

## Light pollution

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**Summary.** Light Pollution can be prevented. It has to be prevented – for the sake and for the benefit of ecology, economy and sensory physiology. And the beauty and the magnificence of the world heritage Starry Sky.

**Key words:** Light pollution, chronodisruption, ecology, daytime running lights (DRL).

### ‘Light pollution’

**Zusammenfassung.** ‘Light-Pollution’ und Licht-Smog, überdosiertes blaustichiges Licht, wertloser, sinnloser Licht-‘Abfall’ samt Nebenwirkungen kann nicht mehr ent‘sorgt’ sondern muss prophylaktisch verhindert werden. Weltweit.

**Schlüsselwörter:** ‘Light pollution’, Chronodisruption, Ökologie, Tagfahrlichter (DRL).

### Light pollution

or Photopollution, Light Smog, Waste Light, etc. The German term ‘Lichtverschmutzung’ – almost a misnomer, is somewhat misleading. ‘Overdosed’ and redundant artificial visible light, gleams and beams almost ubiquitous – in our Brave New World, with an irritating – seemingly irreversible – ‘blue cast’ – trend. To the detriment of ecology and economy [1].

### Introduction

Preventable and unreflective usage of artificial light causes undesired side-effects. Astronomers warn in vivid words that our starry sky becomes veiled by Light Pollution. Thousands of stars should be visible to the unaided eye in unlit places. More and more ‘Dark Night’s Ending’ [2, 3] spoils this delight. Most city children know the ‘Milky Way’ just from hearsay. Even in the countryside light exposed areas are spreading and expanding like invading metastases. Sky glow, urban glow: Bell – or cupola – shaped shining light domes above cit-

ies. The ‘glow’ is propagated by flare, straylight and scatter, due to dust, fine dust, aerosols etc. Within a radius of about one hundred kilometers the darkness of the night is fading. In the south of Vienna a ruddy – false – ‘dawn’ seems to be gleaming from the wrong direction – from the North.

For decades Lepidopterologists, Ornithologists and Entomologists report on utmost unpleasant observations in connection with undesired light-side-effects on animal behavior. Improper outdoor lighting affecting baby-sea-turtles (Fig. 1) – a well known example.

Light-Designers, Light-Architects, Light-Engineers und all sorts of Light-Artists ‘dance the night away’. High-Intensity – LED – (HI-LED) spots, embedded in pavements, ramps and streets emit light into the cosmos. Futile. The beams are targeted at the stars. The desired promotional effects equal zero. Those inverted, amiss floodlights blind and irritate pedestrians, cyclists, bikers and other traffic participants as well.

Luminous advertising of all kinds, ‘dynamic’, flashing and blinking, inapt street lighting, imperfect accent- and effect lighting, flood lighting, bright skyscraper-illumination, ‘decorative’-bridge-lightings, lighting installations for ‘mega-events’, night-skiing-slopes, sky-beamers, laser shows, blazing jumbo fireworks in increasing numbers, chintzy illumination of waterfalls – in candy colors –, light graffiti (in the streets, in nature), projection bombing (Fig. 2) ‘madness’ (modern hooligan ‘fun’), systematic light- ‘embellishments’ (‘Behüb-



**Fig. 1.** Baby-sea-turtles

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**Fig. 2.** Projection ‘bombing’

schung’) for whole towns – inexcusable waste of public money.

The majority of vehicle lights, daytime running lights (DRL), brighter than the eye can tolerate (causing discomfort – or even disability – glare), brighter than the law allows, targeting and aiming (DRL – ‘isotropic’ radiance) at the eyes of traffic participants – in order to ‘outshine the competition’ – according to aggressive advertisement, ‘branding’ the company’s logo with HI-LED-light.

Even traffic lights, construction site lightings, bluish-white super-bright toll-terminal and toll plaza illuminations, signalling and flashing blue lights (emergency vehicles, outranging other light sources with substantially higher intensities in order to increase their conspicuity and to be detected in the disconcerting light chaos of dazzling motor vehicle headlights and bluish-white ‘super-bright’ DRL-traffic scenarios).

More and more of these light sources (the list is far from complete) develop such a high brightness that even young people with healthy eyes (not yet affected by light-damage or other retinal disorders [4]) increasingly complain about glare. A few professional drivers have had to give up their jobs already because they were unable to endure the amassing effect of glare and irritations any further.

## Man

‘Modern’ homo sapiens increases the dosages of stimuli more and more (epigenetic ‘imprinting’ probably [5]). This also applies to light – stimulation – in discotheques e.g. – enormous acoustic pressure combined with extreme bright light flashes, ‘black’ (UV) – light and drugs. All these stimulants and stimulations have to be increased, enhanced and ‘topped’ compulsively.

‘Rottweiler’-light, unbeatably bright, was meant to protect property and to improve security of private homes. Unfortunately – this proved to be wrong. Brightly illuminated objects do not only attract moths – as was shown in the past. Continuous light – during the whole night – did not seem to solve the problem. ‘Intelligent light control systems’ (integrated motion sensors) have proven successful and are preferable (QED).

## ‘Light trespassing’

When stray rays of light get ‘over the fence’ or even worse – intrude into bedrooms – irritation and ‘chronodisruption’ can be the consequence. This subject matter occupies light-experts, chrono-biologists, medical science – and lawyers [6].

## Indoor light pollution

Improper usage of indoor lighting, light at the wrong time, at the wrong place, light rays radiating into the wrong direction, particularly the overdose of light intensity, bluish-white glaring – irritating light – all that is subsumable and could be coined with the term ‘Light pollution’ or ‘waste light’. In shopping malls and shopping-‘temples’, supermarkets, in nurseries, schools, bureaux, factories, pharmacies, tunnels, and even in retirement homes the intensity of artificial lighting increases and – on top of that – blue wavelengths within spectral distributions of the light sources in use begin to dominate gradually. Cui bono?

Melanopsin expressing intrinsically photosensitive Retinal Ganglion Cells (ipRGC or mRGC), the substrate of non-image forming responses (NIF) supporting spatial visual perception [7] seemed to be highly sensitive to blue light stimuli – according to early experiments [8]. These shunting ipRGCs play a crucial role in the pathogenesis of sleep abnormalities [9], modulating circadian photoentrainment processes via suprachiasmatic nucleus (SCN), thereby modifying the delicate circadian physiology of neuroendocrine balance, when suppressing pineal Melatonin [10]. As a matter of fact polychromatic light is more effective in human NIF- and higher CNS-processing than pure blue light-stimulation [11]. It could be demonstrated with immunohistochemistry and high-power confocal microscopy in three dimensional analyses that ipRGC are connected to rods and all three cone-systems (not only to S-cones) supporting electrophysiological recordings [12]. In the course of evolution of the pineal organ in several classes of vertebrates the ‘achromatic response’ plays a prominent role (see phylogeny ~ ontogeny). This could be demonstrated in electro-physiological and behavioral experiments furthermore [13].

In other words: According to the studies cited above it is hardly conceivable that ‘overdosed’ bluish-white light – as it is becoming a ‘modern’ trend now – and quite a nuisance, is able to improve vigilance, alertness, zeal, stimulate buying behavior, prevent ‘micro sleep’ at the steering wheel, brighten the dull and mentally retarded, improve contrast vision [14], ease and sweeten waking by means of special blue-light alarm clocks (Fig. 3).

## Chrono-disruption

The circadian rhythm of night shift workers is disrupted by artificial light at the wrong time. Higher risk of cancer in these groups [15] was ascribed to the influence of light being the sole and exclusive cause – allegedly –



**Fig. 3.** Blue-light alarm clock

suppressing Melatonin, triggering or inducing interferences with physiological hormonal and immunological functions. However, abridgements and simplifications like ‘mono-causal-constructs’ are out of touch with our overly complex reality. There are more entrainment pathways for circadian clocks and a considerable number of disease-causing factors during shift work. Sleep deprivation per se, stress, food quality (unwholesome ‘night shift – snack’ – causing obesity etc.) untimely food intake timings and intervals, sick building syndrome, smoke, air condition side effects, frequent relationship-conflicts (family, partners), pill taking habits, – a ‘morbid’ way of living –, etc. Of course, the influence of light, the very timing (‘Zeitgeber’-role), wavelengths and dose of light are of particular importance for health or disease in man. The answer to that must be ‘Light-Hygiene’ and a general ‘Zeitgeber-Hygiene’ – a rational use of light and sensible patterns as well as attempts to prevent undesired side-effects of the ‘drug’ light. But, once more, all these numerous factors as mentioned above with possible side effects have to be taken into consideration seriously when analysing possible light-side-effects, and should be prevented or – at least – reduced [16].

### Outdoor light pollution

A single photon triggers electrophysiological measurable and reproducible reactions in rods [17]. One single light-stimulus (HI-LED light beam e.g.) causes oscillations of the standing potential of the eye over periods of more than two hours – before the ‘steady state’ will be attained again [18]. Both these observations illustrate the utmost sensitivity of human retinae in quite an impressive way.

Disregarding sensory – and electro – physiological characteristics ‘overdosed’ light pounds incessantly ‘like a steam hammer’ as it were, on highly vulnerable retinal photoreceptors and structures – during day and night. Isotropic daytime running lights (HI-LED-DRL)-‘eye-catchers’, radiating intense blue-white light into all directions, irritate and distract. Disorders of cognitive processing (multiple dynamic DRL-stimuli incapacitat-

ing visual short term memory (VSTM) working memory etc.) like ‘inattention blindness’ are a threat to the ‘weakest’ and most vulnerable under all raffic participants – those who are in need of protection particularly, our children – at zebra crossings [19].

DRL violate against *The Convention Concerning the Power of Authority, The Law in Respect of the Protection of Infants (1969), The Obligation of Protection, The Principle of Equality, The Declaration of Human Rights (1948) Article Three, The Laws of Logic, Public Ethics and Morals.*

Attorney-at-Law Dr. Gerald G. Sander, M.A., Mag.rer. publ.

### Light sources

Design and spectral distribution of outdoor lighting elements needs redesigning and reshaping. Worldwide. ‘Full-cutoff’ lamps can guarantee that light gets there where it is needed and does not go astray into the sky or somewhere else. Spherical outdoor-lamps have to be avoided by all means. In addition – the unfortunate ‘blue-trend’ being more and more in use in outdoor lighting is no ideal solution at all [20].

### Flora and fauna

‘Light-Pollution’ causes harm to night-active insects, moths, butterflies, bats, migratory birds, reptiles, sea-turtles, etc. One single inapt outdoor light source can depopulate whole areas clearing and ‘cleaning’ them from night active insects and other violative species. These animals pollinate also plants from the Red Lists. Insecticides (even in almost unverifiable concentrations) are neurotoxic (also for bees), disturbing the sense of orientation. Side-effects caused by genetically modified plant cultures might – in concert with the through-out growing light pollution – add more noxae to these populations. The sum of all interferences and encroachments upon eco-systems is gradually increasing and is becoming a serious problem already.

Plants do have memories. Illuminated (by artificial light) plants record, register and save the information – in concreto – the light history. They may cast their leaves later. Changed growth cycles and frost damage could be the consequence contingently. Particularly delicate: artificial light at the waterside.

### Prophylaxis

Slovenia has issued a law against ‘Light Pollution’. In Austria, a ‘Länderkompetenz’ (local legislative competence) together with lack of a so called ‘Bundes-Harmonisierung’ (whateverthatmeans) thwarts the cut of this peculiar ‘Gordian knot’. An Austrian ‘Light -Pollution law’ – remains illusionary – under these remarkable circumstances.

Yet, for the good of future generations we should leave behind a liveable planet, a loveable one. A blooming garden for flora, fauna, biodiversity and – for the ‘pride of creation’.

**Conflict of interest**

The author declares that there is no conflict of interest.

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