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Environmental Effects of Artificial Light

Physics

KEYWORDS : Artificial light, light pollution, sky glow, light trespass, clutter, glare, wildlife health, astronomy, LED.

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ABSTRACT

Artificial light has benefited society by offering more time not just for working but also for recreational activities that require light. Numbers of outdoor lights are growing rapidly across the world, far outpacing general population growth. When artificial outdoor lighting becomes inefficient, annoying, and unnecessary, it is known as light pollution. It includes effects like sky glow, light trespass, clutter and glare. Research in this field suggests that light pollution can have lasting adverse effects on both human and wildlife health and on astronomy. As a number of environmentalists, naturalists, and medical researchers consider light pollution to be one of the fastest growing and most pervasive forms of environmental pollution: it is required to discuss different component of light pollution, its adverse effects and remedial methods. One more important concern is related to LED. LEDs may still be the best choice regarding light quality, energy use and environmental footprint. It does seem to be the wave of the future right now but there is a darker side of LED as toxic hazards. This study finds important voids in knowledge and makes some recommendations for further research.

Introduction: The Invention of Electrical light is one of the greatest inventions of Science which has changed our world and converted darkness into light. Artificial light has benefited society by offering more time not just for working but also for recreational activities that require light. Numbers of outdoor lights are growing rapidly across the world, far outpacing general population growth. But when artificial outdoor lighting becomes excessive, inefficient, annoying, inappropriate and unnecessary, it is known as light pollution. Light pollution is an unwanted consequence of outdoor lighting and includes such effects as **Sky glow**, **Light Trespass**, **Clutter** and **Glare** (Figure 2)**.** Many environmentalists, naturalists, and medical researchers consider light pollution to be one of the fastest growing and most pervasive forms of environmental pollution, and a growing body of scientific research suggests that light pollution can have lasting adverse effects on both human and wildlife health. A more important concern is related to LED. LEDs may still be the best choice regarding light quality, energy use and environmental footprint. It does seem to be the wave of the future right now but there is a darker side of LED as toxic hazards.

Components of Light Pollution: Light is among the fastest growing human-made pollutants of the natural environment. The four components of light pollution are often combined and may overlap:

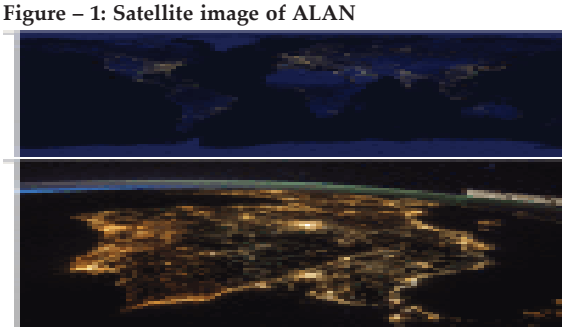
Sky Glow—the brightening of the night sky over inhabited areas caused by both natural and human made factors. The key factor of sky glow that contributes to light pollution is outdoor lighting.

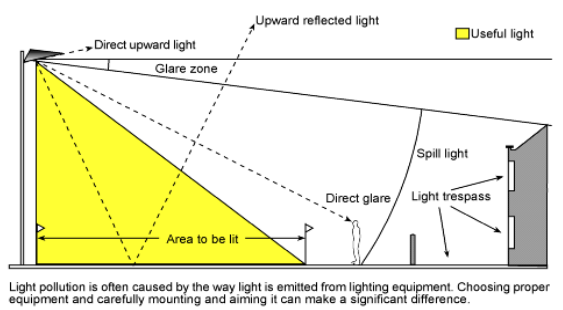
Light Trespass—light falling where it is not intended, wanted, or needed such as light from a streetlight, floodlight or neighbour's security light brings about an unwanted lighting onto our property or into our bedroom at night making it difficult to sleep.

Glare—excessive and objectionable brightness which causes visual discomfort. It can be disabling or discomforting. There are several kinds of glare, the worst of which is **disability glare**, because it causes a loss of visibility from stray light being scattered within the eye. **Discomfort glare** is the sensation of annoyance or even pain induced by overly bright sources. Think of driving along a dark road when an oncoming car with bright headlights suddenly appears. The sudden bright light can be uncomfortable and make it difficult to see. Discomfort and even disability glare can also be caused by streetlights, parking lot lights, floodlights, signs, sports field lighting, and decorative and landscape lights.

Clutter—bright, confusing, and excessive groupings of light sources, commonly found in over-lit urban areas. The proliferation of clutter contributes to urban sky glow, trespass, and glare.

Figure – 1: Satellite image of ALAN





Light pollution is often caused by the way light is emitted from lighting equipment. Choosing proper equipment and carefully mounting and aiming it can make a significant difference.

Figure 2: Light pollusion is often caused by the way light is emitted from lighting equipment. Choosing proper equipment and carefully mounting and aiming it can make a significant difference.

Adverse Effects of Light Polliution: Daily lunar and seasonal cycles of natural light have been key forms of environmental variation across the Earth's surface since the first emergence of life. They have driven the development of biological phenomena from the molecule to the ecosystem including metabolic and physiological pathways, the behaviour of individuals, geographical patterns of adaptation and species richness, and ecosystem cycles (e.g. [1]). Indeed, biological systems are arguably organized foremost by light [2].

The natural patterns of light have over the last 100 years come to be greatly disrupted through the introduction of artificial light into the night-time environment. It disrupts natural patterns of light both via direct effects of illumination from various sources as well as via skyglow.

On the ground, this disruption of natural patterns of light takes two principal forms. First, light has been introduced in places, times and at intensities at which it does not naturally occur. This has been firmly fixed in the public imagination through the creation from satellite and astronaut acquired night-time imagery of pictures of the Earth which illustrate the extent of artificial lighting at night, of urbanization and of major centres of human population (figure 1).

Although there are documented examples of the impacts of artificial lighting at night on prey influencing their predators, and of impacts on predators influencing their prey, the manner in which such influences ramify through communities remains poorly understood [3]. Bennie *et al.* [4] report experimental evidence of bottom-up, but not top-down, effects in simple plant–herbivore–predator communities.

Although largely unknown, it has to be expected that effects on ecosystem functions and services do occur. In the tropics, for example, nocturnal seed dispersers such as bats are crucial for ecosystem functioning. It was found that natural forest succession and connectivity of forest patches may suffer owing to artificial lighting at night through a reduction in nocturnal seed disperser activity in illuminated areas.

LED as Toxic Hazard: LED (light emitting diode) lighting indeed seems to be the wave of the future right now, given the mercury content and light quality issues with the current king-of-the-hill of green bulbs, the compact fluorescent (CFL). LEDs use significantly less energy than even CFLs, and do not contain mercury. And they are becoming economically competitive with CFLs at the point of purchase while yielding superior quality lighting and energy bill savings down the line.

But LEDs do have a dark side. A study published in late 2010 in the journal *Environmental Science and Technology* found that LEDs contain lead, arsenic and a dozen other potentially dangerous substances. LEDs are touted as the next generation of lighting," says Oladele Ogunseitan, one of the researchers behind the study and chair of the University of California (UC)-Irvine's Department of Population Health & Disease Prevention. "But as we try to find better products that do not deplete energy resources or contribute to global warming, we have to be vigilant [about] toxicity hazards…."

Ogunseitan and other UC-Irvine researchers tested several types of LEDs, including those used as Christmas lights, traffic lights, car headlights and brake lights. What did they find? Some of the worst offenders were low-intensity red LEDs, which were found to contain up to eight times the amount of lead, a known neurotoxin, allowed by California state law and which, according to researchers, "exhibit significant cancer and noncancer potentials due to the high content of arsenic and lead." Meanwhile, white LEDs contain the least lead, but still harbor large amounts of nickel, another heavy metal that causes allergic reactions in as many as one in five of us upon exposure. And the copper found in some LEDs can pose an environmental threat if it accumulates in rivers and lakes where it can poison aquatic life.

Ogunseitan adds that while breaking open a single LED and breathing in its fumes wouldn't likely cause cancer, our bodies hardly need more toxic substances floating around, as the combined effects could be a disease trigger. If any LEDs break at home, Ogunseitan recommends sweeping them up while wearing gloves and a mask, and disposing of the debris — and even the broom — as hazardous waste. Furthermore, crews dispatched to clean up car crashes or broken traffic lights (LEDs are used extensively for automotive and traffic lighting) should wear protective clothing and handle material as hazardous waste. LEDs are currently not considered toxic by law and can be disposed of in regular landfills.

Remedial Methods:

To determine the effects of artificial lighting at night on populations, communities and ecosystems most effectively, it is necessary to establish replicated field experiments. The first such experiments report findings in this special issue—the ECOLIGHT experiment [51], the 'Verlust der Nacht' experiment and the Light On Nature experiment. Early evidence is suggesting that there may be marked between-year variation in the influences of artificial lighting at night, emphasizing the importance of developing or maintaining long-term experiments including several generations of key species. Understanding of both dose-response and spectral-response relationships, and their interaction, will be critical to providing the best advice on how to limit the negative biological impacts of artificial lighting at night.

According to Ogunseitan, LED makers could easily reduce the concentrations of heavy metals in their products or even redesign them with truly safer materials, especially if state or federal regulators required them to do so. "Every day we don't have a law that says you cannot replace an unsafe product with another unsafe product, we're putting people's lives at risk," he concludes. "And it's a preventable risk."

Conclusion:

Over just the last few years there has been an explosion of research interest in the biological impacts of artificial lighting at night (albeit the topic has deep historical roots). This has been fuelled by (i) several policy reports that have highlighted its likely importance among the plethora of anthropogenic influences on the environment; (ii) the need to cut energy costs by altering public lighting systems and the associated potential for environmental gains; (iii) the wide-scale change to LED lighting and calls for the design of eco-friendly spectral composition of lamps [5] and arguably, (iv) the serendipitous contemporaneous emergence both of major independent funded research programs experimentally addressing ecological impacts of artificial lighting at night [6] and of the interdisciplinary 'Loss of the Night Network' funded by the EU COST program. The resultant body of research work has mapped out the potential breadth of biological impacts of artificial lighting at night, has highlighted many important targets for future work and has begun to identify ways in which practical steps can be taken to reduce environmental concerns.

Of course, we all need some kind of lighting in our lives and, despite their flaws, LEDs may still be the best choice regarding light quality, energy use and environmental footprint. That said, researchers are busy at work on even newer lighting technologies that could render even today's green choices obsolete.

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