Toxics Link
for a toxics-free world

Toxics In That Glow

Mercury in Compact Fluorescent Lamps (CFLs) in India

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Study by:

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Toxics Link
H-2, Jangpura Extension
New Delhi - 110014
Phone: +91-(11)-24328006, 24320711
Fax: +91-(11)-24321747
Email: info@toxicslink.org
www.toxicslink.org

Research Team:
Rajeev Betne, Senior Programme Coordinator, Toxics Link
Dr. Prashant Rajankar, Senior Programme Officer, Toxics Link

Editorial Assistance:
Rambha Tripathy, Coordinator, Toxics Link

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Foreword

Compact Florescent Lamps (CFLs) have been widely accepted to be the substitute for incandescent lamps. Not only is their energy consumption lower for the same light produced, but also in their life cycle they emit less mercury released owing to electricity used if generated from coal.

However as is well known, each CFL contains tiny amounts of mercury. This amount is strictly regulated in many countries, and in the European Union, it is restricted to 5 mg under their RoHS regulations to be reduced to 2.5 mg by 2013.

In India however, such lamps have been exempt from our recent regulations (WEE), which govern a RoHS type limit, and hence there is no mandatory standard for them. The Central Pollution Control Board Guideline, 2008, although mentions ongoing efforts to reduced mercury dosing in CFLs to an optimum level using internationally best available technology, has not prescribed an upper limit. The Indian CFL Industry has been resisting a mandatory limit, despite the massive new markets, which have opened up for them. This study finds that CFLs in India can contain more than 10 times the current 5 mg limit.

It may seem quibbling over small numbers. Except in the world of mercury, small numbers have major impacts on health. The health risk between a CFL breaking in your child's room with 5 mg or a 30 mg mercury load, is very significant, and can cause mercury exposures, which are serious.

Secondly the introduction of massive amounts of CFLs in the market has led to broken and discarded CFLs, with nowhere to go. These are dumped, lie around or are sometimes scavenged for glass, metals and electronic chips. However not only do this cause exposure to wastepickers, but also leads to environmental contamination. Mercury evaporates, and resettles on water and grass, metabolizing into deadly methyl mercury, contaminating food, fish and water. It is one of the deadliest toxins in our everyday use.

It is time the Indian CFL industry adopted the lowest limit technically being used today to protect children and the consumer. Simultaneously the Government must mandate a take back and recycling program immediately and link its compliance to accessing markets for the industry. CFLs should also carry labeling about the hazards of mercury as well its amount on each lamp.

Toxics Link presents yet another study aimed at protecting the consumer from toxics and also reminding the industry of its responsibility as well as the Government of its mandate to safeguard the citizen from such impacts.

Ravi Agarwal
Director

About Toxics Link

Toxics Link's Mission Statement - *"Working together for environmental justice and freedom from toxics. We have taken upon ourselves to collect and share both information about the sources and the dangers of poisons in our environment and bodies, and information about clean and sustainable alternatives for India and the rest of the world"*

Toxics Link emerged in the mid 90's due to a perceived need to establish a mechanism for disseminating credible information about toxics in India, and for scaling up the debate on these issues. The goal is to develop an information exchange system and support stakeholders in strengthening campaigns against toxic pollution and specifically to help industries move towards a cleaner production regime.

Toxics Link has a unique expertise in areas of hazardous, medical and municipal wastes, international waste trade, and the emerging issues of pesticides, Persistent Organic Pollutants (POPs), hazardous heavy metal contamination etc. from the environment and public health point of view. We have successfully implemented various best practices and have brought in policy changes in the aforementioned areas apart from creating awareness among several stakeholder groups.

We work from New Delhi and have our nodal offices in Chennai in Tamil Nadu and Kolkata in West Bengal states of India.

Acknowledgements

We take this opportunity to thank all those who were instrumental in the shaping-up of this report.

We would like to record our special appreciation for Mr. Dinesh Goel, and Mr. Shiv Lal Singh, Director and Sr. Analyst respectively of Delhi Test House, New Delhi for jointly exploring and developing the Standard Operating Procedures with Toxics Link for this study.

We express our gratitude towards Ms. Lolita Shukla for editing of this report.

Toxics Link

Executive Summary

A Compact Fluorescent Lamp (CFL), also known as a compact fluorescent light or energy saving light, is a type of fluorescent lamp, which can replace an incandescent lamp (ICL) as it can fit into most existing light fixtures. A CFL would normally last between 6,000 and 15,000 hours, 8 to 15 times higher than a conventional incandescent lamp with visible light output four times that of a conventional lamp.

According to a document of the ***Worldwatch Institute***, under a global scenario, substituting incandescent lights with CFLs would reduce the lighting sector's energy demand by nearly 40 percent and save 900 million tons of CO_2 annually by 2030.

With its energy saving character, portable size and the ability to produce soft white light, CFL is storming into the conventional lighting market globally. At the policy level too the claim over reduction of carbon footprint due to this replacement has given CFL a special push in various energy saving schemes. At present the CFL's share in the lighting market is between 14-30% in different countries; in India the share is approximately 21%. (ICL's share is around 63%). China is the world leader with over 80% global production of CFL.

CFLs use less energy than the conventional incandescent lamps reducing the mercury (Hg) emissions associated with generating the energy to power conventional lamps. There are however, environment and health issues related to CFLs as they contain mercury that is integral to them (the white light produced by CFLs is possible because of the presence of mercury).

Although the overall mercury footprint of a CFL is much lower (almost half) compared to that of an ICL's, the fact that mercury might leak out from broken or burnt-out lamps is a cause of worry. There is also a high chance of toxic mercury entering into the waste stream, especially in this part of the world, posing dangers to local inhabitants and waste workers. This, calls for standardization of mercury dosing (and lowering the mercury content) in CFLs and designing appropriate end-of-life management policies for such devices.

Awareness about the dangers posed by mercury has led some developed countries to take steps to reduce the mercury dosing in CFLs. In the U.S. in 2007, the members of the National Electrical Manufacturers Association (NEMA) have voluntarily capped the amount of mercury used in CFLs. They lowered the cap again in 2010 bringing it down to 4mg/ CFL for units up to 25 watts and 5mg/CFL for units over 25 watts. The 2007 cap was a milligram higher for each of the ranges stated above. In the European Union (EU), the Restriction of Hazardous Substances (ROHS) Law mandates the mercury capping at 5mg/CFL.

India's growing energy dependency and worries about the impact of climate change have forced successive governments to promote energy saving devices. CFLs are promoted in place of incandescent lamps since 2007. The Prime Minister, in his first meeting at the Council of Climate Change had announced Bachat Lamp Yojna (BLY) to phase out incandescent bulbs. This scheme was launched in February 2009.

However, even before the launch of the Bachat Lamp Yojna in the early 2009, CFLs had penetrated into the Indian market and grew from mere 20million units in the year 2003 to 200 million units by the year 2008. The average annual penetration rate of CFL in the Indian lighting market has been

36% in the last five years. At present the CFL has a market share of 21% with over 300 million units (annually) and is slated to go beyond 400 million units by end of the year 2012.

With trends suggesting 400 million units of CFLs to be manufactured annually by the end of the year 2012, the total consumption of mercury by the CFL industry would be about 3 tonnes each year (considering 7.5mg as the average mercury dosing as per Central Pollution Control Board's, 2008 document), which would ultimately contaminate different mediums, if India fails to have appropriate end-of-life management policy and practices in place. In addition about 8 tonnes of mercury goes into the manufacturing of fluorescent lamps (double ended long tubes) per annum. Thus, even with these estimates (conservative) we are already into a dangerous trend. Further, the mercury in CFL is neither regulated in India nor there is any voluntary cap declared by any of the lighting manufacturers or their associations on mercury dosing in CFLs.

Toxics Link has undertaken this study to assess the total quantity of mercury present in CFLs with an objective to reduce mercury levels in lighting products and flag the issue of its end-of-life management:

The Objectives Are

a. To detect the total mercury content in CFL lights sold in India;

b. To study the trend of mercury dosing in CFLs of different wattage and estimate the variance in mercury concentration;

c. To assess divergence in mercury levels in Indian CFLs from globally best known standards;

d. To make recommendations to regulators for mercury standards in CFLs and end of life management for lights containing mercury.

The Study

Twenty-two samples of CFL lights of well-known brands were purchased from authorized dealers in New Delhi. The samples were randomly picked with wattages ranging between 5 and 20. The CFL samples were sent to ***Delhi Test House (NABL accredited lab – ISO/ IEC 17025:2005), A- 62/3, G.T. Karnal Road, Industrial Area, Opposite Hans Cinema, Azadpur, Delhi- 110033*** for further analysis of mercury content. There has been no universally acceptable Standard Operating Protocol (SOP) for analyzing mercury content in CFLs. Toxics Link and Delhi Test House have jointly developed the SOP for this study, taking cues from a few internationally available SOPs and also our past experience in analyzing heavy metals in consumer products.

Key Findings

a. The average mercury content per unit (CFL) has been found to be 21.21mg;

b. The average mercury content in 5, 8, 11, 15 and 20 watts (across studied brands) samples are 22.2mg, 7.8mg (the least), 31.5mg 18.8mg and 17.7mg respectively;

c. The maximum mercury content was found in Brand (B) 11 watts sample with 62.56mg and the minimum was found in Brand (D), 15 watts sample with 2.27mg;

d. The average mercury content has been found lowest in units of Brand (D) with 5.97mg unit;

e. Fifty percent of the samples analyzed were found to have a high average mercury content ranging between 12.24mg and 39.64mg across different wattages;

f. The mercury content per watt has been found to be highest in Brand (A) - 4.39mg/watt followed by Brand (B) with 3.25mg/watt;

g. While available best practices do suggest that there will be a marginal variation in mercury dosing based on wattage, our results show a huge variation across wattage even within a brand. Two trends were observed while comparing mercury content vis-à-vis the wattage of CFLs:

    i. In most brands the mercury content decreased with increasing wattage;

    ii. Only a few brands exhibit mercury content increasing with increasing wattage;

h. Overall, mercury dosing in Indian CFLs seem to be quite random. However, it seems the majority of lower wattage units have a higher mercury dosing than those with higher wattage;

i. The study also analyzed four samples of double-ended fluorescent Lamps (40watts each) of four different brands for their mercury content. The highest mercury content was recorded 81.39mg/ tube in brand F while Brand C contained the least 53.63mg/tube. The average mercury content in all FL units is 64.12m per tube (Table 7).

Conclusions

a. Indian CFLs are quite high in their mercury content and the study suggests that the average mercury dosing is four to six times the standards followed in some of the developed countries. In individual cases it exceeds by 20 times. Importantly, observed mean mercury levels are much higher than CPCB's 2008 estimates.

b. It can be concluded that with the present rate of average mercury dosing in Indian CFLs, approximately 8.5 tonnes of mercury would be consumed on an annual basis that would ultimately have to be managed when these units burn out or are discarded. This is dangerous considering the astronomical growth of the CFL market in recent years with an aim to replace ICLs completely;

c. There is lack of a regulatory framework or standard for limiting mercury dosing in CFLs in India. Also the end-of-life management principles are at the conceptual level with a lot of dots that need to be joined. There is no disposal mechanism or infrastructure to deal with the discarded and used-up lamps which points towards imminent danger of mercury getting released in the immediate environment from these devices. This is a matter of concern considering, that local inhabitants and waste workers might directly get exposed to the mercury released.

d. There is no indication of voluntary action being taken by manufacturers or their associations to cap mercury dosing in lighting devices / CFLs. This points towards a need for stricter and mandatory standards for mercury dosing in CFLs;

e. The fluorescent lamps sold in Indian markets have a much higher mercury content compared to some of the internationally available best reference standards.

Recommendations

a. **Standard:** The Government must come up with a maximum limit for the mercury dosing in CFLs. It is technically feasible to achieve 2-3 mg/CFLs in India, have the standards set accordingly. As the matter concerns environment and public health, this standard must be a mandatory one.

b. **Consistent Practice:** Since most multinational players in the organized sector have the means to move towards safer regimes, they must immediately standardize their production process as followed by them in other parts of the world;

c. **End-of-life management:** What India lacks is the infrastructure for end-of-life management of CFLs. This needs to be the key priority area for us. The concept of Extended Producers Responsibility (EPR) must be brought in as well for financing and maintaining the infrastructure for CFL/ mercury management. The end-of-life management must, however, be the joint responsibility of manufacturers, regulatory agencies and executive bodies. Consumers, too, have a responsibility for the proper disposal of broken and used-up lamps. For recycling etc. the best-suited technology must be decided based on a collective dialogue between various stakeholders.

d. **Labeling:** Cautionary (Hg) mark must be made mandatory with specific amount present in CFL. Proper instructions on managing broken CFLs along with disposal guidelines for burnt-out units must also be provided.

1. Introduction

1.1 What is a Compact Fluorescent Lamp

A Compact Fluorescent Lamp (CFL), also known as a compact fluorescent light or energy saving light, is a type of fluorescent lamp, which can replace an incandescent lamp as it can fit into most existing light fixtures used for incandescent lamps[1].

As a thumb rule CFLs, as compared to general service incandescent lamps, give the same or more amount of visible light, use far less power and have a longer rated life. Wattage wise (Table 1) CFLs consume just about one-third to one-fifth of the power. In other words CFLs use about 75% less energy than conventional incandescent light bulbs.

There are many types of CFLs, each constructed differently, but with technology that is similar. Their wattage normally ranges between 5 and 50 watts and generally comes in U-bar or spiral shapes. A good CFL would last between 6,000-15,000 hours, 8 to 15 times higher to that of a conventional incandescent lamp[3]. Also the light output of a CFL is roughly four times per watt compared to an ICL (Table 1).

Table 1: Electrical power equivalents for different lamps[2]

Electrical power consumption Watts (W)		Minimum light output lumens (lm)
CFL	Incandescent	
9–13	40	450
13–15	60	800
18–25	75	1,100
23–30	100	1,600
30–52	150	2,600

1 Compact fluorescent lamp - http://en.wikipedia.org/wiki/Compact_fluorescent_lamp
2 U.S. Household Electricity Report, U.S. Energy Information Administration. 2005 and http://www.energystar.gov/index.cfm?c=cfls.pr_tips_cfls
3 The National Energy Foundation - Low Energy Lighting - How to Save with CFLs - http://www.nef.org.uk/energysaving/lowenergylighting.htm

According to a document of the ***Worldwatch Institute***, under a global scenario, substituting incandescent lights with CFLs would reduce the lighting sector's energy demand by nearly 40 percent and save 900 million tons of CO_2 annually by the year 2030[4].

With its energy saving character, portable size and the ability to produce soft white light, CFL is taking the conventional global lighting market by storm. At the policy level too, the claim of reduction of the carbon footprint due to this replacement has given CFL a special push in various energy saving schemes.

At present CFL's share in the lighting market is between 14-30% in different countries; in India the share is approximately 21%[5]. ICL's share is around 63%. China is the global leader manufacturing over 80% of the world's CFLs[6].

1.2 Mercury in CFL

CFLs radiate a different light spectrum from that of ICLs. Over time improved phosphor formulations have enhanced the perceived colour of the light emitted by CFLs[7]. This visible white light (Figure 1) emission by CFLs is possible because of the mercury (Hg) contained in these tiny tubes (Box 1). Ideally a standard CFL would contain mercury in the range of 2-4 mg.

CFLs use less energy than conventional incandescent lamps reducing the mercury (Hg) emissions[8] associated with generating the energy to power conventional lamps. There are, however environment and health issues related to CFLs as they contain mercury that is integral to them.

4 Strong Growth in Compact Fluorescent Bulbs Reduces Electricity Demand - http://www.worldwatch.org/node/5920
5 Financing Lighting Market Transformation, January 2011 (Clinton Climate Initiative) - http://www.sari-energy.org/PageFiles/What_We_Do/activities/Lighting_Transformation_Forum_Jan2011/15_-_Pradeep_Nair.pdf
6 Strong Growth in Compact Fluorescent Bulbs Reduces Electricity Demand - http://www.worldwatch.org/node/5920
7 Masamitsu, Emily (May 2007). "The Best Compact Fluorescent Light Bulbs: PM Lab Test". Popular Mechanics. - http://www.popularmechanics.com/home/reviews/news/4215199
8 NRDC: Light Bulbs And Mercury - The Facts - http://www.nrdc.org/legislation/files/lightbulbmercury.pdf

Box 1: Mercury (Hg) Integral to CFL

Like all fluorescent lamps, mercury is integral to CFLs. The mercury is in liquid form when the lamp is not operating and the lamp is at room temperature. The mercury vaporizes when the electrical flow through the argon gas starts, and the presence of gaseous mercury greatly increases the ultraviolet light produced. Mercury also helps increasing the amount of current that can flow through the gas, and in turn helps generate even more ultraviolet light. This ultraviolet light strikes a layer of phosphor that coats the inner part of the fluorescent lamp that blocks most of the ultraviolet light. Because of the ultraviolet light, the phosphor emits various frequencies of visible light.

However, mercury dosing complicates final disposal/ recycling of CFL and its numerous components.

Although the overall mercury footprint of a CFL is much lower (almost half) compared to that of an ICL's, the fact that mercury might leak out from broken or burnt-out lamps is a cause of worry. There is also a high chance of toxic mercury getting into the waste stream, especially in this part of the world posing dangers to local inhabitants and waste workers. This, therefore, calls for standardization of mercury dosing in CFLs and also designing appropriate end-of-life management policies for such devices.

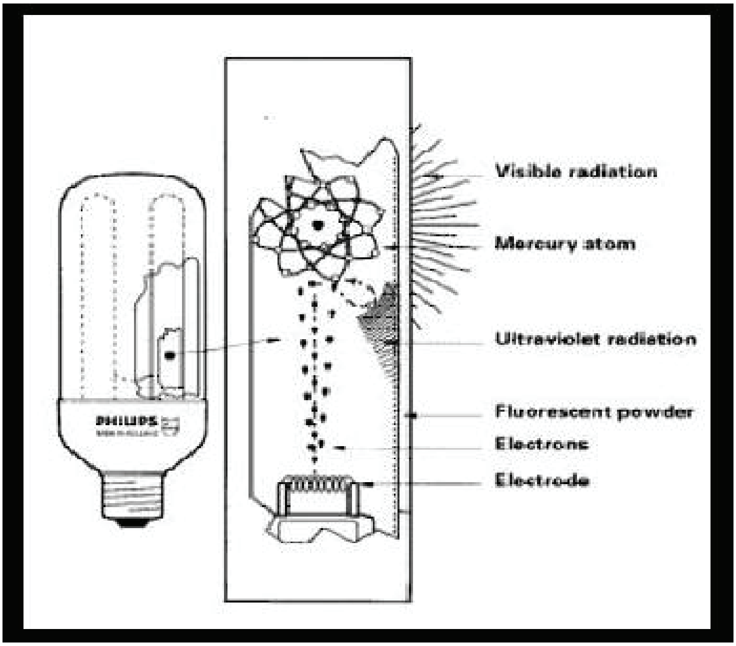
There are examples of global efforts to reduce mercury dosing in the range of 1-2 mg per unit of CFL irrespective of wattage due to the known toxicity of mercury and the problems associated with its end-of-life management. In the U.S., lighting manufacturer members of the National Electrical Manufacturers Association (NEMA) have voluntarily capped the amount of mercury used in

CFLs in 2007 and lowered the cap again in 2010. The current cap is decided at 4mg/ CFL for units up to 25 watts and 5mg/CFL for units over 25 watts[9]. In the European Union (EU), the Restriction of Hazardous Substances (RoHS) law mandates the mercury limit at 5mg/CFL[10].

However, since there is an increasing market potential for the CFL the world over and most nations do not have a manufacturing base, the CFL market is greatly dependent on imports. In the developing and transitional economies the regulatory mechanism is either too loose or non-existent. Further, the CFL promotional strategy of most governments is based on perceived reduction in energy demand and carbon emission and thus the mercury factor gets diluted attention.

While there are technologies available for lowering the mercury dosage in CFLs to below 5mg, review of literature indicates that manufacturers tend to dose-in excessive mercury to increase the light output per wattage. In countries such as India, with no strict regulations for CFLs, such probabilities might be higher.

Figure 1: Schematic representation of visible light radiation from a CFL



9 NEMA Lamp Companies Agree to Reduction in CFL Mercury Content Cap, October 2010 - http://www.nema.org/media/pr/20101004a.cfm

10 Managing mercury risks from energy-saving light bulbs - http://ec.europa.eu/environment/integration/research/newsalert/pdf/129na1.pdf

2. Study Rationale

2.1 Rationale

Toxics Link has undertaken this study on assessment of the total quantity of mercury present in CFLs with an objective to reduce mercury levels in lighting products.

1. The CFL market share is growing in India at an astronomical rate (about 36% in the past half-a-decade). Further, due to a strong manufacturing base in India, CFL manufacturing would enjoy significant economies of scale and helping it to rapidly replace the ICLs;
2. It is quite apparent that mercury in CFLs in India is neither capped nor regulated. With an increasing market share as stated above, coupled with higher mercury dosing, the overall quantum of mercury dosing would be huge in this sector;
3. India doesn't have any mechanism or programme yet on end-of life management on CFLs. Used-up mercury containing lighting devices are usually thrown out in the open or dumped in landfills along with general waste causing widespread dispersal of mercury in the environment. We still do not have enough regulatory or institutional mechanisms to tackle mercury (the trade, its multiple uses, storage or the final disposal);
4. Exposure to mercury is hazardous to humans (Annexure V). Used-up CFLs or broken units could become a prime source of mercury exposure in households and workplaces. We need a check on this.

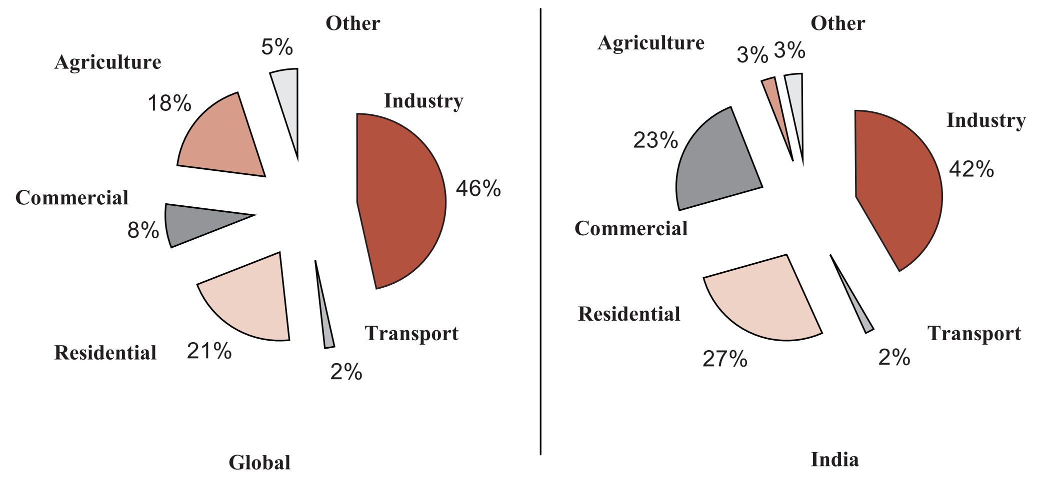
2.2 CFL's Growing Market Share

The residential sector consumes about one third of power in India[11] (Chart 1). However, at present India's lighting segment as a whole (including all the sectors) accounts for 18% consumption of total power generated in the country[12]. This figure is slated to rise further manifold owing to increasing urbanization and rural electrification programme. This challenge of growing energy demand in the lighting sector has provided greater impetus to new technologies like CFL, which the world is looking up to as one of the best available alternatives.

11 International Energy Agency (IEA statistics), 2008- http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=29 and http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=IN

12 Financing Lighting Market Transformation, January 2011 (Clinton Climate Initiative) - http://www.sari-energy.org/PageFiles/What_We_Do/activities/Lighting_Transformation_Forum_Jan2011/15_-_Pradeep_Nair.pdf

Chart 1: Energy Consumption by Sector



Source: International Energy Agency (IEA), 2008

India's growing energy dependency and worries about the climate change impacts have forced successive governments to promote energy saving schemes. CFLs are promoted in place of conventional electric lamps since 2007. The Indian Prime Minister in his first meeting at the Council of Climate Change had announced ***Bachat Lamp Yojna*** (BLY) to phase out incandescent bulbs. This scheme was launched in February 2009[13]. The programme envisages providing CFLs at a discount of over 70% (at Rs 15 as opposed to a market price of Rs 80 to 100), to nearly 10 million people. Before the formal launch of the plan, two pilot projects were carried out in Visakhapatnam (Andhra Pradesh) and Yamunanagar (Haryana) to assess the potential uptake of CFLs by consumers.

The BLY is designed as a public-private partnership between the Government of India, private sector CFL suppliers and State level Electricity Distribution Companies (DISCOMs). The CFL suppliers would sell high quality CFLs to households at a price of Rs. 15 per CFL within a designated project area in a DISCOM region of operation. The CFL suppliers will be chosen by the DISCOM through a diligently monitored process from a list of CFL suppliers empanelled by BEE. Under the scheme only 60 Watts and 100 Watts incandescent lamps will be replaced with 11-15 Watts and 20 - 25 Watts CFLs respectively. It is expected that around 50 lakh CFLs will replace ICLs in each DISCOM area. BEE, the monitoring body for this project, expects the plan to cover all of India by the end of year 2011.

To ensure that the agencies responsible for distribution are able to recover costs through the sale of carbon credits, Bachat Lamp Yojana relies on a reliable market for certified carbon credits post 2012[14].

However, even before the launch of the BLY in the early 2009, CFLs had penetrated into the Indian market; the growth from 2003 to 2008 has been 10-fold, from a mere 20 million units to about 200 million units. The average annual penetration (or growth) rate of CFLs in the Indian lighting market has been 36% in the last five years (Table 2 and Figure 2). At present the CFLs have a market share of 21% with over 300 million units (Table 2 and Figure 2) manufactured annually and it is slated to go beyond 400 million units by end of the year 2012.

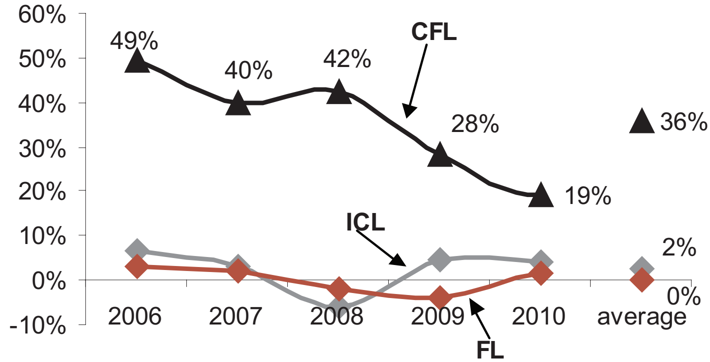
13 Khan, Noor (10 Aug 2009). "Govt aims to cover 400 cities, towns under Bachat Lamp Yojana". SamayLive.com. http://www.samaylive.com/news/govt-aims-to-cover-400-cities-towns-under-bachat-lamp-yojana/645456.html

14 India's CFL programme: A logistics challenge for lighting, Preeti Malhotra, Climate Group, April 2009 - http://www.climatechangecorp.com/content.asp?ContentID=6069

Table 2: Annual Manufacturing Trends in India by Lamp Category[15]

Lighting devices	Quantity in million pieces					
	2005	2006	2007	2008	2009	2010
Incandescent Lamp (ICL)	711	757	779	734	766	797
Fluorescent Lamp (FL)	180	186	190	186	179	182
Compact Fluorescent Lamp (CFL)	67	100	140	199	255	304

Figure 2: Growth Trends in India by Lamps Category in last five years (2006-2010)



Source: Toxics Link, 2011

It is important to note that India imports around one-third[16] of CFLs to meet the local demand with the balance being supplied by Indian manufacturers.

2.3 CFLs: Quality, Environment and Health Concerns

If we focus entirely on the energy saving features of CFLs, its current market trend is a matter to cheer. There are however, concerns associated with these devices. For instance, most energy distribution companies do not have effective Management Information Systems to help understand product costing or capacities to do extensive research. Some independent studies have shown that CFLs have a high failure[17] rate in India due to lack of adherence to product specifications and therefore there is a high rate of replacement during the warranty period itself

Quality control is other major concern. The import-based, unorganized nature of the CFL industry in India makes quality control and regulation difficult. Some manufacturers due to the associated costs and additional checks have often resisted the plan to bring-in a set of regulations.

Concerns related to mercury dosing and CFL's end-of-life management has been elaborated in the previous sections (1.2 Mercury in CFL). According to the government estimation[18] the CFL units

15 Lighting Industry in India at end consumer prices – http://www.elcomaindia.com/Lighting_Industry_in_India2010.pdf

16 Phasing In Quality: Harmonizing CFLs To Help Asia Address Climate Change - http://usaid.eco-asia.org/programs/cdcp/reports/phasing_in_quality.pdf

17 The Way Forward - Promoting Compact Fluorescent Lamps (By P.K.Ranganathan, SECO Controls P. Ltd) - http://www.pennenergy.com/index/energy-issues-and-solutions/hsse/display/4232135956/articles/pennenergy/ugc/hsse/the-way-forward-promoting-compact-fluorescent-lamps.html

18 Guidelines For Environmentally Sound Mercury Management In Fluorescent Lamp Sector, Central Pollution Control Board Ministry Of Environment Of Forests, Government of India, November 2008

available in India contain mercury in the range of 3-12 milligrams (simple mean at 7.5mg per unit). With trends suggesting 400 million units of CFLs to be manufactured annually by 2012, the total consumption of mercury by the CFL industry would be 3 tonnes each year, which would ultimately contaminate different mediums if India fails to have an appropriate end-of-life management policy (and practice) in place. In addition about 8 tonnes per annum of mercury goes into the manufacturing of fluorescent lamps (double ended long tubes). Thus even with these estimates (conservative) we are already into a dangerous trend. Further, the mercury in CFL is neither regulated in India nor there is any voluntary cap declared by any of the lighting manufacturers or their associations on mercury dosing in CFLs.

Keeping these factors in mind Toxics Link, has undertaken this study to assess the total quantity of mercury present in CFLs with an objective to reduce mercury levels in lighting products and flag the issue of its end-of-life management.

3. Scope and Objectives

3.1 Focus of the Study

The primary focus of this study is to find the total mercury content in well-known CFL brands available in the Indian market. However, the study would perhaps also reveal the total mercury burden on the ecology contributed through this sector. Simultaneously the study should also be able to suggest some policy and practice measures that could be taken up and implemented in the Indian context.

The study refrains from naming any brand tested solely focuses and on the broader issue of mercury management in CFLs. The purpose is to raise relevant concerns, suggest appropriate policy measures and practices for India.

3.2 Objectives

a. To detect the total mercury content in CFLs sold in India;

b. To study the trend of mercury dosing in CFLs of different wattages and estimate the variance in mercury concentration;

c. To assess divergence in mercury levels in Indian CFLs as compared with the globally best known standards;

d. To make recommendations to regulators for mercury standards in CFLs and end of life management for lights containing mercury.

4. Sampling and methodology

4.1 Sampling

Twenty-two samples of CFL of well-known brands were purchased from authorized dealers in New Delhi. The samples were randomly picked with wattages ranging between 5 and 20. The CFL samples were sent to ***Delhi Test House (NABL accredited lab – ISO/ IEC 17025:2005), A- 62/3, G.T. Karnal Road, Industrial Area, Opposite Hans Cinema, Azadpur, Delhi- 110033*** for further analysis of mercury content.

4.2 Methodology for Determining Mercury Content in CFLs

At the outset we would like to state here the fact that there is no universally acceptable Standard Operating Procedures (SOP) for analyzing mercury content in CFLs. Toxics Link and the Delhi Test House have developed the SOP for this study jointly taking cues from a few internationally available SOPs and also our past experience in detecting heavy metals in products (Annexure VI).

4.2.1 Scope

The scope of this SOP includes determination of mercury in CFL/Tube light by ICP-MS.

4.2.2 Principle

When a sample is aspirated into the centre of the plasma toroid, it dissolves instantly, dissociates, vaporizes, atomizes and ionizes. The plasma ejects electrons from the shell. The result is a positively charged analyte-ion. Ions are selected as a function of mass and are measured for determining the mercury content.

4.2.3 Materials

- Ultra pure acid HNO_3, H_2O_2
- De-Ionized water (free from elements) and clean sample preparation environment
- Hot plate and 1000 or 500 ml beakers
- 100 ml volumetric flask
- 0.45 micron membrane filter paper and filtering units
- Final sample solution containers made up of high quality e.g. Nalgene

- High quality gloves
- Centripure reference standards for ICP-MS

4.2.4 Standard preparation

- Prepare stock solution of 1 ppm from Centripure standard in 2% HNO_3
- Make the final dilutions to concentrations of 0, 1, 5, 10, 20, 50, 100 ppb to achieve a linearity of minimum of 6 points

4.2.5 Sample preparation

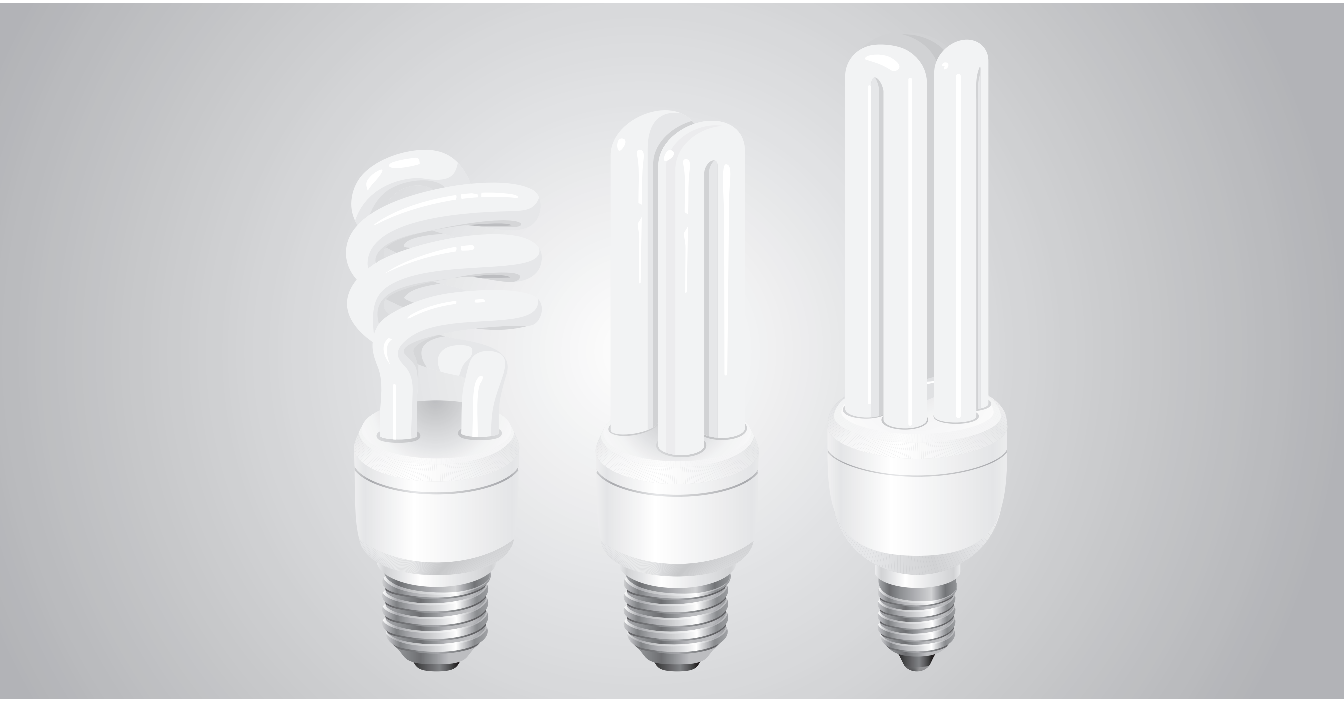
- Put the bulb into a glass chamber
- Remove the plastic base and metal parts with a knife or pliers
- Take a beaker containing 50% HNO_3 and 10% H_2O_2 solution and break the bulb inside it
- Stir or wash the pieces around the container with a glass rod until no more phosphor comes off from the glass
- Heat the beaker on a hot plate (90^0C for 50 minutes). Cool the solution to room temperature
- Transfer the solution into a volumetric flask and make up the volume to 100 ml with de-ionized water
- Filter the sample with 0.45 micron membrane filter papers and put the filtrate in the sample containers to be nebulised into the ICP-MS

4.2.6 Precautions

- Use high quality gloves while adding ultra pure acid into the samples
- Preserve the final sample solution in sample storage rooms if the samples are not getting analyzed immediately after filtration

4.2.7 Calculations

$$\text{Final Conc. of Mercury (Hg) mg per CFL} = \frac{[\text{Measured Conc. x Dilution Factor x Avg. Wt}]}{[\text{Sample Wt. (gm) x 1,000 x 1,000}]}$$



5. Result and Discussions

5.1 Key Findings

a. The average mercury content per unit (CFL) has been found to be 21.21mg (Table 3);

b. Average mercury content in 5, 8, 11, 15 and 20 watts (across studied brands) samples are 22.2mg, 7.8mg (the least), 31.5mg, 18.8mg and 17.7mg respectively;

c. The maximum mercury content was found to be in Brand (B) 11 watts sample with 62.56mg and the minimum was found to be in Brand (D), 15 watts sample with 2.27mg;

d. Average mercury content was found lowest in units of Brand (D) with 5.97mg (Table 6);

e. Of the samples analyzed 50% were found to have a high average mercury content ranging between 12.24mg and 39.64mg across different wattages;

f. The mercury content per watt has been found to be highest in Brand (A) - 4.39mg/watt followed by Brand (G) with 3.87mg/watt and Brand (B) with 3.25mg/watt (Fig 3);

g. While available best practices do suggest that there will be a marginal variation in mercury dosing based on wattages, our results show a huge variation across wattage even within a brand. Two trends were observed while comparing mercury content vis-à-vis the wattage of CFLs

   i. In most brands the mercury content decreased with increasing wattage;

   ii. Only a few brands exhibit mercury content increasing with increasing wattage;

h. Overall, mercury dosing in Indian CFLs seem to be quite random. However, it seems the majority of lower wattage units have a higher mercury dosing than those with higher wattage;

i. The study also analyzed four samples of double-ended fluorescent Lamps (40watts each) of four different brands for their mercury content. The highest mercury content was recorded 81.39mg/ tube in brand F while Brand C contained the least 53.63mg/tube. The average mercury content in all FL units is 64.12m per tube (Table 7).

Table 3: Mercury (Hg) content in CFL of well-known brands sold in India (Lab results)					
Brand Name	Hg Caution mark	Wattage	Price Tag (Rs)	Month/ Year of Manufacture	Hg (mg/ piece)
Brand – A	Present	20	195	Sep-10	45.57
	Present	11	150	March-10	34.73
	Present	5	135	June-10	38.63
Brand – B	Present	11	230	January-10	62.56
	Present	5	115	August-10	25.25
	Present	11	140	May-10	18.41
	Present	18	175	Not clear	10.52
Brand – C	Present	13	210	Sep-10	24.64
	Present	8	130	Sep-09	3.23
	Present	15	135	Not clear	8.87
Brand – D	Present	20	205	April-10	3.30
	Present	15	150	August-10	2.27
	Present	8	125	August-09	12.34
Brand – E	Not Present	15	145	Oct-09	15.51
	Not Present	11	140	October-07	10.28
	Not Present	5	140	October-07	2.74
Brand – F	Present	20	190	October-10	8.11
	Present	15	150	October-10	18.36
Brand – G	Present	15	150	October-10	58.0
Brand – H	Not Present	20	185	Not clear	13.85
Brand – I	Not Present	15	60	No info	9.85
Brand – J	Not Present	No mention	No mention	No info	39.66
Average Hg content across brands and wattage					21.21

5.2 Discussions

5.2.1 Indian CFLs are very high on mercury

The study clearly indicates that the common brands of CFL available in India contain very high levels of mercury across different wattages. On an average the mercury content per CFL was found to be 21.21mg (ranging between 2.27mg to 62.56mg per CFL), near about 3 times the average value (7.5mg per unit; range 3-12mg per unit) documented by CPCB[19]. As compared to CFLs sold in the US and Europe, Indian CFLs seem to contain mercury about four times more (Table 4), with some manufacturers being common in these nations.

With our results extrapolated, the collective mercury consumption by all CFLs in India should reach around 8.5 tonnes per annum by the year 2012. Higher mercury dosing means higher risk

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of toxic exposure at household and workplaces. With no sound end of the life management practice existing in India so far, a large portion of the mercury contained in CFLs would reach the waste stream posing dangers to local inhabitants and waste workers. The toxics residues would also be stored and/or carried by mediums like air, soil and water eventually managing to enter into the food chain.

High levels of mercury in CFLs could also pose danger to the occupants indoor. For example in a closed room of dimension of about $20m^3$ (8*10*9 ft^3), a broken Indian CFL could release mercury vapors up to $3.07mg/m^3$ with an average indoor concentration of $1.04mg/m^3$ considering the maximum and average content of mercury found in our CFLs to be 62.56mg and 21.21mg respectively. This is unsafe and over 100 times the acceptable limit ($0.01mg/m^3$, The Second Schedule, Factory Act 1948/1987). India does not yet have a standard limit for mercury in indoor air. Also consumers are unaware of mercury spill management.

The test results also point towards some international brands following differential mercury dosing. For example Brand B in Europe and US sells CFLs with mercury content at 1.4mg / CFL[24] (for units up to 26 watts), while in our tests the same brand was found to contain a mean level of 29.18 mg of mercury per CFL (mean value for units with 5 to 20 watts) in India.

Table 4: Mercury Concentration in Mercury bearing Lamp[20,21,22,23]

SN	Type of Lamp	Mercury Content (mg/lamp)	Country/Region for data
1	Fluorescent Tubes (Double end)	15 (1997)	European Union (RoHS)
		10 (2002)	
		3-5 (2012)	
		15-45	Russia
		10-22	USA
		23-46	Canada
		15-60	India
		3-4	Global best
2	Compact Fluorescent Lamp	4-5	USA *
		5 (up to 150 watt) 3.5 (<30 watt – by 2012) 2.5 (<30 watt – by 2013)	European Union (RoHS)
		10	Canada
		12-30	Russia
		3-12	India

** EPA is considering putting an upper limit of 3 mg of mercury in CFL in coming days*

20 Managing mercury risks from energy-saving light bulbs - http://ec.europa.eu/environment/integration/research/news-alert/pdf/129na1.pdf

21 Guidelines For Environmentally Sound Mercury Management In Fluorescent Lamp Sector, Central Pollution Control Board Ministry Of Environment Of Forests, Government of India, November 2008

22 UNEP - Toolkit for identification and quantification of Mercury release-November 2005

23 Fact Sheet on Mercury Content Standards for Lamps, Mercury Policy Project, Zero Mercury Working Group - http://mercurypolicy.org/wp-content/uploads/2011/05/eu_hg_content_standards.pdf

5.2.3 Mercury Dosing in CFL haphazard in India

There is no clear trend observed in mercury dosing, neither intra-brand nor between different brands (Figure 4-9). There are however,

24 RoHS Annex Review, BEE letter to European member states, Brussels, 7 October 2009

two distinct patterns visible. In most brands the mercury content was seen decreasing with increasing wattage. In a few brands mercury content increased with increasing wattage. It is quite possible that the manufacturers are consciously aiming to capture different segments of consumers based on lumen output.

Internationally however, mercury dosing in CFLs varies only marginally with the wattage.

Table 5: Average Mercury (Hg) Content by wattage (all Brands)

S.No	Watt	Hg Content
1	5	22.2
2	8	7.8
3	11	31.5
4	15	18.8
5	20	17.71

Table 6: Average Mercury (Hg) Content per Unit in Common CFL Brands Sold in India (across wattage)

S.No	Brand	Number of Sample	Hg (mg), in increasing order
1	D	3	5.97
2	E	3	9.51
3	I	1	9.85
4	C	3	12.24
5	F	2	13.24
6	H	1	13.85
7	B	4	29.18
8	A	3	39.64
9	J	1	39.66
10	G	1	58

Figure 3: Average Mercury (Hg) Content / watt in Common CFL Brands sold in India

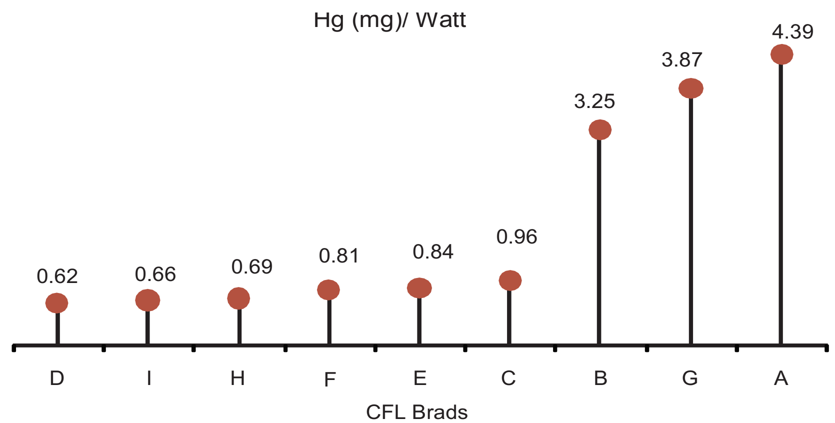
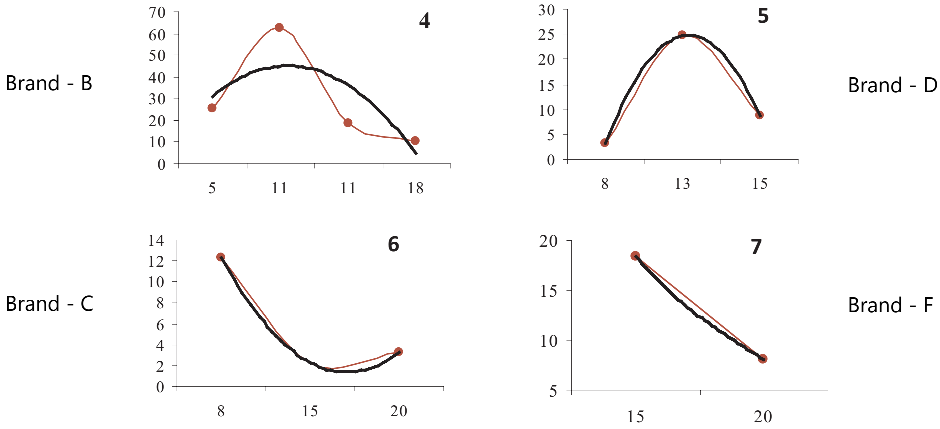
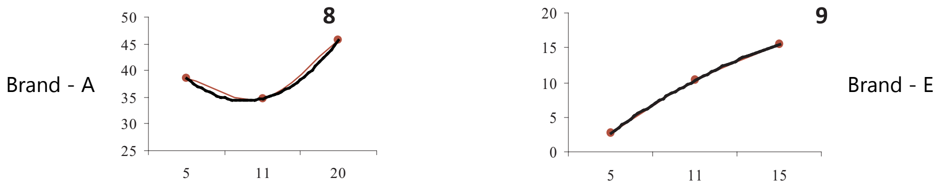


Figure 4-9: Trends in Mercury Dosing vis-à-vis Wattage in Common CFL Brands sold in India

Mercury dosing generally decreasing with increasing wattage



Mercury dosing generally increasing with increasing wattage



Note: Wattage on 'x' axis and mercury content (mg) on 'y'axis

5.2.4 Indian FL's are also too high on Mercury

Double ended fluorescent lamps have a considerable market share (15%) in India and have been in use for several decades. We thought of carrying out this pilot test to gauge the extent of mercury dosing in them (which eventually needs to be managed when they are used-up, discarded or replaced). It is found that they, too, are quite high on mercury with an average of 64.12mg/ tube (Table 7). This again is quite an elevated level as compared to international practices.

On an average, Indian manufacturers seem to be using much higher mercury dosing (this pilot study shows six times more) in comparison to their counterparts in Europe or America as far as FLs are concerned.

Table 7: Mercury (Hg) content in Double Ended Fluorescent Lamps (FL- 40 Watt) sold in India (Lab results)

S.No	Brand	Price Tag (Rs)	Hg Content (mg)
1	F	45.00	81.39
2	H	44.00	66.93
3	B	46.00	54.52
4	C	42.00	53.63
Average Hg content across brands			64.12

6. Conclusions and Recommendations

6.1 Conclusions

a. Indian CFLs are quite high in their mercury content and the study suggests that the average mercury dosing is four to six times the standards followed in some of the developed countries. In individual cases it exceeds by 20 times. Importantly, observed mean mercury levels are much higher than CPCB's 2008 estimates.

b. It can be concluded that with the present rate of average mercury dosing in Indian CFLs, approximately 8.5 tonnes of mercury would be consumed on an annual basis that would ultimately have to be managed when these units burn out or are discarded. This is dangerous considering the astronomical growth of the CFL market in recent years with an aim to replace ICLs completely;

c. There is a lack of a regulatory framework or standard for limiting mercury dosing in CFLs in India. Also the end-of-life management principles are at the conceptual level with a lot of dots that need to be joined. There is no disposal mechanism or infrastructure to deal with the discarded and used-up lamps which points towards imminent danger of mercury getting released into the immediate environment from these devices. This is a matter of concern considering that the local inhabitants and waste workers might directly get exposed to the mercury released;

d. There is no indication of voluntary action being taken by manufacturers or their associations to cap mercury dosing in lighting devices / CFLs. This points towards a need for stricter and mandatory standards for mercury dosing in CFLs;

e. Fluorescent lamps sold in Indian markets too have much higher mercury content compared to some of the internationally available best reference standards.

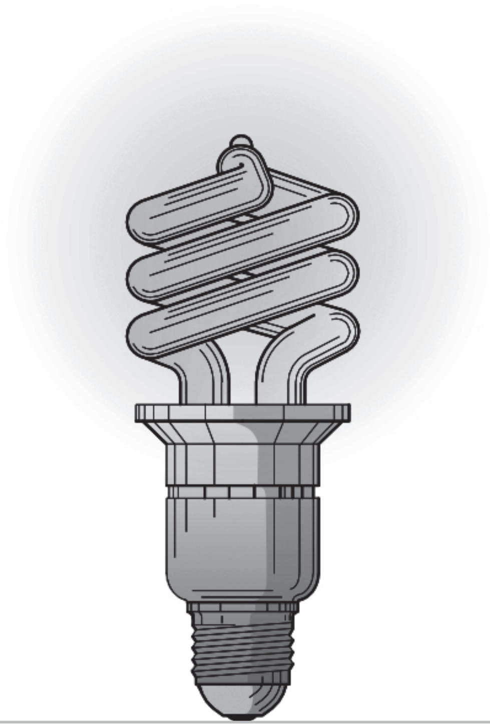
6.2 Recommendations

a. **Standard:** The Government must come up with a maximum limit for the mercury dosing in CFLs. It is technically feasible to achieve 2-3 mg/CFLs in India, have the standards set accordingly. As the matter concerns environment and public health, this standard must be a mandatory one;

b. **Consistent Practice:** Since most multinational players in the organized sector have the means to move towards safer regimes, they must immediately standardize their production process as followed by them in other parts of the world;

c. **End-of-life management:** What India lacks is the infrastructure for the end-of-life management of CFLs. This needs to be the key priority area for us. The concept of Extended Producers Responsibility (EPR) must be brought in as well for financing and maintaining the infrastructure for CFL/ mercury management. The end-of-life management must, however, be the joint responsibility of manufacturers, regulatory agencies and executive bodies. Consumers, too, have a responsibility for the proper disposal of broken and used-up lamps. For recycling etc. the best-suited technology must be decided based on a collective dialogue between various stakeholders.

d. **Labeling:** Cautionary (Hg) mark must be made mandatory with specific amount present in CFL. Proper instructions on managing broken CFLs along with disposal guidelines for burnt-out units must also be provided.



7. Bibliography

CFL Lamp Recycling, MRT Systems - http://www.mrtsystem.com/index.asp?page=40

Compact Crush & Separation Plant, http://www.environmental-expert.com/products/compact-crush-separation-plant-124074

Compact fluorescent lamps - http://en.wikipedia.org/wiki/Compact_fluorescent_lamp

Do CFLs contain mercury? – USEPA - http://energystar.supportportal.com/link/portal/23002/23018/Article/15099/Do-CFLs-contain-mercury

Exposure To Mercury: A Major Public Health Concern (WHO) - http://www.who.int/phe/news/Mercury-flyer.pdf

Fact Sheet on Mercury Content Standards for Lamps, Mercury Policy Project, Zero Mercury Working Group - http://mercurypolicy.org/wp-content/uploads/2011/05/eu_hg_content_standards.pdf

Financing Lighting Market Transformation, January 2011 (Clinton Climate Initiative) - http://www.sari-energy.org/PageFiles/What_We_Do/activities/Lighting_Transformation_Forum_Jan2011/15_-_Pradeep_Nair.pdf

Guidelines For Environmentally Sound Mercury Management In Fluorescent Lamp Sector, Central Pollution Control Board Ministry Of Environment Of Forests, Government of India, November 2008

India's CFL programme: A logistics challenge for lighting, Preeti Malhotra, Climate Group, April 2009 - http://www.climatechangecorp.com/content.asp?ContentID=6069

International CFL Harmonization Initiative-Performance Testing of CFLs: A Comparative Analysis for the APEC Region - Working Group – http://www.apec-esis.org/www/UploadFile/113_174.pdf

International Energy Agency (IEA statistics), 2008- http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=29 and http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=IN

Khan, Noor (10 Aug 2009). "Govt aims to cover 400 cities, towns under Bachat Lamp Yojana". SamayLive.com. http://www.samaylive.com/news/govt-aims-to-cover-400-cities-towns-under-bachat-lamp-yojana/645456.html

Lighting Industry in India at end consumer prices – http://www.elcomaindia.com/Lighting_Industry_in_India2010.pdf

Managing mercury risks from energy-saving light bulbs - http://ec.europa.eu/environment/integration/research/newsalert/pdf/129na1.pdf

Masamitsu, Emily (May 2007). "The Best Compact Fluorescent Light Bulbs: PM Lab Test". Popular Mechanics. - http://www.

popularmechanics.com/home/reviews/news/4215199

NEMA Lamp Companies Agree to Reduction in CFL Mercury Content Cap, October 2010 - http://www.nema.org/media/pr/20101004a.cfm

NRDC: Light Bulbs And Mercury - The Facts - http://www.nrdc.org/legislation/files/lightbulbmercury.pdf

Phasing In Quality: Harmonizing CFLs To Help Asia Address Climate Change - http://usaid.eco-asia.org/programs/cdcp/reports/phasing_in_quality.pdf

RoHS Annex Review, BEE letter to European member states, Brussels, 7 October 2009

Strong Growth in Compact Fluorescent Bulbs Reduces Electricity Demand - http://www.worldwatch.org/node/5920

The Bulb Eater, recycling Doesn't Cost the Earth http://www.bulbeater.co.uk/

The National Energy Foundation - Low Energy Lighting - How to Save with CFLs - http://www.nef.org.uk/energysaving/lowenergylighting.htm

The Way Forward - Promoting Compact Fluorescent Lamps (By P.K.Ranganathan, SECO Controls P. Ltd) - http://www.pennenergy.com/index/energy-issues-and-solutions/hsse/display/4232135956/articles/pennenergy/ugc/hsse/the-way-forward-promoting-compact-fluorescent-lamps.html

U.S. Household Electricity Report, U.S. Energy Information Administration. 2005

UNEP - Toolkit for identification and quantification of Mercury release-November 2005

Annexure – I

Lighting Industry in India[25,26,27,28]

Lighting is a necessity in households and industries, and therefore it is bound to lead to the development of this market. The lighting industry has shown an annual growth rate of about 12% in the last 6 years. The lighting industry in India is valued at INR 71.7 bn in 2009.

Amongst various lighting products in demand, the consumption of CFLs has contributed to a very high growth rate, 50% in 2006. This product segment has registered a total quantity of >100 million pieces during 2006 as per the estimates. A lot of new plants manufacturing CFLs have come up in the last three years in India.

In terms of the quality of CFLs, the market can be divided into four groups. The best quality CFLs, with over 8,000 hours of life and a power factor of 0.8 or more, have a market share of 20%. The second group, comprising 40% of the market, has a lamp life of 6,000 to 8,000 hours and a power factor of 0.5 or more. The third are low quality CFLs that run for 3,000 to 6,000 hours and have a market share of 10 %. Then there are CFLs with no guaranteed life. There are three types of players existing in the Indian market which include manufacturer-cum-importers, importer-cum-assemblers and importer-cum-traders. The first category comprises big brands that belong to well-known manufacturers of lighting products. They import both the ready-to-use CFLs and raw materials such as cut glass tubes and tri-band phosphor and electrical components such as the ballast.

Most of these companies have their own production chains where about 90% of the manufacturing process is carried out. The second category is a mix of well-known names and small-scale operators who import parts of CFL, and have the facilities to assemble them. Both the first and the second category are ISI marked. The third category is fly-by-night operators who import parts as well as the finished product, but of the poorest quality. CFLs produced by this group have no ISI mark and are sold without any warranty.

25 Compact fluorescent lamp - http://en.wikipedia.org/wiki/Compact_fluorescent_lamp

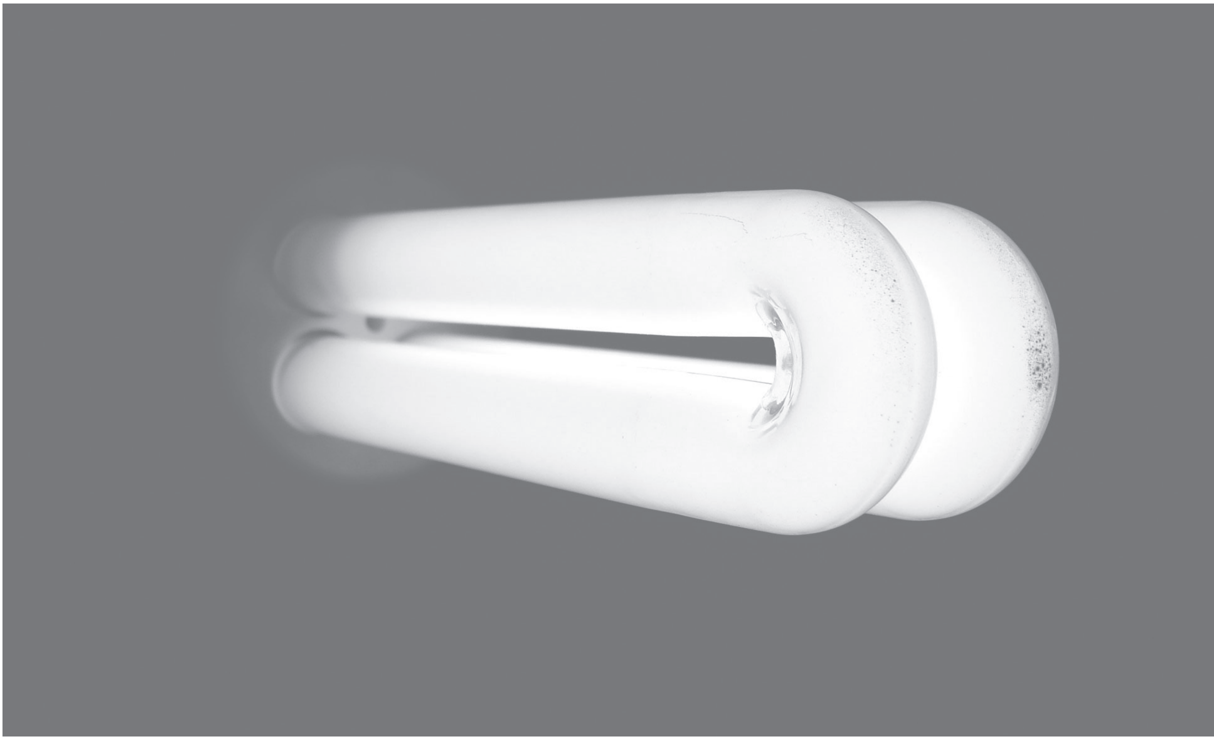
26 Lighting Industry in India at end consumer prices – http://www.elcomaindia.com/Lighting_Industry_in_India2010.pdf

27 Guidelines For Environmentally Sound Mercury Management In Fluorescent Lamp Sector, Central Pollution Control Board Ministry Of Environment Of Forests, Government of India, November 2008

28 Phasing In Quality: Harmonizing CFLs To Help Asia Address Climate Change - http://usaid.eco-asia.org/programs/cdcp/reports/phasing_in_quality.pdf

According to Bibison Baby of Market Pulse, the CFL market in India is very difficult to keep track of. However various sources see Philips as having the largest share of about 35% in the CFL market and Bajaj controlling about 15% market. Halonix, Wipro and Havells have about 10% share each. The rest of the market share goes to Crompton Greaves, CE, Osram etc. in the organized sector.

Nonetheless, the unorganized and small players dictate over 40% CFL market in India.



Annexure – II

Manufacturing Process of Fluorescent Lamps[29,30]

Straight glass shells are cut to the required size and bent into a U shape. Later these tubes are washed with DM water at a temperature of 65-75 ^{0}C and then dried with hot air at 70-80 ^{0}C for about 25 minutes. After they are dry they are coated with fluorescent powder coating prepared with binder and DM water. The coated tubes are dried again with hot air at a temperature of 70-80 ^{0}C for about 25 minutes. These tubes are transferred to backing machine, and are subjected to a temperature of about 550 ^{0}C for about 3 minutes. There after they are transferred to end wiping and the ends are wiped. These shells are loaded into a sealing machine with mounts on one side of each U-tube.

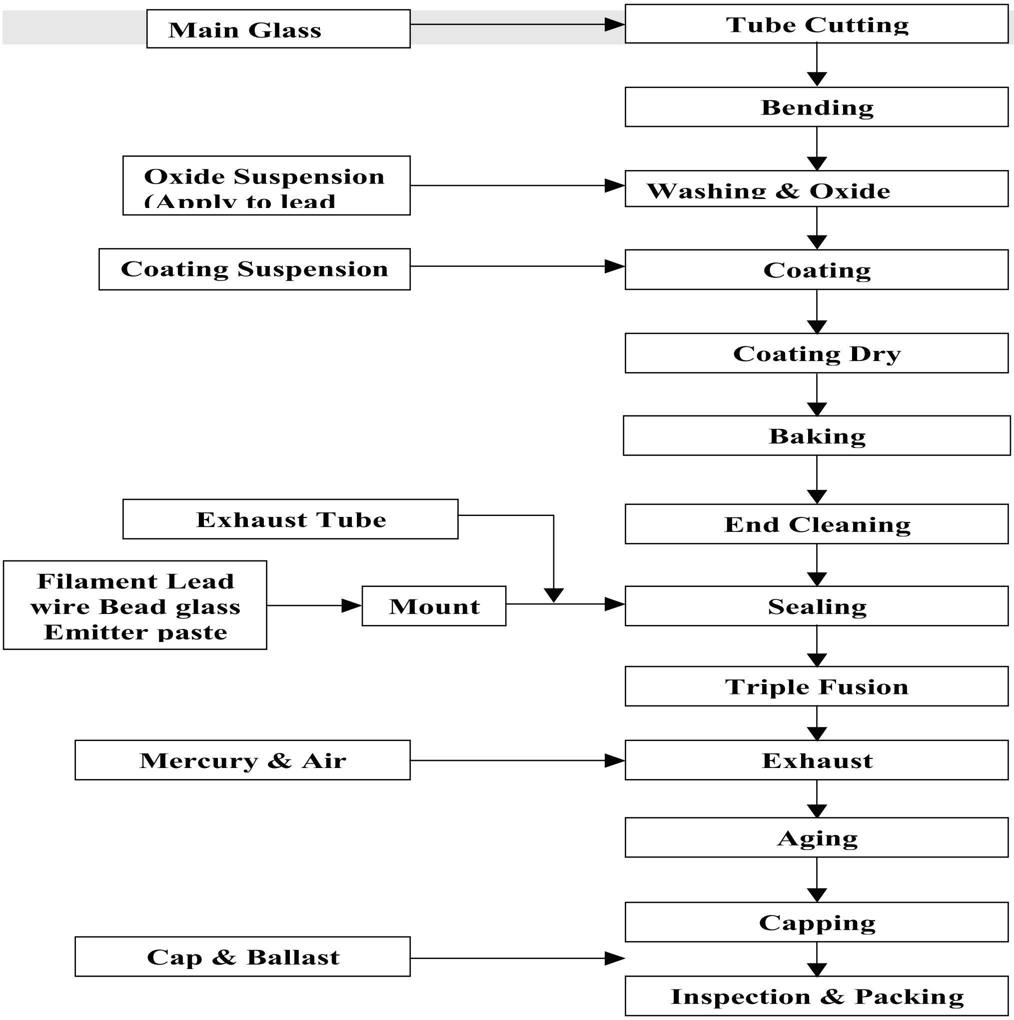
The sealed tubes are then transferred to the machine for making U shaped tubes. Sealed and used tube groups are then transferred to Exhaust Machines, for evacuation, Cathodes are heated and the required quantity of mercury is introduced. Cathode heating and activation is continued. The required quantity of inert gas is injected into the tubes and the tubes are vacuum – sealed by using tipping burners. The lamps are then subjected to the Aging Process. Thereafter these lamps are pasted with PVC covers, the lamps are baked at 120 ^{0}C for about 1 ½ minutes to make a good binding between the PVC cover and the glass. The wires are inserted into the ballast and soldered. These lamps are tested and the base-fitting process is completed.

The complete lamp is rechecked and aluminum caps are fitted and soldered on top of the lamp. The PVC base and cap is crimped with tools and the Quality Assurance (QA) department inspects these lamps. After being checked they are sent for packing and dispatch.

29 Compact fluorescent lamp - http://en.wikipedia.org/wiki/Compact_fluorescent_lamp

30 Guidelines For Environmentally Sound Mercury Management In Fluorescent Lamp Sector, Central Pollution Control Board Ministry Of Environment Of Forests, Government of India, November 2008

Process Flow Chart for Manufacture of Fluorescent Lamps



Annexure – III

Government of India Guidelines for CFL and Mercury Management[31]

Manufacturer's Level

In fluorescent lamps (FL) manufacturing the mercury should be handled properly to minimize its impact on the environment. The FL manufacturers may adopt the best internationally available technologies, including mercury dosing & lamp flushing techniques such as:

(i) Pill dosing techniques, in place of direct dosing of liquid mercury, for desired optimum content of mercury in the lamp.

(ii) Argon flushing, in place of mercury flushing, so that less mercury is consumed in the process.

The above techniques help to prevent leakages of mercury into the environment at various stages of mercury handling and control of mercury releases in compliance with the prevailing norms. The Bureau of Indian Standards (BIS) may formulate the standards for mercury consumption and dosing technologies, so as to minimize the consumption of mercury in the process of manufacturing Fluorescent lamps.

Raw mercury could be recovered during this process using the distillation set up, if required, which may be completely leak proof and operating under a proper vacuum. The provision for a proper fume extraction system may be made to take care of fumes or mercury vapors generated, if any, around the distillation set up.

Consumer's Level

The consumers may handle and dispose the used lamps as described below:

Domestic Consumers:

(i) The consumer must not throw used lamps in the general trash bin but hand them over (in a properly packed form) to a kabari (an individual) or a collection agency identified by an authorized Lamp Recycling Unit for proper recycle / disposal of used FLs.

31 Guidelines For Environmentally Sound Mercury Management In Fluorescent Lamp Sector, Central Pollution Control Board Ministry Of Environment Of Forests, Government of India, November 2008

(ii) The used intact FLs may be stored either in the same boxes in which new lamps are brought or other boxes of a similar size. They should be stored upright. This precaution should be taken while packing more than one used lamp, so as to prevent the possibility of breakage during the storage and transportation.

(iii) After the broken FLs, have been treated as mentioned in section 4.2.2, they may be handed over for safe recycling and disposal.

Bulk Consumers:

(i) Bulk consumers must ensure that used lamps are not disposed in the general trash bin but handed over (in a properly packed form) to an authorized Lamp Recycling Unit (for proper recycle / disposal of used FLs) either directly or through a collection agency identified by such a facility.

(ii) Bulk consumers must construct a particular type of disposal bin suited for the purpose of depositing only the used lamps. The management of the institute may be required to issue necessary instructions, to ensure this happens, to the staff and workers handling the lamps.

(iii) The used intact FLs, as collected in the special bins may be stored in either the same boxes in which new lamps are brought or other boxes of a similar size. They should be stored upright. This precaution is required while packing more than one used lamp, so as to avoid the possibility of breakage during the storage and transportation.

(iv) Even, the broken FLs, after a thorough clean up, as mentioned below, may be handed over for safe recycling and disposal.

(v) The concerned official of the Institute may inform the authorized Lamp Recycling Unit, of the timely disposal of the used lamps. Such used lamps should not, preferably, be stored for a period exceeding one year.

(vi) Guidelines for Cleanup of Broken FLs: The amount of mercury in a CFL is very small, about five milligrams, or the size of the tip of a ball point pen. If a CFL bulb breaks, a small amount of the mercury vapor will be released into the air. It is important, though, to carefully clean up and dispose off a broken CFL to avoid spreading around the phosphorus powder, glass and any remaining mercury.

Here are some guidelines for cleaning up a broken CFL:

(i) Open a window and leave the room (restrict access) for at least 15 minutes. If you have portable fans, place the fans in the windows and blow the air out of the room. Note: If the room has no windows, open all doors to the room and windows outside the room and use fans to move the air out of the room and to the open windows.

(ii) Remove all the materials you can without using a vacuum cleaner:
   - Wear disposable rubber gloves, if available (do not use your bare hands).
   - Carefully scoop up the fragments and powder with stiff paper or cardboard.
   - Wipe the area clean with a damp paper towel or disposable wet wipe.
   - Sticky tape (such as duct tape) can be used to pick up small pieces and powder.

(iii) Place all cleaning materials in a plastic bag and seal it, and then place it in a second sealed plastic bag, dispose of it properly and wash your hands after disposing off the bags.

(iv) The first time you vacuum the area where the bulb was broken, remove the vacuum bag once the area is cleaned (or empty and wipe the canister) and put the bag and/ or vacuum debris, as well as the cleaning materials, in two sealed plastic bags in the outdoor trash or protected outdoor location for normal disposal.

Treatment, Recycling and Disposal:

A Lamp Recycling Unit (LRU), developed as a common facility for the environmentally sound collection, transport, treatment, recycling and disposal of used FLs from the consumers, will need the set up as described under Section 4.1.4.This is required for the treatment-cum-recycling, in addition to the set up for proper collection and transportation of used FLs. Such LRU may have the following facilities, in addition to those mentioned above: • Adequate used lamp storage facilities, with stacking on a 'pucca' platform, preferably under a shed • Mercury spill collection system for further treatment on-site, as described under Section 4.1.6. • Mechanical feeding system, if possible, to have a better check on the breakage of lamps • Training of the handlers, covering manpower (either ***kabaris*** or a collection agency) engaged for the collection and transportation of used lamps to the treatment site.

Annexure – IV

Some Examples of End life Management Challenges and Practices

- Compact crush and separation plant[32]
- Bulb eater[33]
- MRT End Cut Machine[34]

32 Compact Crush & Separation Plant, http://www.environmental-expert.com/products/compact-crush-separation-plant-124074
33 The Bulb Eater, recycling Doesn't Cost the Earth http://www.bulbeater.co.uk/
34 CFL Lamp Recycling, MRT Systems - http://www.mrtsystem.com/index.asp?page=40

Annexure – V

Exposure to Mercury: A Major Public Health Concern[35]

Mercury is highly toxic to human health, posing in particular a threat to the development of the child in utero and in the early years. It occurs naturally and exists in various forms: elemental (or metallic); inorganic (e.g. mercuric chloride); and organic (e.g., methyl- and ethyl mercury). All these forms have different toxicities and implications for health and for measures to prevent exposure. Elemental mercury is a liquid that vaporizes readily. It can stay for up to a year in the atmosphere, where it can be transported and deposited globally. It ultimately settles in the sediment of lakes, rivers or bays where it is transformed into methyl mercury, absorbed by phytoplankton, ingested by zooplankton and fish, and accumulates especially in long-lived predatory species, such as sharks and swordfish.

35 Exposure To Mercury: A Major Public Health Concern (WHO) - http://www.who.int/phe/news/Mercury-flyer.pdf

Mercury releases

- Natural: volcanic activity, weathering of rocks, water movements, biological processes;
- Human activities: combustion of fossil fuels (specially coal), electricity-generating power stations, gold and mercury mining, manufacture of cement, pesticides, chlorine, electric lamps, caustic soda, mirrors and medical equipment, industrial leaks, dentistry, waste and corpse incineration;
- Remobilization of historic sources: mercury in soil, sediment, water, landfill, waste.

Health Effects

Elemental and methyl mercury are toxic to the central and peripheral nervous system. The inhalation of mercury vapor can produce harmful effects on the nervous, digestive and immune systems, lungs and kidneys, and may prove to be fatal. The inorganic salts of mercury are corrosive to the skin, eyes and gastrointestinal tract, and may induce kidney toxicity if ingested.

Neurological and behavioral disorders may be observed after inhalation, ingestion or dermal application of different mercury compounds.

Symptoms include tremors, insomnia, memory loss, neuromuscular effects, headaches and cognitive and motor dysfunction. Mild subclinical signs of the central nervous system toxicity can be seen in workers exposed to an elemental mercury level in the air of $20 \mu g/m^3$ or more for several years. The effect on the kidneys and the immune system has been reported. There is no conclusive evidence linking mercury exposure to cancer in humans.

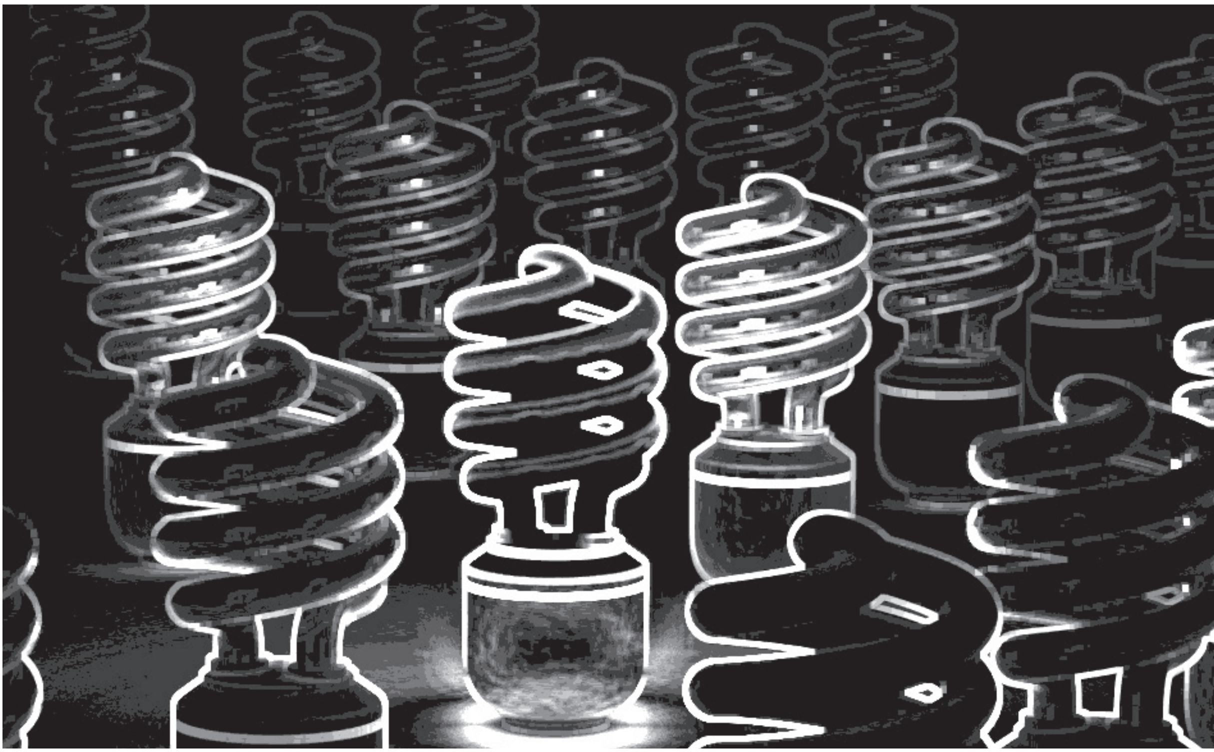
Children are especially vulnerable and may be exposed directly by eating contaminated fish. Methyl mercury bio accumulated in fish and consumed by pregnant women may lead to neuro-developmental problems in the developing foetus. Trans placental exposure is the most dangerous, as the fetal brain is very sensitive. Neurological symptoms include mental retardation, seizures, vision and hearing loss, delayed development, language disorders and memory loss. In children, a syndrome characterized by red and painful extremities called acrodynia has been reported to result from chronic mercury exposure.

Biological measurement of mercury, for example in hair and blood, allows exposure to be quantified and linked to possible health effects. It also permits estimates of the burden of disease (BoD).

WHO Recommendations

National, regional and global actions, both immediate and long-term, are needed to reduce or eliminate releases of mercury and its compounds to the environment. Recommendations are:

- Reduce mercury exposure;
- Eliminate the use of mercury wherever possible;
- Promote the development of alternatives to the use of mercury.



Annexure – VI

Some References in Analyzing Mercury Content in CFLs[36]

A small amount of mercury is used in all fluorescent lamps including CFLs. When the lamp is disposed, the mercury could be released into soil and water, causing mercury pollution. Mercury pollution has serious impacts on human health and child development, thus is controlled in many parts of the world.

Our review found three points of references measuring the mercury content of CFLs: JEL 303-2004, Standard of Japan Electric Lamp Manufacturers Association; the proposed Australia/New Zealand Standard, Fluorescent Lamps – Mercury Content in lamps; and EU Eco-label testing method for light bulbs, Method to Test Mercury Content.

All three testing methods involve the chemical digestion of mercury in the lamp and determine the content of mercury by comparing the test solution to standard mercury solutions. However, the degree of details varies considerably, with the EU Eco-label test method being the least comprehensive. Further, the EU testing method did not address the issue of mercury amalgam, which could lead to serious under-evaluating of mercury content. The Australian/New Zealand proposal matches the Japanese testing method closely, and both clearly laid out the different approaches to address the mercury amalgam issue. Thus, they should be used over the EU Eco-label test method.

Given that the Japanese test method is relatively new, there is a need to conduct more extensive testing in laboratories in other economies in the region to gain acceptance, particularly with regard to CFLs with mercury amalgam.

A second alternative is the Toxicity Characteristic Leaching Procedure (TCLP) test for fluorescent lamps that US EPA conducts to characterize such lamps as either hazardous or non-hazardous for the purpose of disposal. The TCLP test does not measure total mercury content; rather, it measures the potential for mercury to seep or "leach" into groundwater if a waste is disposed off in a landfill. In the TCLP test, lamps are crushed into small pieces and mixed with an acidic solution. The acidic solution is

36 International CFL Harmonization Initiative- Performance Testing of CFLs: A Comparative Analysis for the APEC Region - Working Group 3 – http://www.apec-esis.org/www/UploadFile/113_174.pdf

then filtered out from the lamp pieces. If less than 0.2 mg of mercury are found per liter of acidic test solution, the waste is characterized as non-hazardous waste under federal law. However, the TCLP test as it currently stands was developed for linear fluorescent lamps. An early attempt to adapt this test to CFLs has not been successful.

It appears that, at present, none of the above tests currently provide an easily adopted test for the Mercury content. However, extensive research is being conducted within a number of jurisdictions with early results showing great promise.

It is also worth noting at this point that all the proposed methods for testing mercury content would usually be performed in chemical/ environmental laboratories, typically outside the existing lighting testing infrastructure. Therefore, including mercury testing as part of a revised CFL testing procedure would add to the cost of testing, although currently this increase is estimated to be under 10%.

The fact here that there is no universally acceptable Standard Operating Protocol (SOP) for analyzing mercury content in CFLs. Toxics Link and the Delhi Test House have developed the SOP for this study jointly taking cues above mentioned SOPs and also our past experience in detecting heavy metals in consumer products.

Toxics Link
for a toxics-free world

DELHI

H-2, (Ground Gloor), Jangpura Extension, New Delhi - 110014

T: +91-11-24328006, 24320711 *F*: +91-11-24321747 *E*: info@toxicslink.org

CHENNAI

9/5 (2nd Floor), Second Street, Padmanabha Nagar, Adyar, Chennai 600 020.

T: +91-44-42607642 *E*: tlchennai@toxicslink.org

KOLKATA

52D/12/1A Babubagan Lane Kolkata - 700031.

T: 033-32023410

www.toxicslink.org