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## PHOTO-POLLUTION

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### **Abstract**

Photo pollution is not only a hindrance to astronomy, but it also impacts us directly. Photo pollution can be harmful to life and fatal to migrating birds. It also kills one of nature's great spectacles—a starry sky. Any adverse effect of artificial light including sky glow, glare, light trespass, light clutter, decreased visibility at night, and energy waste. Photo pollution affects every citizen. It is a serious environmental concern that wastes money and resources while jeopardizing wildlife, our environment, health, and human heritage. Too much photo pollution has consequences: it washes out starlight in the night sky, interferes with astronomical research, disrupts ecosystems, has adverse health effects and wastes energy.

### **Introduction**

For most of human history, the phrase "photo pollution" would have made no sense. Photo pollution is excessive and inappropriate artificial light. If humans were truly at home under the light of the moon and stars, we would go in darkness happily, the midnight world as visible to us as it is to the vast number of nocturnal species on this planet. Instead, we are diurnal creatures, with eyes adapted to living in the sun's light. This is a basic evolutionary fact, even though most of us don't think of ourselves as diurnal beings any more than we think of ourselves as primates or mammals or Earthlings. Yet it's the only way to explain what we've done to the night: We've engineered it to receive us by filling it with light. This kind of engineering is no different than damming a river. Its benefits come with consequences—called photo pollution—whose effects scientists are only now beginning to study.

For thousands of years, man lived in synchronicity with day and night patterns, his wakefulness and sleep tracking light and dark. Then he invented artificial light and suddenly our rhythms were out of sync. We extended the day and got a lot more done—but with impacts to our physiology that we're still only beginning to understand. A little more than 100 years ago, you could walk outside at night even in a city and see the Milky Way galaxy arch across the night sky. By allowing artificial lights to wash out our starry night skies, we are losing touch with our cultural heritage. We are also losing touch with what could inspire future generations. With more than half of the world's population now living in cities, 3 out of every 4 people in cities have never experienced the

wonderment of pristinely dark skies. our spectacular universe of stars and galaxies has been visible in the darkness of the night sky. From our earliest beginnings, the vast spectacle arrayed across the dark sky has inspired questions about our universe and our relation to it. The history of scientific discovery, art, literature, astronomy, navigation, exploration, philosophy, and even human curiosity itself would be diminished without our view of the stars. In 1879, Thomas Edison's incandescent light bulbs first illuminated a New York street, and the modern era of electric lighting began. Since then, the world has become awash in electric light. Powerful lamps light up streets, yards, parking lots, and billboards. Sports facilities blaze with light that is visible for tens of miles. Business and office building windows glow throughout the night. According to the Tucson, Arizona-based International Dark-Sky Association (IDA), the sky glow of Los Angeles is visible from an airplane 200 miles away. In most of the world's large urban centres, stargazing is something that happens at a planetarium. Indeed, when a 1994 earthquake knocked out the power in Los Angeles, many anxious residents called local emergency centres to report seeing a strange "giant, silvery cloud" in the dark sky. What they were really seeing – for the first time – was the Milky Way, long obliterated by the urban sky glow.

But today, the increasing number of people living on earth and the corresponding increase in inappropriate and unshielded outdoor lighting has resulted in photo pollution – a brightening night sky that has obliterated the stars for much of the world's population. Most people must travel far from home, away from the glow of artificial lighting, to experience the awe-inspiring expanse of the Milky Way as our ancestors once knew it. Now most of humanity lives under intersecting domes of reflected, refracted light, of scattering rays from overlit cities and suburbs, from light-flooded highways and factories.

Increased urban sky glow is responsible for the disappearance of the Milky Way from our night skies. For professional astronomers, the increasing distance to prime observing sites, well away from sources of air pollution and urban sky glow, becomes more problematic as economic and environmental energy costs continue to rise. Amateur astronomers, meanwhile, find prime observing spots eradicated by commercial and residential development and must travel farther from home for a clear view of the skies. Increasingly, the most important equipment needed to enjoy the wonders of the night sky is an automobile with a full tank of gas and a map.

Photo pollution is largely the result of bad lighting design, which allows artificial light to shine outward and upward into the sky, where it's not wanted, instead of focusing it downward, where it is. Ill-designed lighting washes out the darkness of night and radically alters the light levels – and light rhythms – to which many forms of life, including ourselves, have adapted. Wherever human light spills

into the natural world, some aspect of life—migration, reproduction, feeding—is affected.

The negative effects of the loss of this inspirational natural resource might seem intangible. But a growing body of evidence links the brightening night sky directly to measurable negative impacts on human health and immune function, on adverse behavioural changes in insect and animal populations, and on a decrease of both ambient quality and safety in our night time environment. Astronomers were among the first to record the negative impacts of wasted lighting on scientific research, but for all of us, the adverse economic and environmental impacts of wasted energy are apparent in everything from the monthly electric bill to global warming.

### **Identifying Photo-Pollution**

Photo pollution is light that is not being efficiently or completely utilized and is often pointed outwards or upwards and not downwards. Hence it is light that is often found to be rude or oppressive to the non-owners of the light. How so? Well imagine spending an hour outside at night to enjoy the stars, when someone walks up to you and shines a flashlight in your face. The light hurts your eyes and temporarily blinds you. Such an action is clearly rude. Yet no one thinks that it is equally and permanently rude that a person installs an outward pointing light on the side of a building to illuminate their grounds or parking lot or area around the building. Such people fail to consider just how far their security lights extend and bother other people. Such owners seem to think that if you wanted it to be dark, then you should go somewhere else. Yet the problem is that in today's society there is nowhere else to go to avoid lights at night. The darkest region in America, the American desert, can still see the lights of Las Vegas from 250 miles away. Such owners have, in all probability, chosen to locate them to be close to where people live and work. I can guarantee that the other people, downlight from them, did not move to be near that offender's light.

### **Types of Photo-pollution**

**Urban Sky Glow-** The brightening of the night sky over inhabited areas. It is the "glow" effect that can be seen over distant populated areas. This light that escapes up into the sky is created by the combination of all light reflected off of what is being illuminated, from all of the badly directed light in that area, and from that light that is scattered by the atmosphere itself from reaching the ground. This scattering is very strongly related to the wavelength of the light when the air is very clear. Rayleigh scattering dominates in such clear air, making the sky appear blue in the daytime.

**Light Trespass—** Light falling where it is not intended, wanted, or needed. Street lighting, for example, should light streets and sidewalks, not shine into peoples'

bedroom windows or illuminate rooftops or tree branches. Also known as spill light, light trespass occurs whenever light shines beyond the intended target and onto adjacent properties.

**Glare**— the sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to. It creates an unnerving, oppressive, annoying, discomforting feeling that can cause a loss in our visual performance, visibility and can be dangerous. High levels of glare can decrease visibility for the elderly, drivers of motor vehicles and astronomers. It is easily recognized by when a viewer's pupils will close down in its presence. This makes dimmer objects harder to see, and that increases the danger

**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.

**Up light** - wasted light, pure and simple. Light that goes directly up into the night sky is "lost in space" and serves no useful purpose. Up light is the bane of astronomers and the occasional stargazer because atmospheric scattering artificially brightens the night sky, making distant celestial light sources difficult or impossible to see. Up light often results from light fixtures which also produce glare and light trespass.

#### **Important facts of photo- pollution**

Street lighting has been blamed for up to 50% of the urban sky glow due to 95% of the light directed down toward the pavement being reflected upward at reflectance rates ranging from 6% for asphalt to 25% for concrete Urban sky glow has been reported to be increasing around 30% annually in some American cities., A study found that Hong Kong is one of the worst offenders in the world for photo pollution. Parts of the territory have been registered as 1,200 times brighter than a normal dark sky.

These days, there are light-dimming technologies other than low-pressure sodium that are very safe. Depending on the method employed, dimming can also reduce energy demand by 40% and maintenance costs by 50%.<sup>68</sup> Although centralised management systems can be more expensive to install, the payback time can be as little as 4-5 years.

Our understanding of the adverse effects of photo pollution is vague and based mostly on purely observational case studies. Nonetheless, there is clear evidence that artificial lighting can alter physiology, including hormonal balance, as well as behaviour, orientation, organism fitness, food web interactions, and biotope connectivity. The artificial disturbance of the natural day/night cycle may, as a result, have serious psycho-physiological and even medical consequences for

humans, along with ecological and evolutionary implications for animals, plants, and even entire terrestrial, freshwater, and marine ecosystems

### **Photo Pollution and Health Effects**

In disrupting ecosystems, photo pollution poses a serious threat in particular to nocturnal wildlife, having negative impacts on plant and animal physiology. It can confuse the migratory patterns of animals; alter competitive interactions of animals, change predator-prey relations, and cause physiological harm. The rhythm of life is orchestrated by the natural diurnal patterns of light and dark; so disruption to these patterns impacts the ecological dynamics.

With respect to adverse health effects, many species, especially humans, are dependent on natural body cycles called circadian rhythms and the production of melatonin, which are regulated by light and dark. If humans are exposed to light while sleeping, melatonin production can be suppressed. This can lead to sleep disorders and other health problems such as increased headaches, worker fatigue, medically defined stress, some forms of obesity due to lack of sleep and increased anxiety. And ties are being found to a couple of types of cancer. There are also effects of glare on aging eyes. Health effects are not only due to over-illumination or excessive exposure of light over time, but also improper spectral composition of light.

With respect to energy wastage, lighting is responsible for at least one-fourth of all electricity consumption worldwide. Over illumination can constitute energy wastage, especially upward directed lighting at night? Energy wastage is also a waste in cost and carbon footprint.

The evidence that indoor artificial light at night influences human health is fairly strong, but how does this relate to photo pollution? The work in this area has just begun, but two studies in Israel have yielded some intriguing findings. Stevens was part of a study team that used satellite photos to gauge the level of night time artificial light in 147 communities in Israel, and then overlaid the photos with a map detailing the distribution of breast cancer cases. The results showed a statistically significant correlation between outdoor artificial light at night and breast cancer, even when controlling for population density, affluence, and air pollution. Women living in neighbourhoods where it was bright enough to read a book outside at midnight had a 73% higher risk of developing breast cancer than those residing in areas with the least outdoor artificial lighting. However, lung cancer risk was not affected. "It may turn out that artificial light exposure at night increases risk, but not entirely by the melatonin mechanism, so we need to do more studies of 'clock' genes—nine have so far been identified—and light exposure in rodent models and humans," Stevens says. Clock genes carry the genetic instructions to produce protein products that control circadian rhythm.

Research needs to be done not just on the light pollution–cancer connection but also on several other diseases that may be influenced by light and dark. Travis Longcore, co-editor of *Ecological Consequences of Artificial Night Lighting* and a research associate professor at the University of Southern California Center for Sustainable Cities, suggests two ways outdoor photo pollution may contribute to artificial light-associated health effects in humans. “From a human health perspective, it seems that we are concerned with whatever increases artificial light exposure indoors at night,” he says. “The effect of outdoor lighting on indoor exposure could be either direct or indirect. In the direct impact scenario, the artificial light from outside reaches people inside at night at levels that affect production of hormones. In an indirect impact it would disturb people inside, who then turn on lights and expose themselves to more light.”

“The public needs to know about the factors causing, but research is not going at the pace it should,” Blask says. Susan Golden, distinguished professor at the Centre for Research on Biological Clocks of Texas A&M University in College Station, Texas, agrees. She says, “Light pollution is still way down the list of important environmental issues needing study. That’s why it’s so hard to get funds to research the issue.”

“The policy implications of unnecessary light at night are enormous,” says Stevens in reference to the health and energy ramifications “It is fully as important an issue as global warming.” Moreover, he says, artificial light is a ubiquitous environmental agent. “Almost everyone in modern society uses electric light to reduce the natural daily dark period by extending light into the evening or before sunrise in the morning,” he says. “On that basis, we are all exposed to electric light at night, whereas before electricity, and still in much of the developing world, people get twelve hours of dark whether they are asleep or not.” Sources believe that the meeting at the NIEHS in September 2006 was a promising beginning for moving forward on the light pollution issue. “Ten years ago, scientists thought something was there, but couldn’t put a finger on it,” says Leslie Reinlib, a program director at the NIEHS who helped organize the meeting. “Now we are really just at the tip of the iceberg, but we do have something that’s scientific and can be measured.” The 23 participants at the NIEHS-sponsored meeting identified a research agenda for further study that included the functioning of the circadian clock, epidemiologic studies to define the artificial light exposure/disease relationship, the role of melatonin in artificial light-induced disease, and development of interventions and treatments to reduce the impact of light pollution on disease.

### **Control of photo-pollution-**

Unlike other pollution matters, photo-pollution has not been considered as a major issue until recently. The good news is that, the solutions that experts

suggest are not as complex and difficult as those of air and water pollution. Photo pollution can be significantly reduced by some engineering and structural design policies and considerations. Besides that, education will be needed to get the message across and get people more informed about the issue and take the step of becoming part of the solution. Engineers must invest and use new lighting technology that uses the full cut-off concept. This way, lights escaping upwards from large commercial places, stadiums, theatres and public places will be reduced. For example about 30% of road light fittings in the UK have reached their lifespan and need changing. This is a good time to engage new technology to ensure that the replaced fittings will not cause too much photo pollution. Government policies on the use of lights must be stepped in a way that forces consumers to buy more energy-reduced light. These policies must be enforced. Research shows that too much light does not necessarily improve visibility. This means that smart choices can be made to improve visibility in the night without splashing too much light into the sky. Individuals must also begin to install motion sensor-lights and bulbs in their homes, so that they are not kept on all night. Garden and landscape lights must be used effectively and should not be too bright to bother others.

It is important that education of light pollution and its consequences are stepped up and taught in all schools, just as water, land and air pollution.

It's an obvious one, but switch off any lights you are not using.

Ensure indoor and outdoor lighting is directed at what you're trying to light and that it's shaded. Table and floor lamps are better for this than overhead lights.

Use low-watt lightbulbs – you'll save on bills and reduce glare.

Install dimmer switches so you can alter brightness to suit ambient light.

Use motion sensors or timers so outdoor lights are only on when they need to be.

Install thick curtains or blinds to minimise light escaping your home at night.

Ask your local councillor to get street lamps fitted with directional, low energy lights – after all, residential areas don't need to be lit up like football pitches 24 hours a day.

### **Summary**

Photo pollution wastes money and energy. Billions of dollars are spent on unnecessary lighting every year in the United States alone, with an estimated \$1.7 billion going directly into the night time sky via unshielded outdoor lights. Wasted lighting in the US releases 38 million tons of carbon dioxide into the atmosphere annually; unshielded outdoor lights are directly responsible for 1.2 million tons of carbon dioxide waste. Simply reducing and removing

unnecessary lighting saves money and energy, often at minimal expense. Over-lighting the night neither improves visibility nor increases night time safety, utility, security, or ambiance. The adverse effects of light pollution extend well beyond astronomy. New research suggests that light at night may interfere with normal circadian rhythms—the 24-hour cycle of day and night that humans have used to maintain health and regulate their activities for thousands of years. Light trespass, occurring when streetlights or a neighbour's security light directs unwanted lighting onto our property or into our homes, contributes to a loss of natural darkness. Wildlife, too, is harmed by the unnecessary brightening of the night. From newly hatched sea turtles to migrating birds, fish, frogs, salamanders, and lightning bugs, artificial night lighting disrupts the cycles of nocturnal creatures in potentially devastating ways. While research is still ongoing, it is becoming apparent that both bright days and dark nights are necessary to maintain healthy hormone production, cell function, and brain activity, as well as normal feeding, mating, and migratory behavior for many species, including humans. In refreshing contrast to some of today's complex and lingering environmental problems, many existing solutions to light pollution are simple, cost-effective, and instantaneous. Recognizing when outdoor lighting no longer serves its function and becomes a pollutant is the first step toward choosing appropriate solutions.

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**Internet Resources:**

- [www.google.com](http://www.google.com)
- [www.answers.com](http://www.answers.com)

