darkness. Low melatonin, with downstream effects including elevated headache incidence, stress, mood and anxiety disturbances, increased cancer risk, and raised blood pressure. Emerging evidence also links chronic ALAN exposure to neurodegenerative conditions such as Alzheimer's and prion disease (Miao Cao *et al.*, 2023).

Resource and energy waste

Excess lighting consumes large quantity of fossil-derived electricity; since fossil fuels such as coal remain major inputs to power generation, unnecessary illumination indirectly depletes non-renewable resources.

Ecosystems, plants, and animals

Ecosystems are highly sensitive to environmental change and often cannot adapt to a stimulus, such as ALAN, that has no natural precedent. In animals, artificial light alters migration timing, sleep cycles, and foraging behaviour and causes fatal building collisions from light reflected off glass surfaces. In plants, ALAN disrupts the circadian clock, alters seasonal phenology, and interferes with the dark-recovery period essential for stress repair, with consequences for photosynthesis and yield.

Astronomy, air quality, and climate

Sky glow over large cities severely limits the ability of astronomers to observe stars and

galaxies. The electricity demand of night lighting also raises CO₂ and other emissions, contributing indirectly in global warming.

Mitigation, legislation, and suggestion

Practical mitigation measures include (Kaushik *et al.*, 2022):

- ✓ Switching off lights when not in use and minimizing indoor lighting.
- ✓ Using night-shift settings on digital devices and closing blinds/drapes after dark.
- ✓ Deploying LED and fully shielded, downward-facing fixtures.
- ✓ Adopting smart-city and intelligent street-lighting systems with sensors, controllers, and management software to curb pollution and energy use without compromising safety.

On the policy side, recommended measures include standardised limits on lighting consumption and supply, penalties for excessive or non-compliant lighting, curfews after which decorative lighting is reduced to essential levels, and regulation of high-powered laser-light import and production.

Future perspective

Feasible new lighting technologies should be adopted to reduce night-time light emissions. In India specifically, awareness of light pollution as an environmental hazard remains low relative to its ecological and health impact, underscoring the need for public education. Policymakers should draft explicit guidelines promoting sustainable, needs-based night-time lighting.

Conclusion

Light pollution is one of the major problems which is affecting people adversely. Over-brightening of the sky is responsible for variety of biological disorders like, sleep deprivation, behavioral changes, cardiovascular diseases and other psychological disorders etc. Light pollution is not limited merely to the astronauts or space explorers but are also causing damage to our daily lifestyle and environment. The problem has gained attention in recent years owing to the increment in damage being caused. Research work in this regard is being carried out by scientific community at global level but the decisions regarding mitigation measures are left with the stakeholders, with the ordinary inhabitants, with policymakers and politicians.

Conflict of Interest:

The authors declare that there are no competing financial or personal interests that could have influenced the work reported in this article.

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