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A Comparative Study : Impact of Different Artificial Light Sources on Human Being

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ABSTRACT

In 20th century narrow spectrum incandescent electric light bulb and low pressure sodium (LPS) lamp has been widely used. But to improve efficiency and to cut carbon dioxide (CO_2) emission this old narrow spectral light sources are replaced by broader spectrum light sources such has high pressure sodium (HPS) lamp, compact fluorescent lamp (CFL), light emitting diode (LED). CFLs and LEDs are more efficient and cut carbon emission in environment. These light sources save much more electric energy as compared to incandescent bulbs and provide to improve colour rendering capability for humans. Shifting broadening the spectra of artificial light (white light) may leads adverse effect on human health. Some CFLs emits a short wavelength (254nm) ultraviolet (UV) radiation that causes different skin diseases. Broken CFLs and compact light tubes emit mercury in air which is produce hazards effect on human health. LED at colour temperature (CT) 4000K to 5000K contain high level of short wavelength blue light that can cause damage to retina of human eye. High intense white light sources also produce problems seeing for safe driving and working at night. LED sources can suppress melatonin secretion which affects on circadian rhythms, sleep disorders, problem of obesity and thyroid. As this impact of broaden spectrum white light sources is concern there is need to make some policies and to develop a such artificial light which is energy efficient and make less harmful effect on human health and environment.

Keywords : LPS, HPS, LED, CFLs, UV, CT, Watts, KWh/yr, Lumen, pounds, pupillary, retina, melatonin, circadian rhythm.

I. INTRODUCTION

Light is a basic requirement for life on earth. The sun sustains life and is still the major source of lighting for humankind. Progress in electric lighting continued throughout the 19th century, Thomas Edison and Joseph Wilson Swan being credited with the invention of the incandescent lamp in 1878, albeit at least 22 other inventors would challenge this claim(1). In 1906, the tungsten filament was introduced as a more efficient incandescent source and this formed the basis of the common light bulb that has been in widespread use for over a century. Now a day to improve efficiency and to cut CO2 emission incandescent lamp replaced by compact fluorescent lamps (CFLs) and light-emitting diodes (LEDs). Lighting technology is changing rapidly from traditional incandescent bulbs to CFLs, on to light-emitting diodes (LEDs). The common incandescent lamp emits a small amount (10%) of light and a lot of heat (2).

Radiation from an incandescent source is generated as a result of heating a tungsten filament to white hot temperatures by conduction of an electrical current through the filament. The spectral emission is characterized by basic physical laws. One of these, the Stefan–Boltzmann law, states that the power radiated per unit area is proportional to the fourth power of the absolute temperature. Hence, the hotter the filament, the more the radiation emitted. The shape of the spectral distribution is governed by Planck's law, according to which the proportion of short-wavelength radiation (i.e. UV) increases with

temperature. Incandescent sources are usually ascribed a certain colour temperature, defined as the temperature of a perfect emitter (called a 'black body') that emits the same relative visible radiation as the source. An ordinary tungsten light bulb operates at a colour temperature of 2600 K (3). The quartz halogen bulb also contains a tungsten filament; tungsten that evaporates from the hot filament is re-deposited on the filament via the halogen cycle. It has a colour temperature of 3000 K and thus emits more radiation, and in particular, more UV radiation than the common incandescent lamp. The amount of light emitted by an incandescent lamp is highly dependent on the current following the Stefan–Boltzmann law. Light from a fluorescent lamp does not arise from incandescence but from excitation (3).

A fluorescence lamp generates light from collisions in a hot gas ('plasma') of free accelerated electrons with atoms – typically mercury- in which electrons are bumped up to higher energy levels and then fall back while emitting at two UV emission lines (254nm and 185nm). The created UV radiation is converted into visible light by UV excitation of a fluorescence coating on glass envelope of the lamp. The construction of a CFL bulb tube consists of a tube filled with a gas containing low pressure mercury vapour and noble gas at total pressure of about 0.3% of the atmospheric pressure. A pair of filament emitters is heated by a current and emits electrons which excite the noble gases and the mercury gas by impact ionization (4).

Considerable research activity is underway to improve efficiency and reduce the cost of LEDs. They are widely expected to rival the CFL in terms of energy efficiency within the near future. LEDs contain a semiconductor doped with impurities to produce the so-called N-type material, with excess free electrons, and the P-type material, containing 'holes,' into which electrons may jump. Electrical current moves in one direction only through an LED, in the course of which electrons drop into holes releasing energy in the form of light. LEDs are very promising candidates for future energy-saving light sources suitable for office and home lighting applications. Today, the entire visible spectrum can be covered by light-emitting semiconductors: AlGaInP and AlGaInN compound semiconductors are capable of emission in the red to yellow wavelength range and ultraviolet to green wavelength range, respectively. Currently, two basic approaches exist for white light sources: The combination of one or more phosphorescent materials with a semiconductor LED and the use of multiple LEDs emitting at complementary wavelengths. Both approaches are suitable for high efficiency sources that have the potential to replace incandescent and fluorescent lights (5).

II. METHODS AND MATERIAL

All data sources were identified through searching of different reports of American Medical Association (AMA) on impact of artificial light, data declared on different websites and related research articles.

III. RESULTS AND DISCUSSION

Table-1 shows that traditional incandescent bulb required more electric power to produce same brightness as compared to broaden spectrum white light sources i.e. CFLs and LEDs. Therefore CFLs and LEDs are more efficient compared to traditional incandescent bulb.

Table-2 shows that LEDs and CFLs reduce CO2 emission as compared to incandescent bulb. In contrast to the Incandescent lamp, LEDs does not contain a filament and emit less heat. Therefore white light sources save energy and reduce production cost. LED

Table 1 : Electric power required to produce energy in the form of light in lumen (6).

Incandescent Watts	CFL Watts	LED Watts	Lumen (Brightness)

40	8 – 12	6 – 9	400 – 500
60	13 – 18	8 – 12.5	650 – 900
75-100	18 – 22	13+	1100 – 1750
100	23 -30	16 – 20	1800+
150	30 – 55	25 – 28	2780

Table 2: CO_2 emission, Mercury content, Electricity used and Life span of different light sources (7), (8).

Light Source	Incandescent bulb	CFL bulb	LED bulb
Carbon Dioxide Emissions (30 bulbs per year) Lower energy consumption decreases: CO_2 emissions, sulfur oxide, and high-level nuclear waste.	4500 pounds/year	1051 pounds/ year	451 pounds/year
Contains the TOXIC Mercury	No	Yes - Mercury is very toxic to your health and the environment	No
Kilo-watts of Electricity used (30 Incandescent Bulbs per year equivalent)	3285 KWh/yr	767 KWh/yr.	329 KWh/yr.
Life Span (average)	1,200 hours	8,000 hours	50,000 hours

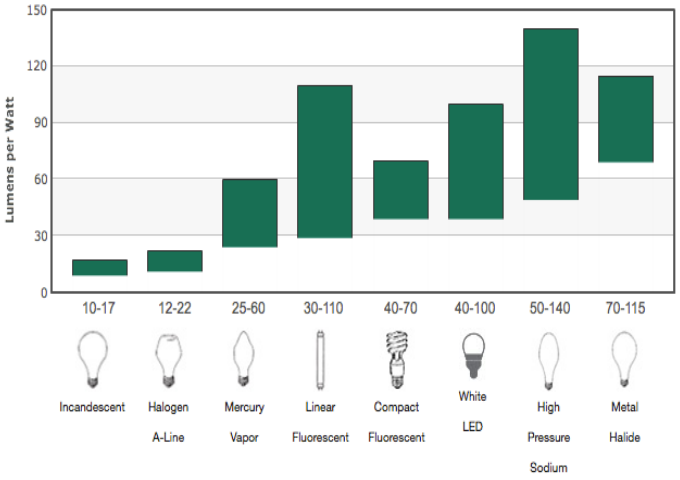

Figure1: Graph of Lumens per Watts Vs. different category of bulbs (9).

Lighting has no warm up requirement with a rapid "1 turn on and off" at full intensity.

Luminous efficiency (lumen per watt produced) of High pressure sodium (HPS) and metal halide (MH) lamp is high (figure-1) but these sources produces more heating effect. HPS and MH have short life, material and process limitation. Metal halide lamp is difficult to start special trigger is required. HPS source contain mercury which is hard to dispose. HPS and MH sources are expensive and more bright produces more light pollution.

Adverse effect of white light on human health

CFLs are the most common type of low-energy light bulb in the market, are set to replace incandescent lamps in order to improve lighting efficiency and cut carbon dioxide emissions. One of the downsides of CFLs is the environmental and human health impact of mercury release from broken CFLs; each CFL contains 3–5 mg of mercury (10). Breaking a CFL releases mercury vapour into the air. The United States Environmental Protection Agency recommends leaving the room for at least 15 min after breaking a CFL.

UV radiation emitted from uncovered white light sources (LEDs, CFLs) causes different skin diseases. An incandescent bulb has a color temperature (CT) of 2400K, which means it contains far less blue and far more yellow and red wavelengths. Before electric light, we burned wood and candles at night; this artificial light has a CT of about 1800K, quite yellow/red and almost no blue.(11) LED light sources has CT 3000K and for street LED light has CT 4000K TO 5000K (12) which emits large amount of blue light. Because LED light is so concentrated and has high blue content, it can cause severe glare, resulting in pupillary constriction in the eyes. Blue light scatters more in the human eye than the longer wavelengths of yellow and red, and sufficient levels can damage the retina (13). This can cause problems seeing clearly for safe driving or walking at night. In the case of white LED light, it is estimated to be five times more effective at suppressing melatonin at night than the high pressure sodium lamps (given the same light output) (14). Exposure to the blue-rich LED outdoor lights might decrease people's secretion of the hormone melatonin. Secreted at night, melatonin helps balance the reproductive, thyroid and adrenal hormones and regulates the body's circadian rhythm of sleeping and waking (15).

IV. CONCLUSION

To improve efficiency and cut CO2 emission there is need to replace incandescent light bulb by white light sources (LEDs and CFLs). The white light source generates less heat and save energy consumption. But on other side artificial white light sources emits UV radiations and short wavelength blue light which is adversely affect on human health and environment. Mercury released from broken CFL also produces hazardous effect on human health.

We can minimize potential harmful effect of broaden spectrum white light by using proper shielded white light sources which reduce emission of UV radiations. Dim white light sources to reduce glare and intensity. Use LEDs which as CT less than 3000K to reduce blue light component.

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