



LIGHT QUALITY INDEX (LQI_- PHYSIOLOGY AND LIGHT

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Abstract: From the research work, light therapies, experiments, implementations, going through various research platforms, books, journals and the relevant courses. It's been more than 200 years the human beings are subjected to the world of artificial lights, yet a common person's knowledge is far from the real world of this subject – THE LIGHT. Out of these 200 years the maximum time has been spent under the fluorescents by the urban population as compared to past one decade with LEDs).

Introduction

As I am writing this article, one of the repetitive question asked by many (including architects, PMCs, lighting enthusiasts, interior designers and the occupants) to me is, that how light as a zeitgeber influences the molecular mechanism are sensing the environment for the time cues? How circadian is disrupted or aligned, what is the connection between immune system and light, why there are chances of being prone to some types of cancer-with relation to light, how retina gets damaged, effects of white LED exposure on retinal pigment epithelium, relationship of metabolism and muscular atrophy with respect to light and many of these inquisitiveness.

The Facts

The fact and the answer is that there has been thousands of researches and the establishments of researches, but most of the human beings are unaware or have lack on subject (including the people from lighting fraternity), as they have not undergone in depth towards the relationship between physiology and light which is so true to be criticized or ignored. I for one have no doubts now after going through this over the past six years.

The idea that there can be an “unambiguous technique” for human-bio favorable lighting like tunable white with the absence of other non-visible and visible parameters is totally unrealistic, because of the tremendous variability between individuals based on their age, genetics, environmental factors, individual physiology, eating habits, and wake up or the sleep timings and our behavioral aspects.

The harmony of the glands is accomplished by constantly synchronizing our body's atoms, glands, genes, molecules, cells hormones in alignment of time cues- the LIGHT.

Being tenacious and ascertaining a healthier lighting space always requires a process of trading off some aesthetical and volumetric aspects of the space for healthier future gains.

However, this has been a very thick proposition from an architectural and interior point of view, especially in the office and the residential segments.

We need to strategies w.r.t. legislative to be proposed and implemented regarding ILQI-INDOOR LIGHT QUALITY INDEX., as there is an exponential rise in severe neuro and retinal disorders as well as the related illnesses. This is due to the inappropriate forms and sources of light that are contributing negatively to our health are:

- Retinal damage
- Brain fatigue
- Stress
- Migraine
- Insomnia
- EFD
- Cancer
- Obesity
- Age related Macular degeneration
- Skin diseases

As compared INDOOR AIR QUALITY, INDOOR LIGHTING QUALITY IS EQUALLY ESSENTIAL TO GUAGE.

We are being misled in the name of Human centric lighting, tunable circadian lighting in a very absurd and unethical ways, The greed and the unawareness of hazardous factors we are being played with respect to our physiological parameters levied by our body (Our body is not a machine but an assembly of molecules- Seven trillion trillion trillion toms and 89 billion neurons)

The inclusions and the audits of these inclusions of healthy parameters of lighting like IRC*-IRB*-IRA*-Mitochondrial and other related benefit, The mimic of Blue, Bluish white and Bluish grey sky- limbic ways and psychological benefits / low energy dissipation / luminance balance, Inclusion of UVA* Solitrol activation etc. is must apart from industry specific and guidelines like: Percent Flicker (IEEE Std 1789- 2015, IES: RP-16-10, CIE: TN-006) /

Flicker Index (IEEE Std 1789-2015, IES: RP-16-10, CIE: TN-006) / Pst LM Short Term Flicker Severity (CIE: TN-006, IEC TR 61547) / Full CIE S 026:2018 metrics / Blue pump/accordance wavelengths & red pump accordance wavelengths / PAR PPF $\mu\text{mol}/\text{m}^2/\text{s}$ / Ratio functions, e.g. red/F far red / Programmable weighting functions / Melanopic irradiance / TM-30 parameters

Data Sources: Relevant books, NASA, IES, CIBSE, IWBI, USGBC, SLL

What is Visible light?

Light is electromagnetic radiation within the portion of the electromagnetic spectrum that can be either perceived or might not be perceived by the human eye. Light sometimes refers to electromagnetic radiation of any wavelength, whether visible or not. In this sense, gamma rays, X-rays, microwaves and radio waves are also light. Light exerts physical pressure on objects in its path, of velocity, wavelength & frequencies. (There is a definite process of thermodynamics in the light.)The photon is a type of elementary particle. It is the quantum of the electromagnetic field including electromagnetic radiation such as light and radio waves, and the force carrier for the electromagnetic force.

LIGHT IS THE GOVERNOR OF THE UNIVERSE AND THE MOLECULAR MECHANISM

Misconceptions about light.

The biggest misconception about light is that we only believe that light means the visible spectrum which has no physiological effects.

For example X ray is the form of light which has advantages though getting an application of imaging, but at the same time too much exposure to X rays can lead to DNA rupture, cancer etc. Similarly with UVB/UVC.

On the other hand the IRB or NIR, FIR or IRC are very much beneficial for human being and many creatures. The existence of light starts from the cosmic ray, gamma rays, X rays, UV, VIBGYOR, NIR, FIR, Microwaves. Radio waves and the broadcast waves

Why is natural light important

Let's reveal the benefits of the Natural light – The sunlight

Immune system: The immune system boost up when we are exposed to the sunlight but not too much of exposure. The presence of near infra-red and infra-red light waves strengthens and boosts our immune system.

Good for Bones: Our bones need lot of Vitamin D and it's the SUN which can help in an enormous way to impart vitamin D. The presence of UVA (Ultraviolet-A) imparts Solitrol which is also known as the Sun hormone.

Alignment of our sleep: The sleep and the wake cycles are governed primarily by the light and most importantly by Sunlight. The alignment of our circadian rhythm is totally dependent on the sunlight.

Energy production: MITOCHONDRIA, in these we have specific molecule known as Cytochrome C oxidase, which is responsible to produce energy within MITOCHONDRIA. This means Adenosine Triphosphate (ATP), which is the end product of energy correlation and is the fuel our cells need for transporting irons for metabolism. If ATP production is stopped, we can die in 15-20 seconds. Our body produces 30-100 KG of ATP in 24 hours depending upon our weight, height, age etc. The other hidden fact is that only 1/3rd part of the energy in our body comes from the food rest 2/3rd comes from the radiations and the light, and especially the Sunlight.

What Is LQI?

The LQI is the term coined by me, after being fed up by witnessing the AQI-Air Quality Index, WQI-Water Quality Index. It was a clear indication that most of the human beings are unaware on the subject LIGHT and taken the light for granted as a subject.

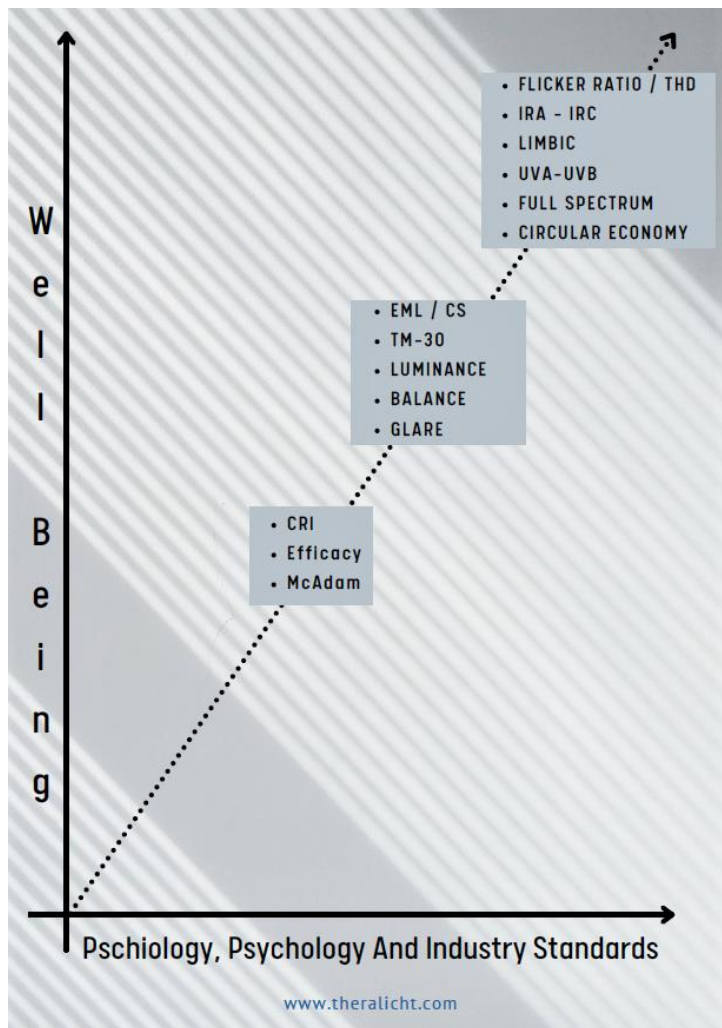
There are many levels of complexities and understandings (Physiological point of view and light as a subject, thus our involvement with physiology and psychology as subjects are very important and must not be ignored or avoided.

Thus the quality parameters in the environment where the light is subjected (especially in the offices, homes and on the roads) are from physiological based rather only industry standards like lux levels, Rg, Ra, CRI, MacAdam, T1/T2, EML Lumens, efficacies etc.

Equations and the frame work

How does the LQI works?

The DNA of our lighting industry changed with the arrival of LEDs. Thus our parameters w.r.t. the biology has to be restructured. The LQI primarily works on the contribution of lighting parameters (visible and non-visible) on human (the occupants) physiology and the psychology.



What do the LQI values mean?

The purpose of the LQI is to help you understand what Light Quality is contributing to our health. For example:

As NIR light photons reach these molecules, this stimulates the cells' mitochondria (colloquially termed the "power generators" of cells) to produce more adenosine triphosphate (ATP), which fuels cellular energy production.

This, in turn, energizes all cells irradiated by the light

To make it easier to understand, the LQI is divided into DIFFERENT levels of health concerns like

- a. Effects of different spectrums on human health
- b. By an appropriate use of lighting controls, tunable white light blending with bioled* and bioblue* lights to induce replica of the nonvisible and visible parameters of light { dawn, full sunny day & dusk timelines. }
- c. Combination of appropriate forms of LEDs.
- d. Avoiding the direct view of light sources, incorporating a lighting design to reduce the number of lights in a pragmatic manner.
- e. Allowing the maximum parameters of Sunlight through the glass enveloped buildings

What is unhealthy light?

I would like you all to recollect and hold on to one fact that the DNA of LIGHT has changed with the arrival of LEDs. Previously light was in the form of heat energy but now it's not.

Thus as the DNA has changed, so our way of approach on managing the parameters of light must change as well. We have to brainstorm and reinvent the thinking process, to better our obsolete methods of lighting consultancy and offer the best to the users (office goers, residences, hospitality & health care).

As we are spending more than 90% of our times in the indoors, it is essential to know that general the emission of short wavelength produced by LEDS from computer screens, smartphone, television, and tablet screens apart from the general lighting fixtures (exceptions are always there) for our homes and workplaces are giving rise to many disorders like sleep disorder, migraine, insomnia obesity, retinal damage, brain fatigue and many.

The continuous triggering of cortisol is detrimental as not only it hampers the immune system but also resulting in our bullied behaviors.

What are the health effects?

The severe disorders and the illnesses the inappropriate forms and sources of light that are contributing negatively to our health are:

- Retinal damage
- Brain fatigue
- Stress
- Migraine
- Insomnia
- EFD
- Cancer
- Obesity
- Age related Macular disorder
- Skin diseases

One of the examples (As many of us are aware and struggling in our daily lives)

Sleep: Sleep is the form of the paybacks to be fatigues of mind and body working throughout the day. Light is the only source which can disrupt the sleep wake cycle known as circadian rhythm? The Intrinsically photosensitive retinal ganglion cells [ipRGC] communicates information directly to SUPRACHIASMATIC Nucleus that forms our biological clock mainly responsible for our CIRCADIAN RHYTHM. A central circadian clock, located in the suprachiasmatic nuclei (SCN) of the hypothalamus, through negative Transcription-translation feedback loop (nTTFL),

The improper forms of LEDs (whether the product or the way these are installed) are giving us migraines, retinal fatigue and many other disorders. Nevertheless LEDs have far more advantages too. (Again I am referring to office, healthcare and residential lighting sector only)

Way forward and approach

Holistic approach LQI (Office luminaires)					
Key Indicators			Type of lighting fixtures and its benefits		
SLNo	Objectives	Parameters	Conventional	HCVL	Salvation Series-CAMA* By Girish Bhardwaj / Tashi Agarwal-PATENT
1	Illuminance	Lux levels Vertical and Horizontal (Balance)	√	√	√
2	Efficiency	(Total cost of ownership a)TCO & CBA (Cost Benefit Analysis)	√	√	√
3	Maintenance	Repair	√	√	√
4	Rejuvenation	Feel good factor (limbic)		√	√
5	Visual Acuity	Actual and perceived illuminance-luminance balance		√	√
6	Psychological need address	Connected to the dynamics of nature		√	√
7	Adherences to the industry standards	EML, CS, TM-30, IEC, IEEE, ASHRAE-RP, ANSI RP, IES-EB10,		√	√
8	Personal User intervention	Lux, Lumens, CCT etc		√	√
9	Health benefits	Addressing: Retinal fatigue, brain fatigue, Migraine etc			√
10	Physiological need address	Immunity, ATP, Mitochondria boost, Homeostasis			√
11	Overall Wellbeing	Physiologically stable and Biophilic factor			√
12	Circadian and Sleep	Rhythmic alignment and Sleep disorder management			√
13	Diurnal adaptation	Precise bio wavelength for healthy lighting parameters eg precise IRB/IRC radiations			√
14	Circular economy	Repair, refurbish, Longevity of the product, Reusable components, and biodiversity pro (TM-CIBSE)			√

A food for thought:

The fluorescents were so easy to recycle (though there were certain protocols). They had good UV in them, they had a better version of balancing luminance / illuminance. Whereas LED waste easy so carcinogenic and land filling which is against circular economy.

However, my point is that, we still have places where we can use fluorescents and incandescent lamps which are very beneficial for human physiology and our circular economy. Though there are now several organizations who are working on these parameters like NIR and F through LEDs.

We need to balance the demands and the design between LED, Fluorescent and incandescent lamps. No one is going to be crucified, no one should be ashamed of specifying the combination of these. Let's give it a try not only for our biological benefits but also to contribute in circular economy, saving bio diversities.

References

- SRS, USA SRBR, USA. IES, iPAN, THE PHYSOC-UK, DR.WUNSCH, MEDACISIS, WIKIPEDIA, CIBSE/SLL, LMU-GERMANY-ONLINE, Dr Till, Dr Merrow, U O Michigan, USA-ONLINE,
- Corrigan JD, Selassie AW, Orman JA. The epidemiology of traumatic brain injury. *J Head Trauma Rehabil.* 2010;25(2):72–80. [PubMed] [Google Scholar] Selassie AW, Zaloshnja E, Langlois JA, Miller T, Jones P, Steiner C. Incidence of long-term disability following traumatic brain injury hospitalization in the United States. *J Head Trauma Rehabil.* 2008;23(2):123–131. [PubMed] [Google Scholar] João Gustavo Rocha Peixoto dos Santos, Wellingson Silva Paiva, and Manoel Jacobsen Teixeira
- Alway Y, McKay A, Ponsford J, Schönberger M. Expressed emotion and its relationship to anxiety and depression after traumatic brain injury. *Neuropsychol Rehabil.* 2012;22(3):374–390. [PubMed] [Google Scholar] Schönberger M, Ponsford J, Gould KR, Johnston L. The temporal relationship between depression, anxiety, and functional status after traumatic brain injury: a cross-lagged analysis. *J Int Neuropsychol Soc.* 2011;17(5):781–787. [PubMed] [Google Scholar]
- Donnell AJ, Kim MS, Silva MA, Vanderploeg RD. Incidence of postconcussion symptoms in psychiatric diagnostic groups, mild traumatic brain injury, and comorbid conditions. *Clin Neuropsychol.* 2012;26(7):1092–1101. [PubMed] [Google Scholar]