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Light Pollution and Its Effects on Human Health and the Environment: A Review

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ABSTRACT

Light pollution, the presence of excessive or misdirected artificial light, has become a growing concern due to its adverse impacts on both human health and the environment. This review explores the multifaceted issue of light pollution, starting with an overview of its various forms skyglow, glare, and light trespass—and how urbanization and industrialization have exacerbated these problems. The review examines key sources of light pollution, including streetlights, commercial signage, and residential lighting, and discusses their contributions to environmental degradation and health issues. The environmental impacts of light pollution are significant, affecting nocturnal wildlife by disrupting natural behaviors and ecological interactions, and altering plant growth and reproduction. The review details how artificial light interferes with natural cycles, including circadian rhythms, and the resultant effects on animal and plant life. From a human health perspective, the review highlights how light pollution disrupts circadian rhythms, leading to sleep disorders, increased stress, and mood disorders. It addresses the psychological and cognitive

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effects of disrupted sleep, including impaired attention, memory, and executive function. Additionally, the review outlines the links between chronic light exposure and increased risks of obesity, cardiovascular diseases, and metabolic disorders. Mitigation strategies, including improved outdoor lighting design and public awareness initiatives, are discussed as essential measures to address light pollution. By providing a comprehensive analysis of the sources, effects, and potential solutions, this review underscores the urgent need for effective interventions to protect both human health and the natural environment from the detrimental effects of light pollution.

Keywords: Light pollution; human health; environmental impact; artificial light; health risks; exposure effects.

1. INTRODUCTION

1.1 Overview of Light Pollution

Light pollution is defined as the presence of excessive or misdirected artificial light in the environment that interferes with natural darkness. It encompasses several forms, including skyglow, glare, and light trespass, all of which can negatively impact both human health and the natural environment [1]. Light pollution includes several key components: skyglow, which is the brightening of the night sky over populated areas; glare, which causes visual discomfort; and light trespass, where unwanted or intrusive light spills over into areas where it is not needed [2]. The disruption of natural darkness due to light pollution affects nocturnal wildlife, disrupts astronomical observations, and alters the natural rhythms of various species [3].

Artificial lighting has evolved significantly over centuries, from early methods such as torches and oil lamps to modern electric lighting. The advent of gas lighting in the 19th century and electric lighting in the 20th century marked major milestones in the development of artificial lighting. As urban areas expanded and industrialized, the increase in artificial lighting led to significant changes in the night environment. The rise of urbanization and increased use of streetlights, commercial signage, and illuminated buildings contributed to the growing problem of light pollution [4,5]. Urbanization has exacerbated light pollution through increased use of artificial lighting in cities, leading to skyglow, glare, and light trespass. The expansion of cities and the proliferation of light sources have transformed natural nightscapes into artificially lit environments [3].

Light pollution has been increasingly recognized for its potential effects on human health. Research has linked excessive exposure to artificial light at night with various health issues, including sleep disturbances, increased risk of metabolic disorders, and potential impacts on mental health [6].

Key sources of light pollution include streetlights, commercial signage, vehicle headlights, and indoor lighting. Each of these sources contributes to various forms of light pollution, such as skyglow, glare, and light trespass, impacting both human health and the environment [7,8].

Mitigation strategies for light pollution include improving outdoor lighting design, using shielded fixtures, and adopting lighting policies that minimize unnecessary illumination. Additionally, public awareness and technological innovations can play significant roles in reducing light pollution [2,9]. The purpose of review is to explore the effects of light pollution on human Health, identify key sources, and discuss potential mitigation Strategies.

2. SOURCES OF LIGHT POLLUTION

2.1 Urban Lighting

2.1.1 Street lights

Street lighting is a major contributor to light pollution, influencing various aspects of the night environment. Inappropriate street lighting can lead to significant skyglow, glare, and light trespass, adversely affecting both human health and the environment [10]. The design of street lighting plays a crucial role in the extent of light pollution. Factors such as fixture types, light intensity, and shielding can either exacerbate or mitigate light pollution. Poorly designed street lights can lead to increased glare, excessive light spill, and skyglow, impacting both the environment and human health [2, 9]. To reduce the impact of street lighting on light pollution, several strategies can be employed, including

the use of shielded fixtures, lower-intensity lighting, and better placement of street lights. These measures can help minimize glare, light spill, and skyglow, contributing to a healthier night environment [10].

2.1.2 Building lighting

Illuminated buildings contribute significantly to light pollution through excessive and misdirected lighting. High-intensity lighting on buildings can lead to skyglow and light spill, which disrupt natural nightscapes and affect both human health and the environment [11].

Illuminated signage and billboards contribute to light pollution by emitting bright, often intrusive light that can lead to glare and light trespass. These sources of artificial light can interfere with natural darkness and impact both human well-being and wildlife [2].

To reduce the impact of illuminated buildings, signage, and billboards, various mitigation strategies can be employed. These include the use of shielded fixtures, reducing the intensity of lights, and implementing zoning regulations that control the brightness and hours of operation of illuminated signs [3,12].

2.2 Outdoor Advertising

2.2.1 Billboards

Traditional billboards contribute to light pollution through their bright and often excessively illuminated advertisements. The high-intensity lighting used to make these billboards visible from long distances leads to skyglow and light spill, affecting both the night sky and the surrounding environment [11,13].

Digital displays on billboards are particularly problematic due to their dynamic nature and high brightness levels. The constant changing of images and high-intensity lighting can lead to increased glare, light trespass, and further contribute to skyglow, disrupting both human and wildlife nocturnal activities [2].

Addressing the impact of billboards on light pollution requires regulatory measures and design improvements. Strategies include limiting the brightness of digital displays, restricting the use of animated or flashing lights, and implementing zoning laws to control the placement and illumination of billboards [3,14].

2.2.2 Commercial lighting

Commercial lighting, including that used in retail stores, shopping centers, and entertainment venues, often involves high-intensity lighting that is operational late into the night. This lighting contributes significantly to light pollution through excessive brightness, skyglow, and light trespass, impacting both the environment and human health [5].

Entertainment lighting, including lighting for events, theaters, and concerts, often involves the use of intense spotlights, lasers, and other high-energy lighting technologies. These practices not only increase light pollution but also contribute to light trespass and skyglow, affecting surrounding areas and ecosystems [13].

Addressing light pollution from commercial and entertainment lighting involves implementing stricter regulations and adopting best practices. These include reducing light intensity, using properly shielded fixtures, and limiting the duration of lighting operations to minimize their impact on the environment and human health [2].

2.3 Residential Lighting

2.3.1 Home lighting

Outdoor residential lighting, including porch lights, garden lights, and security lights, can contribute to light pollution through glare, skyglow, and light trespass. When not properly shielded or used excessively, these lights disrupt natural darkness and affect both human and ecological systems [15].

Security lights and decorative lighting, common in many residential areas, often use high-intensity bulbs and are left on throughout the night. This can lead to significant light pollution, impacting local wildlife and disrupting human sleep patterns due to increased light exposure [3].

Mitigation strategies for reducing light pollution from home lighting include using fully shielded fixtures, selecting lower-intensity bulbs, and implementing motion sensors to minimize unnecessary lighting. Educating homeowners about the impacts of light pollution and best practices for outdoor lighting is crucial [16].

2.3.2 Neighborhood practices

Neighborhoods with a prevalence of unshielded outdoor lights and high-intensity bulbs, such as street lights, garden lights, and decorative lighting, often experience increased light pollution. These lighting practices lead to excessive glare and skyglow, disrupting natural darkness and impacting both human health and the environment [2].

Residential lighting that spills over into neighboring properties, often due to poorly designed fixtures or improper installation, contributes to light trespass and glare. This not only affects the aesthetics of the neighborhood but also disrupts sleep patterns and impacts local wildlife [12,17].

Over-illumination and continuous lighting in residential areas, such as those used for security or decorative purposes, exacerbate light pollution. These practices contribute to skyglow and affect nocturnal wildlife and human circadian rhythms [3,13].

Neighborhood practices can be improved through community initiatives such as implementing lighting ordinances, promoting the use of shielded fixtures, and encouraging residents to adopt best practices for outdoor lighting. Education and awareness campaigns play a key role in reducing light pollution [16].

3. ENVIRONMENTAL AND ECOLOGICAL IMPACTS

3.1 Disruption of Ecosystems

3.1.1 Wildlife

Light pollution significantly impacts nocturnal wildlife by altering their natural activity patterns. Many nocturnal species, such as insects, birds, and mammals, rely on darkness for essential behaviors like foraging, mating, and navigation. Artificial light can lead to changes in these behaviors, often resulting in adverse ecological consequences [3,18].

Artificial light can attract and disorient nocturnal insects, including moths and beetles, leading to changes in population dynamics and ecological interactions. This disruption can affect insect pollination and contribute to declines in both insect and predator populations [19,20].

Light pollution interferes with migratory birds' navigation and can lead to increased collisions with artificial structures. Additionally, artificial light can disrupt breeding behaviors and reduce the availability of suitable nesting sites [21].

Light pollution can alter the behavior and physiology of amphibians and reptiles, affecting their breeding cycles and habitat use. For instance, artificial light can disorient hatchlings and interfere with their ability to find suitable habitats [22,23].

Artificial light can disrupt the predatory-prey dynamics by altering the behavior of both predators and prey. For instance, it may affect hunting efficiency and prey availability, leading to changes in food webs [12,24].

3.1.2 Plant life

Artificial light can influence plant growth patterns by altering light duration, intensity, and spectral quality. Plants rely on natural light cues to regulate growth processes, and deviations from these cues can lead to changes in plant morphology, growth rates, and overall health [12,25].

Artificial light can disrupt the natural flowering cycles of plants by affecting their photoperiodic responses. Many plants rely on specific light and dark periods to trigger flowering, and deviations from these periods can lead to delayed or irregular flowering [26].

Artificial light can influence plant reproduction by affecting pollination and seed production. For example, changes in flowering timing due to artificial light can affect the availability of pollinators and, consequently, the success of pollination [27,28].

Artificial light can alter plant metabolic processes, including photosynthesis and respiration. Changes in light intensity and quality can affect the efficiency of these processes, potentially impacting overall plant health and productivity [29].

Artificial light can influence the dynamics of plant communities by altering competitive interactions. For instance, species that are more tolerant of

artificial light may outcompete others, leading to shifts in plant community composition [30,31].

3.2 Alteration of Natural Cycles

3.2.1 Circadian rhythms

Artificial light at night (ALAN) can interfere with the circadian rhythms of various animal species by altering their natural light-dark cycles. This disruption can lead to changes in behavior, feeding patterns, and reproductive cycles [2,24].

Artificial light can alter the circadian rhythms of bird species, affecting their migratory patterns, foraging behavior, and breeding success. This disruption can lead to decreased fitness and survival rates [21].

In aquatic ecosystems, artificial light can disrupt the circadian rhythms of fish and invertebrates, affecting their feeding, spawning, and predator-prey interactions. This can lead to changes in community structure and ecosystem dynamics [32].

Artificial light disrupts the circadian rhythms of insects, affecting their nocturnal behaviors, such as foraging and mating. This disruption can lead to declines in insect populations and affect ecosystem services [14,33].

Artificial light at night can disrupt human circadian rhythms, leading to various health issues such as sleep disorders, metabolic problems, and increased risk of chronic diseases [34,35].

3.2.2 Breeding and migration

Artificial light pollution can disrupt bird breeding patterns by altering the timing of reproductive behaviors and success rates. Birds exposed to artificial light may experience changes in their breeding cycles, including altered mating calls and nesting habits [21].

Light pollution can affect amphibian breeding by disrupting their reproductive calls and mating behaviors. Amphibians that rely on natural light cues for breeding may experience reduced success and altered behavior patterns [36].

Insects that use light for mating and navigation can experience disrupted reproductive behaviors due to light pollution. For instance, moths and other nocturnal insects may be drawn to artificial lights, leading to decreased mating success and altered population dynamics [14,37].

Artificial light can disrupt the migration patterns of marine species, such as sea turtles and fish, which rely on natural light cues for navigation. This disruption can lead to increased mortality rates and altered migratory routes [38,39].

Artificial light can affect the migration patterns of nocturnal mammals by altering their natural light cues. This can lead to increased predation risks and altered foraging behaviors [40].

4. IMPACTS ON HUMAN HEALTH

4.1 Sleep Disorders

4.1.1 Circadian disruption

Light pollution disrupts the body's natural circadian rhythms, which are essential for regulating sleep-wake cycles, hormone release, and other physiological processes. Artificial light exposure, especially during the night, interferes with these natural rhythms by signaling to the body that it is still daytime [34].

Exposure to artificial light at night can lead to poor sleep quality by interfering with the production of melatonin, a hormone that regulates sleep. This disruption can result in difficulty falling asleep, reduced sleep duration, and lower sleep efficiency [41,42].

Disruption of circadian rhythms due to light pollution is associated with various mental health issues, including increased risk of depression, anxiety, and mood disorders. The misalignment of internal biological clocks with environmental light-dark cycles can exacerbate these conditions [43].

Artificial light at night can disrupt normal sleep architecture by reducing the amount of deep sleep and REM sleep. This alteration in sleep stages can affect overall sleep quality and cognitive function [44,45].

Long-term disruption of circadian rhythms due to light pollution has been linked to various health issues, including obesity, cardiovascular diseases, and metabolic disorders. These health implications arise from the chronic misalignment of biological clocks [46,47].

4.1.2 Sleep disorders

Light pollution has been shown to disrupt sleep patterns significantly. Research indicates that exposure to artificial light during the night can interfere with the body's natural circadian rhythms, leading to difficulties falling asleep and maintaining sleep throughout the night. For instance, a study by Figueiro et al. (2012) found that exposure to light at night suppresses melatonin production, a hormone crucial for regulating sleep-wake cycles, thereby delaying sleep onset and reducing sleep duration [48].

Light pollution is associated with an increased risk of developing insomnia. Patel (2019) conducted research revealing that individuals living in areas with high levels of artificial light experienced more severe symptoms of insomnia compared to those in less illuminated environments. Their study highlighted that exposure to light at night is a significant risk factor for insomnia, contributing to difficulty in both falling asleep and staying asleep [49].

Artificial light exposure at night can adversely affect the quality and quantity of Rapid Eye Movement (REM) sleep. Svechkina et al. (2020) demonstrated that light exposure during the night leads to a reduction in REM sleep, which is essential for cognitive functions such as memory consolidation and emotional regulation. Their findings underscore the detrimental effects of light pollution on essential sleep stages [13].

Children exposed to excessive light at night are particularly vulnerable to sleep disorders. A study by Wang et al. (2022) found a significant association between nighttime light exposure and sleep disturbances in children, including difficulties with sleep initiation and maintenance. The study emphasizes the importance of managing light exposure in children's environments to prevent sleep-related issues [50].

There is growing evidence linking light pollution-induced sleep disorders to mental health issues such as depression and anxiety. Howarth and Miller (2024) reviewed studies showing that chronic sleep disruption caused by light pollution can exacerbate symptoms of depression and anxiety, highlighting the broader mental health implications of poor sleep quality [51].

Long-term exposure to light pollution can have serious health consequences. Medic et al. (2017) found that persistent sleep disruption due to artificial light at night is associated with increased risks of obesity, cardiovascular disease, and metabolic disorders, reflecting the extensive impact of light pollution on overall health [52].

4.2 Psychological Effects

4.2.1 Mood disorders

Exposure to artificial light can significantly influence mood, particularly in the context of Seasonal Affective Disorder (SAD). Magnusson and Boivin (2003) demonstrated that individuals with SAD exhibit improvements in mood with light therapy, suggesting that reduced exposure to natural light during darker months exacerbates depressive symptoms. Their research highlights the role of light in regulating mood and its therapeutic potential [53].

Chronic exposure to artificial light has been linked to increased stress and anxiety levels. Bedrosian and Nelson (2013); LeGates et al. (2014) found that prolonged exposure to bright artificial light at night can lead to elevated stress markers and heightened anxiety, as the disruption of circadian rhythms affects the body's stress response. This research underscores the connection between light exposure and mood disorders [54,55].

Artificial light exposure, particularly during the night, can contribute to depressive symptoms. Menculini et al. (2014) observed that night-time exposure to artificial light impairs mood regulation, contributing to symptoms of depression. Their findings suggest that light pollution disrupts natural sleep patterns and hormonal balances that are crucial for maintaining mental health [56].

Artificial light affects the circadian rhythm, which plays a critical role in mood regulation. Blume et al. (2019) found that exposure to light at night alters circadian rhythms, which can lead to mood disturbances such as irritability and low mood. The study emphasizes the importance of maintaining a consistent light-dark cycle for mental health [34].

Artificial light exposure can also affect cognitive function, which is closely linked to mood. Siraji et al. (2022) found that excessive artificial light exposure can impair cognitive functions, such as attention and memory, which are important for maintaining a stable mood. This impairment can

contribute to mood disorders by affecting the ability to cope with daily stressors [57].

Long-term exposure to artificial light is associated with significant psychological impacts, including increased risks of mood disorders. Bedrosian and Nelson (2013) found that chronic exposure to artificial light at night can lead to persistent mood disturbances and contribute to the development of mood disorders over time [54].

4.2.2 Cognitive impacts

Disrupted sleep caused by light pollution can negatively affect attention and concentration. Killgore (2010) found that sleep disruption due to exposure to artificial light at night impairs cognitive functions, particularly attention and focus. The study indicates that inadequate sleep resulting from light pollution can lead to difficulties in maintaining attention and concentration during daily activities [58].

Light pollution-induced sleep disruption can impair memory functions. Havekes et al. (2016) demonstrated that inadequate sleep due to artificial light exposure affects both short-term and long-term memory consolidation. Their research highlights the detrimental effects of sleep disturbance on the ability to process and retain information, which is crucial for learning and cognitive development [59].

Disrupted sleep from light pollution can also affect executive functions, such as decision-making and problem-solving. Yang et al. (2024) found that chronic exposure to artificial light at night leads to impairments in executive function, including difficulties in planning, organizing, and executing tasks. The study suggests that these cognitive impairments are linked to the disruption of the circadian rhythm and subsequent sleep disturbances [60].

Long-term exposure to artificial light at night can contribute to cognitive decline. The chronic sleep disruption from light pollution may be associated with cognitive decline, particularly in older adults. Their research underscores the impact of prolonged exposure to artificial light on cognitive health, emphasizing the importance of maintaining a regular sleep pattern to preserve cognitive function.

Light pollution can negatively impact learning and academic performance. Portnov (2024) showed that students exposed to high levels of artificial light at night experience decreased academic performance due to poor sleep quality. Their findings suggest that disrupted sleep from light pollution affects cognitive processes critical for learning and academic achievement [61].

Artificial light at night can lead to mental fatigue and reduced cognitive efficiency. Siraji et al. (2022) found that individuals exposed to artificial light during nighttime have higher levels of mental fatigue, which impairs cognitive performance. The study highlights the importance of managing light exposure to prevent mental fatigue and maintain cognitive efficiency [57].

4.3 Increased Risk of Chronic Diseases

4.3.1 Obesity and metabolic syndrome

Disrupted sleep patterns are strongly associated with an increased risk of obesity. Patel and Hu (2008) found that insufficient sleep or irregular sleep patterns can lead to weight gain and higher body mass index (BMI). The study demonstrates that sleep deprivation can influence appetite-regulating hormones, leading to increased food intake and reduced energy expenditure, which contributes to obesity [62].

Disrupted sleep patterns are linked to the development of metabolic syndrome, a cluster of conditions including hypertension, hyperglycemia, and dyslipidemia. Knutson and Van (2008); Arora and Taheri (2015) reviewed evidence showing that sleep disturbances can impair glucose metabolism, increase insulin resistance, and promote abdominal obesity, all key components of metabolic syndrome [47,63].

Sleep disruptions can lead to hormonal imbalances that contribute to obesity and metabolic syndrome. Spiegel et al. (2004) identified that irregular sleep patterns affect hormones such as leptin and ghrelin, which regulate hunger and satiety. The imbalance of these hormones due to poor sleep can result in increased appetite and weight gain [64].

Insulin resistance is a major factor in the development of metabolic syndrome and is associated with disrupted sleep. Knutson et al. (2006) demonstrated that poor sleep quality and insufficient sleep increase the risk of developing insulin resistance, which is a precursor to type 2 diabetes and a component of metabolic syndrome [65].

Sleep disruption negatively impacts glucose metabolism, contributing to obesity and metabolic syndrome. Stamatakis and Punjabi (2010) found that fragmented sleep can impair glucose tolerance and increase fasting glucose levels, exacerbating metabolic syndrome risk [66].

Disrupted sleep patterns are linked to an increased risk of cardiovascular disease, which is often associated with metabolic syndrome. Meng et al. (2013) reviewed studies indicating that poor sleep quality and short sleep duration are associated with increased risk of hypertension, heart disease, and stroke, which are related to metabolic syndrome [67].

Sleep disruption can trigger inflammatory responses that contribute to obesity and metabolic syndrome. Irwin and Opp (2017) found that irregular sleep patterns increase levels of inflammatory markers such as C-reactive protein (CRP), which are associated with obesity and metabolic syndrome [68].

4.3.2 Cardiovascular health

Light pollution has been associated with an increased risk of hypertension. Koo et al. (2016) found that exposure to artificial light at night can disrupt the circadian rhythm, leading to elevated blood pressure and increased risk of hypertension. The study highlights the physiological stress caused by disrupted sleep patterns and its impact on cardiovascular health [69].

Artificial light exposure at night is linked to a higher incidence of heart disease. Stevens and Zhu (2015) reviewed evidence suggesting that long-term exposure to light pollution can lead to chronic stress and increased risk of cardiovascular conditions, including coronary artery disease and heart failure [70].

Circadian rhythm disruption due to light pollution can negatively impact cardiovascular health. Lamphar et al. (2022) found that exposure to light at night disrupts melatonin production, which is associated with increased cardiovascular disease risk. Melatonin plays a crucial role in regulating cardiovascular functions and its disruption can contribute to heart-related conditions [71]

Light pollution has been linked to the development of metabolic syndrome, which is a risk factor for cardiovascular disease. Obayashi et al. (2013) demonstrated that exposure to artificial light at night can impair glucose metabolism and increase the risk of obesity, both of which are closely linked to cardiovascular health issues [72].

Exposure to light pollution can induce inflammatory responses, contributing to cardiovascular disease. Scheer et al. (2009) found that disrupted sleep and circadian rhythms due to light pollution can increase levels of inflammatory markers such as C-reactive protein (CRP), which are associated with heart disease [73].

Light pollution affects sleep quality, which in turn impacts cardiovascular health. Cappuccio et al. (2011) reviewed how poor sleep quality caused by exposure to light at night can lead to various cardiovascular issues, including increased risk of stroke and heart attack [74].

5. CONCLUSION

Light pollution, characterized by excessive or misdirected artificial light, has become a pervasive issue with significant impacts on both human health and the environment. This review has outlined the various sources and forms of light pollution, including urban lighting, outdoor advertising, commercial and residential lighting, and their detrimental effects on ecosystems and human well-being.

Light pollution disrupts natural ecosystems by altering nocturnal behaviors of wildlife, including insects, birds, and mammals. This interference affects critical activities such as foraging, mating, and navigation, leading to ecological imbalances. Plant life also suffers, with artificial light influencing growth patterns, flowering cycles, and community dynamics.

The review highlights the significant health impacts of light pollution. Disruption of circadian rhythms due to artificial light at night can lead to sleep disorders, including insomnia and reduced sleep quality. This, in turn, has been linked to mood disorders, cognitive impairments, and increased risks of chronic conditions such as obesity and cardiovascular diseases. The disruption of melatonin production and altered sleep architecture are central to these health issues.

Effective mitigation of light pollution requires a multifaceted approach. Implementing better lighting designs, such as shielded fixtures and lower-intensity bulbs, and adopting zoning regulations can significantly reduce light pollution. Public education and awareness are crucial in promoting practices that minimize unnecessary lighting and its impacts.

In summary, addressing light pollution involves understanding its sources and effects on both the environment and human health. By adopting effective strategies and fostering greater awareness, we can work towards minimizing the negative impacts of artificial light and restoring natural darkness.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Falchi F, Cinzano P, Duriscoe D, Kyba CC, Elvidge CD, Baugh K, Furgoni R. The new world atlas of artificial night sky brightness. Science Advances. 2016;2(6):e1600377. Available:https://doi.org/10.1126/sciadv.1600377
2. Longcore T, Rich C. Ecological light pollution. Frontiers in Ecology and the Environment. 2004;2(4):191-198. Available:https://doi.org/10.1890/1540-9295(2004)002[0191:ELP]2.0.CO;2
3. Rich C, Longcore T. (Eds.). Ecological consequences of artificial night lighting. Island Press; 2013.
4. Elvidge CD, Baugh KE, Kihn EA, Kroehl HW, Davis ER, Davis CW. Relation between satellite observed visible-near infrared emissions, population, economic activity and electric power consumption. International Journal of Remote Sensing. 1997;18(6):1373-1379. Available:https://doi.org/10.1080/01431169 7218485
5. Cinzano P, Falchi F, Elvidge CD. The first world atlas of the artificial night sky brightness. Monthly Notices of the Royal Astronomical Society. 2001;328(3):689-707. Available:https://doi.org/10.1046/j.1365-8711.2001.04882.x
6. Stevens RG. Circadian disruption and breast cancer. In The Pineal Gland and Cancer: Neuroimmunoendocrine Mechanisms in Malignancy. Berlin, Heidelberg: Springer Berlin Heidelberg. . 2001;511-517. Available:https://doi.org/10.1007/978-3-642-59512-7_28
7. Holzhauer SI, Franke S, Kyba CC, Manfrin A, Klenke R, Voigt CC, Hölker F. Out of the dark: Establishing a large-scale field experiment to assess the effects of artificial light at night on species and food webs. Sustainability. 2015;7(11):15593-15616. Available:https://doi.org/10.3390/su71115593
8. Falchi F, Cinzano P, Duriscoe D, Kyba CC, Elvidge CD, Baugh K, Furgoni R. The new world atlas of artificial night sky brightness. Science Advances. 2016;2(6): e1600377. Available:https://doi.org/10.1126/sciadv.1600377
9. Gaston KJ, Davies TW, Bennie J, Hopkins J. Reducing the ecological consequences of night-time light pollution: Options and developments. Journal of Applied Ecology. 2012;49(6):1256-1266. Available:https://doi.org/10.1111/j.1365-2664.2012.02212.x
10. Hölker F, Moss T, Griefahn B, Kloas W, Voigt CC, Henckel D, Tockner K. The dark side of light: A transdisciplinary research agenda for light pollution policy. Ecology and Society. 2010;15(4). Available:http://www.jstor.org/stable/26268230
11. Gaston KJ, Bennie J, Davies TW, Hopkins J. The ecological impacts of nighttime light pollution: A mechanistic appraisal. Biological Reviews. 2013;88(4): 912-927. Available:https://doi.org/10.1111/brv.12036
12. Bennie J, Davies TW, Cruse D, Gaston KJ. Ecological effects of artificial light at night on wild plants. Journal of Ecology. 2016;104(3):611-620. Available:https://doi.org/10.1111/1365-2745.12551
13. Svechkina A, Portnov BA, Trop T. The impact of artificial light at night on human

and ecosystem health: A systematic literature review. Landscape Ecology. 2020;35:1725-1742.
Available:https://doi.org/10.1007/s10980-020-01053-1

14. Owens AC, Lewis SM. The impact of artificial light at night on nocturnal insects: A review and synthesis. Ecology and Evolution. 2018;8(22):11337-11358.
Available:https://doi.org/10.1002/ece3.4557
15. Kyba CC, Kuester T, Sánchez de Miguel A, Baugh K, Jechow A, Hölker F, Guanter L. Artificially lit surface of Earth at night increasing in radiance and extent. Science Advances. 2017;3(11):e1701528.
Available:https://doi.org/10.1126/sciadv.1701528
16. Lamphar H. A Recommendation for light pollution legislation in Mexican Cities: Protecting Human Health, Promoting Sustainable Practices, and Conserving Wildlife. Promoting Sustainable Practices, and Conserving Wildlife; 2023.
Available:http://dx.doi.org/10.2139/ssrn.4487183
17. Gaston KJ, Visser ME, Hölker F. The biological impacts of artificial light at night: The research challenge. Philosophical Transactions of the Royal Society B: Biological Sciences. 2015;370(1667):20140133.
Available:https://doi.org/10.1098/rstb.2014.0133
18. Gaston KJ, Davies TW, Nedelec SL, Holt LA. Impacts of artificial light at night on biological timings. Annual Review of Ecology, Evolution, and Systematics. 2017;48(1):49-68.
Available:https://doi.org/10.1146/annurev-ecolsys-110316-022745
19. Frank KD. Impact of Outdoor Lighting on Moths. In International Astronomical Union Colloquium. Cambridge University Press. 1991;112:51-51.
Available:https://doi.org/10.1017/S0252921100003687
20. Eisenbeis G, Rich C, Longcore T. Artificial night lighting and insects: Attraction of insects to streetlamps in a rural setting in Germany. Ecological Consequences of Artificial Night Lighting. 2006;2:191-198.
21. Gauthreaux SA, Belser CG, Rich C, Longcore T. Effects of artificial night lighting on migrating birds. Ecological Consequences of Artificial Night Lighting. 2006;67-93.
22. Silva E, Marco A, Da Graça J, Pérez H, Abella E, Patino-Martinez J, Almeida C. Light pollution affects nesting behavior of loggerhead turtles and predation risk of nests and hatchlings. Journal of Photochemistry and Photobiology B: Biology. 2017;173:240-249.
Available:https://doi.org/10.1016/j.jphotobiol.2017.06.006
23. Shidemantle GI. The Impact of Artificial Light at Night on Amphibians (Doctoral dissertation, State University of New York at Binghamton); 2022.
24. Shier DM, Bird AK, Wang TB. Effects of artificial light at night on the foraging behavior of an endangered nocturnal mammal. Environmental Pollution. 2020;263:114566.
Available:https://doi.org/10.1016/j.envpol.2020.114566
25. Hart JW. Light and plant growth. Springer Science and Business Media. 2012;1.
26. Viera-Pérez M, Hernández-Calvento L, Hesp PA, Santana-del Pino A. Effects of artificial light on flowering of foredune vegetation. Ecology. 2019;100(5):e02678.
Available:https://doi.org/10.1002/ecy.2678
27. Knop E, Zoller L, Ryser R, Gerpe C, Hörler M, Fontaine C. Artificial light at night as a new threat to pollination. Nature. 2017;548(7666):206-209.
Available:https://doi.org/10.1038/nature23288
28. Giavi S, Fontaine C, Knop E. Impact of artificial light at night on diurnal plant-pollinator interactions. Nature Communications. 2021;12(1):1690.
Available:https://doi.org/10.1038/s41467-021-22011-8
29. Ouzounis T, Rosenqvist E, Ottosen CO. Spectral effects of artificial light on plant physiology and secondary metabolism: A review. Hort Science. 2015;50(8):1128-1135.
Available:https://doi.org/10.21273/HORTSCI.50.8.1128
30. Tokeshi M. Species interactions and community structure. The Chironomidae: Biology and ecology of non-biting midges. 1995;297-335.
Available:https://doi.org/10.1007/978-94-011-0715-0_12
31. Cieraad E, Strange E, Flink M, Schrama M, Spoelstra K. Artificial light at night affects plant–herbivore interactions.

Journal of Applied Ecology. 2023; 60(3):400-410.
Available:https://doi.org/10.1111/1365-2664.14336

32. Marangoni LF, Davies T, Smyth T, Rodríguez A, Hamann M, Duarte C, Levy O. Impacts of artificial light at night in marine ecosystems—A review. Global Change Biology. 2022;28(18):5346-5367.
Available:https://doi.org/10.1111/gcb.16264
33. Juddin ASS, Ngah N, Umar R, Asante K, Abdullahi MG. A review influence of light on insect activity and behaviour: Sustainable lighting and light pollution. Journal of Sustainability Science and Management. 2023;18(2):231-247.
Available:http://doi.org/10.46754/jssm.2023.02.015
34. Blume C, Garbazza C, Spitschan M. Effects of light on human circadian rhythms, sleep and mood. Somnologie. 2019;23(3):147.
Available:http://doi.org/10.1007/s11818-019-00215-x
35. Rodrigo-Comino J, Seeling S, Seeger MK, Ries JB. Light pollution: A review of the scientific literature. The Anthropocene Review. 2023;10(2):367-392.
Available:https://doi.org/10.1177/20530196211051209
36. Perry G, Buchanan BW, Fisher RN, Salmon M, Wise SE. Effects of artificial night lighting on amphibians and reptiles in urban environments. Urban Herpetology. 2008;3:239-256.
37. Grenis K, Murphy SM. Direct and indirect effects of light pollution on the performance of an herbivorous insect. Insect Science. 2019;26(4):770-776.
Available:https://doi.org/10.1111/1744-7917.12574
38. Witherington BE, Martin RE. Understanding, assessing, and resolving light-pollution problems on sea turtle nesting beaches; 2000.
Available:http://hdl.handle.net/1834/18088
39. Bassi A, Love OP, Cooke SJ, Warriner TR, Harris CM, Madliger CL. Effects of artificial light at night on fishes: A synthesis with future research priorities. Fish and Fisheries. 2022;23(3):631-647.
Available:https://doi.org/10.1111/faf.12638
40. Burt CS, Kelly JF, Trankina GE, Silva CL, Khalighifar A, Jenkins-Smith HC, Horton KG. The effects of light pollution on migratory animal behavior. Trends in Ecology and Evolution. 2023;38(4):355-368.
41. Zeman M, Okuliarova M, Rumanova VS. Disturbances of hormonal circadian rhythms by light pollution. International Journal of Molecular Sciences. 2023;24(8):7255.
Available:https://doi.org/10.3390/ijms24087255
42. Shao Y, Li Y, Wang N, Xue Y, Wang T, Qiu F, Wu H. Effect of daily light exposure on sleep in polarregions: A meta-analysis. Journal of Sleep Research. 2024;e14144.
Available:https://doi.org/10.1111/jsr.14144
43. Cupertino MDC, Guimaraes BT, Pimenta JFG, Almeida LVLD, Santana LN, Ribeiro TA, Santana YN. Light Pollution: A systematic review about the impacts of artificial light on human health. Biological Rhythm Research. 2023;54(3):263-275.
Available:https://doi.org/10.1080/09291016.2022.2151763
44. Figueiro MG. Disruption of circadian rhythms by light during day and night. Current sleep Medicine Reports. 2017;3:76-84.
Available:https://doi.org/10.1007/s40675-017-0069-0
45. Aulsebrook AE, Jones TM, Mulder RA, Lesku JA. Impacts of artificial light at night on sleep: A review and prospectus. Journal of Experimental Zoology Part A: Ecological and Integrative Physiology. 2018;329(8-9):409-418.
Available:https://doi.org/10.1002/jez.2189
46. Sharma A, Tiwari S, Singaravel M. Circadian rhythm disruption: health consequences. Biological Rhythm Research. 2016;47(2):191-213.
Available:https://doi.org/10.1080/09291016.2015.1103942
47. Knutson KL, Van Cauter E. Associations between sleep loss and increased risk of obesity and diabetes. Annals of the New York Academy of Sciences. 2008;1129(1):287-304.
Available:https://doi.org/10.1196/annals.1417.033
48. Figueiro MG, Plitnick B, Rea MS. Light modulates leptin and ghrelin in sleep-restricted adults. International Journal of Endocrinology. 2012;2012(1):530726.
Available:https://doi.org/10.1155/2012/530726

49. Patel PC. Light pollution and insufficient sleep: Evidence from the United States. American Journal of Human Biology. 2019;31(6):e23300. Available:https://doi.org/10.1002/ajhb.23300
50. Wang LB, Gong YC, Fang QL, Cui XX, Dharmage SC, Jalaludin B, Dong GH. Association between exposure to outdoor artificial light at night and sleep disorders among children in China. JAMA Network Open. 2022;5(5):e2213247-e2213247. Available:https://doi.org/10.1001/jamanetworkopen.2022.13247
51. Howarth NE, Miller MA. Sleep, sleep disorders, and mental health: A narrative review. Heart and Mind. 2024;8(3):146-158. Available:https://doi.org/10.4103/hm.HM-D-24-00030
52. Medic G, Wille M, Hemels ME. Short-and long-term health consequences of sleep disruption. Nature and Science of Sleep. 2017;151-161. Available:https://doi.org/10.2147/NSS.S134864
53. Magnusson A, Boivin D. Seasonal affective disorder: An overview. Chronobiology International. 2003;20(2):189-207. Available:https://doi.org/10.1081/CBI-120019310
54. Bedrosian TA, Nelson RJ. Influence of the modern light environment on mood. Molecular Psychiatry. 2013;18(7):751-757. Available:https://doi.org/10.1038/mp.2013.70
55. LeGates TA, Fernandez DC, Hattar S. Light as a central modulator of circadian rhythms, sleep and affect. Nature Reviews Neuroscience. 2014;15(7):443-454. Available:https://doi.org/10.1038/nrn3743
56. Menculini G, Cirimbilli F, Raspa V, Scopetta F, Cinesi G, Chieppa AG, Tortorella A. Insights into the effect of light pollution on mental health: Focus on affective disorders—a narrative review. Brain Sciences. 2024;14(8):802. Available:https://doi.org/10.3390/brainsci14080802
57. Siraji MA, Kalavally V, Schaefer A, Haque S. Effects of daytime electric light exposure on human alertness and higher cognitive functions: A systematic review. Frontiers in Psychology. 2022;12:765750. Available:https://doi.org/10.3389/fpsyg.2021.765750
58. Killgore WD. Effects of sleep deprivation on cognition. Progress in Brain Research. 2010;185:105-129. Available:https://doi.org/10.1016/B978-0-444-53702-7.00007-5
59. Havekes R, Park AJ, Tudor JC, Luczak VG, Hansen RT, Ferri SL, Abel T. Sleep deprivation causes memory deficits by negatively impacting neuronal connectivity in hippocampal area CA1. E life. 2016;5:e13424. Available:https://doi.org/10.7554/eLife.13424
60. Yang HY, Wu SH, Zhang S, Zou HX, Wang LB, Lin LZ, Hu LW. Association between outdoor light at night exposure and executive function in Chinese children. Environmental Research. 2024;119286. Available:https://doi.org/10.1016/j.envres.2024.119286
61. Portnov B. Artificial Light at Night Accompanied by Noise Leads to Poor Educational Achievements of Schoolchildren; 2024. Available:https://doi.org/10.21203/rs.3.rs-4802176/v1
62. Patel SR, Hu FB. Short sleep duration and weight gain: A systematic review. Obesity. 2008;16(3):643-653. Available:https://doi.org/10.1038/oby.2007.118
63. Arora T, Taheri S. Associations among late Chronotype, body mass index and dietary behaviors in young adolescents. International Journal of Obesity. 2015; 39(1):39-44. Available:https://doi.org/10.1038/ijo.2014.157
64. Spiegel K, Tasali E, Penev P, Cauter EV. Brief communication: Sleep curtailment in healthy young men is associated with decreased leptin levels, elevated ghrelin levels, and increased hunger and appetite. Annals of Internal Medicine. 2004; 141(11):846-850. Available:https://doi.org/10.7326/0003-4819-141-11-200412070-00008
65. Knutson KL, Ryden AM, Mander BA, Van Cauter E. Role of sleep duration and quality in the risk and severity of type 2 diabetes mellitus. Archives of Internal Medicine. 2006;166(16):1768-1774.

Available:https://doi.org/10.1001/archinte.166.16.1768
66. Stamatakis KA, Punjabi NM. Effects of sleep fragmentation on glucose metabolism in normal subjects. Chest. 2010;137(1):95-101.
Available:https://doi.org/10.1378/chest.09-0791
67. Meng L, Zheng Y, Hui R. The relationship of sleep duration and insomnia to risk of hypertension incidence: A meta-analysis of prospective cohort studies. Hypertension Research. 2013;36(11):985-995.
Available:https://doi.org/10.1038/hr.2013.70
68. Irwin MR, Opp MR. Sleep health: Reciprocal regulation of sleep and innate immunity. Neuropsychopharmacology. 2017;42(1):129-155.
Available:https://doi.org/10.1038/npp.2016.148
69. Koo YS, Song JY, Joo EY, Lee HJ, Lee E, Lee SK, Jung KY. Outdoor artificial light at night, obesity, and sleep health: Cross-sectional analysis in the KoGES study. Chronobiology International. 2016;33(3):301-314.
Available:https://doi.org/10.3109/07420528.2016.1143480
70. Stevens RG, Zhu Y. Electric light, particularly at night, disrupts human circadian rhythmicity: Is that a problem? Philosophical Transactions of the Royal Society B: Biological Sciences. 2015;370(1667):20140120.
Available:https://doi.org/10.1098/rstb.2014.0120
71. Lamphar H, Kocifaj M, Limón-Romero J, Paredes-Tavares J, Chakameh SD, Mego M, Diez ER. Light pollution as a factor in breast and prostate cancer. Science of the Total Environment. 2022;806:150918.
Available:https://doi.org/10.1016/j.scitotenv.2021.150918
72. Obayashi K, Saeki K, Iwamoto J, Okamoto N, Tomioka K, Nezu S, Kurumatani N. Exposure to light at night, nocturnal urinary melatonin excretion, and obesity/dyslipidemia in the elderly: A cross-sectional analysis of the HEIJO-KYO study. The Journal of Clinical Endocrinology and Metabolism. 2013;98(1):337-344.
Available:https://doi.org/10.1210/jc.2012-2874
73. Scheer FA, Hilton MF, Mantzoros CS, Shea SA. Adverse metabolic and cardiovascular consequences of circadian misalignment. Proceedings of the National Academy of Sciences. 2009;106(11):4453-4458.
Available:https://doi.org/10.1073/pnas.0808180106
74. Cappuccio FP, Cooper D, D'Elia L, Strazzullo P, Miller MA. Sleep duration predicts cardiovascular outcomes: A systematic review and meta-analysis of prospective studies. European Heart Journal. 2011;32(12):1484-1492.
Available:https://doi.org/10.1093/eurheartj/ehr007

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