Journal of Engineering and Applied Sciences 12 (13): 3495-3498, 2017
ISSN: 1816-949X

Regulatory Framework and Environmental Management of the Compact Fluorescent Lamps

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Abstract: Compact Fluorescent Lamps (CFLs) are an efficient alternative to traditional lighting because they consume a fifth of the energy used by incandescent lamps, reducing demand for electricity. However, because they contain mercury its use requires policies for environmental management. This study aims to analyze the regulatory framework for environmental management and use of CFLs. Analysis must be countries like the US, China and the European Community have carried out plans for incorporating LFC and in parallel have developed environmental policies and reducing the mercury content of these lamps, demonstrating, environmental and social responsibility in the matter.

Key words: Compact fluorescent lamps, mercury pollution, environmental management, China, Colombia

INTRODUCTION

Accelerated marketing of Compact Fluorescent Lamps (CFLs) starts from 1980, since they are more energy efficient than incandescent lamps (LI). Its use has spread to residential lighting as they have improved light quality (NEWMOA, 2009). The use of CFLs requires policies for environmental management because they contain mercury, metals considered as a hazardous substance by its adverse effects on health. Therefore, efforts to achieve efficient lighting should not only be aimed at maximizing energy with the replacement of LI by the LFC but also minimizing pollution mercury in the lamps.

The aim of this research is to analyze the legal framework regulating the use and environmental management of LFC. In the first section general aspects of mercury pollution are presented. Then, it discussed on mercury emissions during the life cycle of LFC. Subsequently, the global environment and regulatory legal framework for the use and environmental management of LFC described. Finally, the conclusions are presented.

Literature review

Overview of mercury contamination: Mercury (Hg), elemental or metallic at room temperature is a dense liquid, bright silvery white and slightly volatile. It occurs in nature in different ways: metallic, inorganic salts (chlorine, sulfur and oxygen) or organically as methylmercury or phenylmercury. The latter is the compound with greater presence in the environment, the most toxic and accumulates in the food chain. Mercury is found in all stages of the environment (atmosphere, hydrosphere, geosphere and biosphere) and has the peculiarity that does not degrade, so it only has changed the distribution of chemical species. Changes in concentration, mobility and accumulation of mercury are generated by a set of processes known as biogeochemical cycling of mercury.

Natural and anthropogenic sources of mercury pollution: It is present in the earth's crust at about 0.5 ppm and large deposits are found in volcanic regions. It is naturally released into the atmosphere by gasification and erosion of the earth's crust by volcanic eruptions the evaporation of water from the hydrosphere and forest fires (Cabanero 2005). Anthropogenic Emissions of Mercury (EAM) are diverse: pigment for body decoration, preparation of cosmetics, medicines and amalgams; barometers and thermometers manufacturing; industrial processes (mining gold and silver, chlorine, pulp and paper, electrical, paint) coal combustion and solid waste. The EAM have been determined between 2000-4500 tons/year of which about 95% are deposited on the earth's surface, 3% water and 2% in the air. It is estimated that two-thirds of the circulating mercury comes from anthropogenic sources and only the remaining third of natural emissions (Jara, 2007).

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Table 1: Health effects of exposure to mercury

Effects	Elemental mercury and inorganic/methylmercury
Nervous system	Elemental mercury and inorganic: Various neurological and behavioral disorders such as tremors, eretismo (characterized by an abnormal irritability or reactivity to stimulation), emotional instability, insomnia, memory loss, neuromuscular changes, headaches, polyneuropathy and deficits on tests of cognitive and motor functions. Methylmercury: in adults, sensorimotor disturbances such as paresthesia, peripheral neuropathy, tremor, dysarthria, cerebellar ataxia and abnormal gait and balance, visual and auditory dysfunction. Prenatal exposure can irreversibly damage the central nervous system of the fetus, causing mental retardation, sensory disturbances, cerebellar ataxia, impaired physical growth
Kidney	Elemental mercury and inorganic: Inhalation of mercury vapors in high concentrations may cause transient macroscopic proteinuria, abnormal urinary excretion, hematuria, oliguria and acute renal failure. Chronic exposure to inorganic mercury compounds orally causes kidney damage
Cardiovascular	Elemental mercury and inorganic: Elevation of blood pressure, palpitations and increased heart rate. Methylmercury raises the risk of acute myocardial infarction and death from coronary heart disease or cardiovascular disease and increases atherosclerosis
Respiratory	Elemental mercury and inorganic: Respiratory disorders such as cough, shortness of breath and tightness or burning sensation in the chest and more serious effects such as pneumonitis, decreased respiratory function, pulmonary edema and fibrosis by lobular pneumonia

Adapted (Poulin and Gibb, 2008)

Effects of exposure to mercury: The level of mercury toxicity in humans and other organisms varies depending on the chemical form, quantity, route of exposure (inhalation, ingestion or skin contact) vulnerability exposed and duration of exposure (OMS, 2013) person. The most dangerous mercury compounds are organic and mercury in vapor form, since its permeability is greater biological membranes (Cabanero, 2005). The effects of exposure to elemental mercury, inorganic mercury and methylmercury presented by WHO (Poulin and Gibb, 2008) are summarized in Table 1.

MATERIALS AND METHODS

Mercury emissions during the life of the LFC: The mercury content in the (LFC) has declined steadily since the start of marketing however it is necessary to minimize the environmental impact occurs during each phase of the life cycle of these lamps. Which consists of the following stages: production, use and treatment of end of life.

Production stage: Within production facilities LFC mercury emissions may occur in purification processes, transfer and injection of mercury and also through releases from broken lamps, spills and waste material. Technological advances have been aimed at reducing mercury content and to modernize mercury injection methods.

Stage use: The (LFC) do not release mercury during the use phase, unless this breaks during installation, storage or transport. The risks for a broken (LFC) are linked to the amount of mercury it contains, fraction of mercury released, absorbency of the affected area, temperature, volume and room ventilation.

Stage end of life useful: Improper handling, collection, storage, transportation and disposal of spent LFC can lead to releases of mercury to the environment. Thus, environmental management for LFC should include collection programs and technologies to safely capture mercury.

RESULTS AND DISCUSSION

World environment and legal framework regulatory of use and environmental management of LFC: Worldwide, several countries have enacted laws, regulations, policies or plans to replace LI by LFC or prohibit the use of LI in order to achieve efficient lighting to minimize energy consumption being shown in Table 2.

Additionally, it is important to note that the use of LFC in some countries can reduce mercury emissions to the atmosphere from burning fossil fuels (UNEP, 2012). According to the US EPA plants that generate electricity from burning coal are the largest source of mercury emissions in the US however this type of power generation varies from one country to another (NEWMOA, 2009). An analysis conducted at Yale University on mercury emissions from power plants based on burning coal and reducing these achieved from the replacement of LI by the LFC, revealed that the determining factor in achieving the reduction of mercury emissions was the recycling rate of LFC because they do not release mercury during use, unless they break during installation, transportation or storage (ScienceDaily, 2008).

In accordance with the foregoing, worldwide have developed laws or programs for environmental management of mercury content in CFLs worn, appearing in Table 3.

Other efforts to reduce emissions of mercury from broken and worn LFC have been aimed at the adoption of standards to reduce and gradually limit the amount of mercury in lamps without compromising efficient lighting or life. In Table 4 are some of the initiatives worldwide

Table 2: Policies on replacing the LI by LFC and ban LI international level

			Politics	
Countries	Years	Legal document	A	B
Cuba	2005	Official Gazette of the republic of Cuba. Resolution No. 190 of MINBAS/MINCEX (Greenpeace, 2010)	X	X
Venezuela	2006	Program "Mission Energy Revolution". National Energy Savings Plan (Greenpeace, 2010)		X
		Official Gazette 40,370 of March 12, 2014. Resolution whereby progressively establishing the ban, import, distribution and marketing of LI	X	**
	2007	Act 2007 energy security and independence ban on the use of LI is established	X	X
US	2007	The ministry of natural resources. Ban the sale of LI from 2012 (Greenpeace, 2010)	X	**
Canada	2007	Law fluorescents. Provides for the substitution of the LI for the LF during the years 2008 and 2009 And the ban on the sale of LI from 2010 (Greenpeace, 2010)	X	X
Honduras	2008	National ampolletas replacement program		X
Chile	2008	034-2008EM Supreme Decree, based on the Law for promotion of effective use of energy and its regulations, establishes the replacement of LI by LFC in the public sector	X	X
Peru	2008	Decree No. 3450 establishes the prohibition of the importation, marketing, distribution and use of the LI from 2011 (Greenpeace, 2011)	X	X
Colombia	2008	Supreme decree No. 29466 of March 5, 2008. It establishes the replacement of LI of households by CFLs for free (Greenpeace, 2010)	**	X
Bolivia	2008	Plan "clearly". Replacing two residential LI two free LFC	X	X
Uruguay	2008	National program to replace incandescent bulbs with Savers	X	X
Ecuador	2009	Initiative Act amending and supplementing various provisions of the Law for Sustainable Use of Energy. Prohibits the use of LI in residential and commercial areas from 2012. It prohibits the production, marketing and import of LI from 2014 (Greenpeace, 2010)	X	X
Mexico	2009	Law 26,473, published in the official Gazette of Argentina on Wednesday, January 21, 2009, Year CXVII No. 31,577 (Greenpeace, 2010)	X	X
Argentina	2013	The energy ministers of Central America approved a strategy of efficient lighting for the region	X	X
Belize		The strategy includes the phasing out inefficient lamps in the region by the end of 2016	X	X
Guatemala		technical regulations will be developed following an integrated policy approach,	X	X
El Salvador		in order to phase out inefficient incandescent and halogen lamps. A maximum limit of mercury	X	X
Honduras		content that is consistent with the recently adopted Minamata Convention on mercury should	X	X
Costa Rica		also be defined. Official Gazette of the Republic of Cuba. Resolution No. 190 of MINBAS/MINCEX (Greenpeace, 2010)	X	X
Panama	2009	Law fluorescents. Provides for the substitution of the LI for the LF during the years 2008 and 2009 And the ban on the sale of LI from 2010 (Greenpeace, 2010)	X	X
European Union	2004	National ampolletas replacement program	X	X
Australia	2005	034-2008EM Supreme decree, based on the law for promotion of effective use of energy and its regulations, establishes the replacement of LI by LFC in the public sector	X	X

**No information; A: prohibition of impost or use of LI; B: LI massive replacement by LFC

Table 3: Programs and legal documents for sustainable environmental management of the mercury in LFC internationally

Countries	Years	Program/Legal document	A	B
US	2010	Program for increasing the recycling rate of CFLs. Department of Environmental Protection Maine State	Si	Si
Mexico	2009	Various programs developed in different states of the country (NEWMOA, 2009)	**	Si
EU	2008	The general law for the prevention and management of waste is amended by adding Article 28 on the management of waste LF and mercury vapor (Greenpeace, 2010)	Si	Si
China	2006*	The WEEE directive established the rules for the collection, recycling and recovery of electrical and electronic products including CFLs	Si	Si
India	-	Rules for handling electrical and electronic waste. Approved by the Chinese National Council (Ewaste, 2008)	Si	Si
Japan	2003	National framework for functional management of spent CFLs and other fluorescent lamps (LF)	**	Si
Taiwan	2002	Countermeasures Law Soil Contamination	Si	No
South Africa	2008	System "zero discharge-the total recycling"	Si	Si
Australia	2010	National environmental waste act	No	Si

Updated 2008; **No information; ***A: extended producer responsibility; ****B: subscribe to the basel convention

Table 4: Regulatory policies mercury content in LFC at international level

Countries	Years	Program/Legal document
USA	2007	California enacted legislation A.B. 1109 which prohibits the sale of lamps commonly used in California that do not meet the EU
	2010	RoHS directive
Colombia	2010	National electrical manufacturers association voluntarily reduced the mercury content limit for making LFC (NEMA, 2010)
European Union	2006*	Regulation of mercury content in CFLs according to Resolution No. 180540 issued by the ministry of mines and energy
Russia	2011	RoHS. Regulation of the use and levels of hazardous substances in electrical and electronic sector. Sets the maximum limit for each type of lamp
China	2006	Decree No. 602. Requirements for electric lamps and lighting devices used in alternating current circuits

Updated, 2010

where the policy of the European Union (Restriction of Hazardous Substances in electrical and electronic equipment) is considered best practice to establish requirements for the manufacture, transport, storage, use

and handling at the end of the life of LFC. Now to compare and integrate Table 2-4 can be seen that only countries like the US, China and also the States of the European Community have plans to incorporate LFC also environmental policies and regulations content mercury in CFLs, demonstrating environmental responsibility in the matter.

CONCLUSION

From the review of the regulatory legal framework worldwide surrounding the LFC it was determined that only countries like the US, China and the European Community have plans to incorporate LFC (by replacing LI) and also developed environmental policies and reduction of mercury content in CFLs, demonstrate an environmental and social responsibility in the matter.

In the research presented the need for environmental management to control the amount of mercury that reaches the atmosphere from the LFC is highlighted. This requires to minimize emissions that occur during each phase of the life cycle of these lamps. Especially to complete its life where metal recovery by treatment of waste they generate is essential.

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