Toxics Link
for a toxics-free world

Looking through Glass

CRT GLASS RECYCLING IN INDIA

About Toxics Link

Toxics Link emerged from a need to establish a mechanism for disseminating credible information about toxics in India, and for raising the level of the debate on these issues. The goal was to develop an information exchange and support organization that would use research and advocacy in strengthening campaigns against toxic pollution, help push industries towards cleaner production and link groups working on toxics and waste issues.

Toxics Link has unique experience in the areas of hazardous, medical and municipal wastes, as well as in specific issues such as the international waste trade and the emerging issues of pesticides and POPs. It has implemented various best practice models based on pilot projects in some of these areas. It is responding to demands upon it to share the experiences of these projects, upscale some of them and to apply past experience to larger and more significant campaigns.

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Of the total e-waste generated, around

80%

*constitutes CRTs**

* by weight, see footnote 1 for more details

1. Introduction

Electrical and Electronic Equipment (EEE) like TV, computers, mobile phones, washing machines etc. are integrated into our modern life to a great extent. They are more affordable than ever and their consumption has grown manifold in the last few decades. The rapid change in technology has not only powered growth, but has also triggered the obsoleteness of EEE. End-of-life EEE or e-waste is one of the fastest growing waste streams globally and is one of the emerging issues facing environmental policy makers and waste management professionals today. The collection and management of discarded electronic devices and possible negative environmental consequences of improper recycling has been a topic of debate and discussion all across the world. Globally around 50 million tons of e-waste is being generated annually. With the introduction of completely new technologies, especially LCD and plasma, replacing the traditional CRTs and the looming replacement of standard–definition television with high–definition television, this waste stream has intensified in the developed countries in the last few years and is expected to have an impact on developing countries like India in the coming years. The waste stream presents a problem as most electronic and electrical devices contain a cocktail of toxic chemicals that, if not managed well, can easily leach out causing harm to human health as well as environment. This new and growing waste stream also contains valuable materials, which needs to be put back into the production cycle to sustain the resources and save energy on fresh mining.

India was a late starter in the use of electronics, especially information and communication equipment. But the country has caught up with the global growth in the last two decades and is now one of the fastest emerging markets for electronics. The increasing consumerism, coupled with changing technology and downward price spiral has resulted in a sudden surge of e-waste in the country. The domestic generation and illegal trans–boundary shipment of e-waste have created great challenges and have added to the already existing woes of managing this toxic waste in the country. According to UNU, India presently generates around 2.75 million tons of e-waste annually. According to a study done by MAIT–GIZ in 2009, televisions and computers hold a major share in the total pie of e-waste generated in India.

Cathode Ray Tube (CRT), commonly known as picture tube, constitutes the major part of television and computer monitors. Of the total e-waste generated, around 80% (by weight) constitutes CRTs.[1] CRT contains by far the highest amount of all substances of concern in a PC, the most toxic being lead. There is a substantial amount of lead in CRT encapsulated in the form of leaded glass – perhaps 2–3 kg in older models and 1 kg in new models.

1 Mueller, JR, Boehm, MW, Drummond, C, 2011. 'Direction of CRT waste glass processing: Electronics recycling industry communication', Waste Management, Volume 32, Issue 8, pp. 1560-1565, viewed on 6 July 2012.

As recently as a few years ago, broken monitors and televisions were being recycled with the CRT glass being used to manufacture new CRTs. However, flat–screen technology made these monitors and televisions outdated in European and US markets. Since developing countries like India still had a demand for CRT technology, this waste was dumped here for recycling and making new CRTs. Then again with the Indian market flooded with LCD and plasma screens in the last couple of years, this market has also practically dried up – decimating the demand for recycled tube glass used in them and creating what industry experts call a “glass tsunami”.

CRTs are posing a chief concern in electronic waste recycling due to their volume, recycling costs, toxicity, disposal restrictions in some developed countries, and the trans–boundary movement of the same into poor developing countries. Reports suggest that the CRTs dumping into India still continues. So the country is now left with a huge pile of CRT glass waste generated from its domestic sources as well as from imports. The informal sector still continues to recycle the glass. Since there is no further demand for this glass for manufacturing of new CRTs, it is indeed critical to realize what is happening to this glass and whether it is being handled carefully.

2. Objective of the Study

2.1 Objective

In India, the bulk of e-waste is processed in the informal sector. Since e-waste is a relatively new issue, little has been done to ascertain the vulnerability of the informal recycling sector to the hazards presented in this toxic waste stream. Though there have been some studies to look at the dismantling processes and some of the acid bath or burning processes in the informal sector, very little attention has been paid to the final recycling and recovery of material and the hazards or emissions in that process. Also, there has been no attempt to assess the issue of cross contamination. Brominated flame retardants in plastic, or leaded glass are issues of concern because if they are not treated separately or decontaminated, they can contaminate the whole material chain. In this particular study, we look at the leaded glass from CRT and understand if this glass is being mixed with other glass to form new products. The study intents to assess the downstream flow of waste CRT in India.

The main objectives of the study are as follows:

- To document the flow of CRT glass in the informal sector;
- To assess the possibility of exposure to lead to the workers;
- To investigate if there is an issue of cross contamination, thereby contaminating the entire material chain.

2.2 Methodology

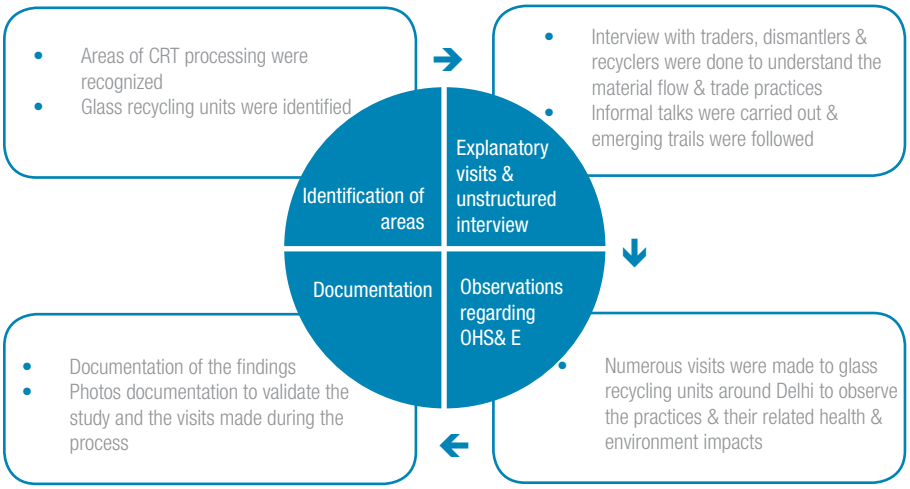
2.2.1 Literature Review

Literature review is one of the most essential components for any survey. It is very important to understand the nature of the survey as well as the subject on which the survey needs to be done before going into the field. A review of the existing literature was carried out to gather information on CRT components, hazards associated with CRT glass, future of CRT technology and best practices followed all around the world to recycle CRT glass or to remove lead from the glass. Health, safety and environmental impacts of using lead embedded CRT glass were also studied.

2.2.2 Field Survey and Documentation

The field survey was carried out to explore and understand the actual processes related to CRT management. Since CRT is traded, processed and refurbished in the informal sector in large quantities, it was important to investigate these operations and observe the possible risks related to occupational health and safety, risk to environment and the issues related to cross contamination. Delhi is one of hotspots of CRT processing and hence most of the field visits were constrained to Delhi informal recycling areas. But investigation into glass recycling led us to the outskirts and neighborhoods of Delhi as well.

The study was carried out in phases (Figure 1):



2.3 Limitations of the Study

There were various challenges faced during the study. The most prominent one was to know about the unorganized sector operation and activities. As these operations were “illegal” and “unauthorized”, getting to know the location was a problem. Even after getting the location, gathering information from them regarding their operations and channels was yet another issue as they were very skeptical about answering. The informal channels are so widespread that, without the support of the informal sector, understanding the complete flow of CRT glass is impossible.

Another limitation of the study was that no lead leaching tests of the recycled glass products could be carried out.

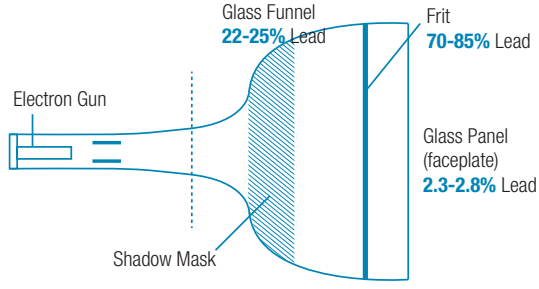
3. Cathode Ray Tube (CRT)

3.1 CRT and its Basic Components

Cathode Ray Tube (CRT) was one of the most innovative and mature technologies invented several decades ago. CRT – well known as picture tube – is a display device that uses electrons fired at phosphors to create images. Since 1930's, it has played an important part in displaying high resolution images, movies, etc. and were considered easy and cheap to manufacture. CRT, which is almost 85% glass, was a part of all computer and TV monitors a decade back and accounted for 55% of the entire weight of a TV and 32% of the PC monitor.

The four main components of CRT (Figure 2) are: glass panel, shadow mask, glass funnel and electron gun.

FIGURE 2: Main Components of CRT



- ***Glass panel (faceplate):*** It is the front part of the CRT which actually displays the image. The inner layer of the faceplate contains inorganic light emitting phosphor. When electron gun produces the electrons, it strikes the glass panel to produce images. This part contains the minimum amount of lead oxide (~2–3%) bound up in the glass matrix. Barium oxide constitutes a major part of the glass panel.

- ***Shadow mask:*** It is a thin metal sheet with apertures positioned immediately behind the glass panel.

- ***Funnel glass:*** It is shaped like a funnel and is attached at the back of the glass panel (faceplate). Lead oxide (22–25%) is bound up in the glass matrix of the funnel as "leaded glass" for shielding us from the radiation produced by the gun. The

glass panel and the funnel glass are connected by frit solder. The lead (~70%) from the frit is in a soluble form as compared to the insoluble lead in the glass matrix of the funnel and faceplate.

- ***Electron gun:*** The electron gun fires electron on the phosphors to display image. It consists of two main parts: cathode and electron beam focuser. Electron then passes through the beam deflector which determines the path of the electron released from the electron gun. Electrons are accelerated while they travel through the deflectors. Velocity change decides the direction of the electron until it hits the screen to display the image. The glass funnel holds the electron gun and forms the back end called the neck. This part constitutes about 30–40% of lead oxide.

Glass in a CRT contains a lot of lead; an average CRT can contain up to 1.5–2 kilograms of lead. It is mixed into the glass for two reasons:

- To improve the optical quality of the glass;
- To act as a shield against radiation generated by the electron gun and electron beam. Lead is added to the specialized CRT glass to protect the user from x-rays generated within the operating CRT.

3.2 Hazards Associated with CRT Glass

The end-of-life management of CRT monitors is of high importance as they contain an extensive variety of hazardous substances such as heavy metals and persistent organic pollutants. In addition to the flame retardants and heavy metals contained in printed wiring boards and plastics, the glass tube itself is of concern because of its high lead oxide content. This is the reason why it is often regarded as one of the most potentially polluting of all electronic waste components. With barium oxide and strontium oxide being an additional concern, the presence of mercury and phosphorous increases the risk associated with CRTs.

However, the primary concern on CRT (as mentioned above) is from the leaded glass. Depending on the size of CRT, the glass of one device contains between 1 and 4 kg of lead.[2] The funnel glass contains about 20–24% lead oxide (PbO), the neck glass about 28–30% PbO and the glass frit about 80% PbO. The lead is encapsulated in glass and cannot be released unless and until the glass is broken. Although under usual circumstances the substances are bound in the glass matrix, crushing and weathering of CRT glass leads to long–term emissions into soil and groundwater – a process that is likely to be accelerated under tropical conditions. However, the glass must be broken into relatively small pieces before significant levels of lead would be available for

2 http://www.ecyclerecovery.com.au/theprocess.htm

release into the environment.[3] The various hazards associated with improper handling or recycling of CRT glass is as follows:

- ***Environmental Hazards:*** Land filling of computers and peripheral materials poses significant environmental and health risks, particularly when specific substances leach into soil and groundwater. The leachate in landfills can be highly acidic and can dissolve materials that might otherwise remain stable (e.g. lead ions from broken CRT glass).[4] Soluble materials like the lead oxide solder in CRT frit may migrate into leachate. Research studies indicate that CRTs could be highly polluting and that the end-of-life scenario adopted, such as land filling, incineration or recycling, could result in the release of contaminants into the air, water, soil, and potentially hazardous residual wastes.

the glass of one CRT device can contain between 1 to 4 kg of lead

When CRT glass containing lead is disposed of in a landfill, it can also break down through compaction. If it comes in contact with rainwater, the heavy metals contained in the glass like lead, strontium, etc. may leach out into the groundwater.[5] Smaller the particle size of the oxides of these metals, higher is the rate of leaching into the groundwater. Also lead from CRT glass may be released as lead oxide dust or lead fume during glass crushing or high temperature process like melting in the furnace.[6] Lead tends to accumulate when released into the environment and they have a long residence time compared with most pollutants, thus polluting air, water and soil.

- ***Occupational Health and Safety:*** Risks associated with processing electronics have been a part of various studies and discussions over the years with CRT featuring prominently in those. This is primarily because of the presence of lead in huge quantities and the known health impacts of this toxic metal. Lead dust, generated during CRT processing, has been a major concern in some of these studies highlighting the risk of exposures to the workers employed in these operations. A study of occupational health risks associated with electronics de-manufacturing showed high levels of lead and cadmium at workstations that manually break CRTs found inside computer monitors and televisions. Another study, done on the occupational risks associated with CRT operations, revealed that significant amount of heavy metals is released during the process. Continuous exposure might lead to various health impacts. Also, the processes involved in CRT operations, like crushing and grinding, are noise intensive, causing hearing

3 BCRC–SEA, 2007. Technical guidelines on the reduce, reuse, recycle (3r) of end-of-life electronic product. Ministry of Environment, Japan, viewed on 15 July 2012 http://www.env.go.jp/en/recycle/asian_net/Project_N_Research/E-wasteProject/12-1.pdf

4 Computer& Peripherals Material Project, October 2001.

5 Rodgers, M, 2010. CRT glass: What's all the fuss about ECS Refining, viewed on 20 July 2012, http://www.ecsrefining.com/blog/crt-glass-what-s-all-the-fuss-about

6 BCRC-SEA, 2007. Technical guidelines on the reduce, reuse, recycle (3r) of end-of-life electronic product. Ministry of Environment, Japan, viewed on 15 July 2012, http://www.env.go.jp/en/recycle/asian_net/Project_N_Research/E-wasteProject/12-1.pdf

impairment among the workers.[7] Various accidents could happen at the workplace if the equipment is not handled with care. If managed improperly, the health risks associated with human contact to these toxic substances within the CRT can be hazardous.

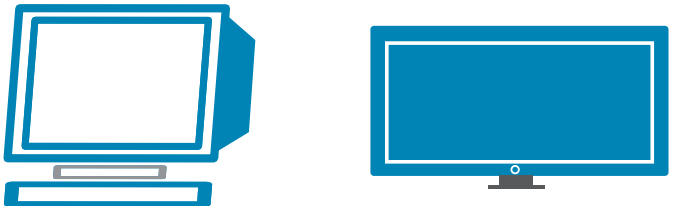
There is another issue of implosion with CRTs. A high vacuum exists within all cathode ray tubes. If the outer glass envelope is damaged, a dangerous implosion may occur. Due to the power of the implosion, glass pieces may explode outwards at high velocities. Hence the CRTs, when removed from equipment, cause accidents and injuries to workers. The workers have very limited knowledge on the technical aspects.

3.3 Future of CRT Technology

CRT–based computer monitors and TVs – one of the most mature technology since decades – have reached a dead end. The plummeting demand of CRT since 2000 is mainly because of rapid advances and falling prices of LCDs and PDPs. However, CRTs are still popular in the printing and broadcasting industries as well as in the professional video, photography, and graphics field due to their greater color fidelity, contrast and better viewing. CRTs still find adherents in video gaming because of their high resolution, lowest possible input lag, fast response time, and multiple native resolutions.

Despite the advantages of quality and durability, CRT technology has remained relatively bulky and heavy as compared to other display technologies. In light of technology advancements, where LCDs and PDPs are thin and wall mountable, CRT is no longer a preferred choice with most consumers (Figure 3).

FIGURE 3: Display Technology



a) CRT monitor b) LCD

In developed countries like Canada and the United States, the sale and production of high–end CRT TVs in the markets ended in 2007. Even though CRT TVs can produce satisfactory performance for 5–6 years, they are being replaced quickly in these countries. In the UK, CRT made up to 80–90% of the television sold in 2004 which decreased to 15–20% in 2006. Major companies like Sony and Samsung has almost

7 Katers, J, Barry, J, and et al, 2010. 'Occupational Risks Associated with Electronics De-manufacturing and CRT Glass Processing Operations and the Impact of Mitigation Activities on Employee Safety and Health'.

reduced their production of CRTs[8] to half in North America in response to the following trend. The United States is projected to face its largest amount of CRT glass waste between the years 2015 and 2020 as products using CRT technology are considered old. CRT glass waste is expected to accumulate until 2026.[9] The demise of CRT, however, has been happening more slowly in the developing world. In countries like India, there was still a demand for CRT, especially CRT televisions, in semi–urban and rural areas. But this demand of CRTs too has decreased substantially in the last few years.

With the increasing demand for LCDs and PDPs, more and more relinquished CRTs will pave their way into the market as waste stream. Since CRT monitors contain high concentration of heavy metals, especially lead, it is important to have a way of recycling or disposing CRT monitors so that it causes minimum damage to health and environment.

By 2015, the CRT shipments are expected to stand at just 4.8 mn units versus LCD shipments of 20.3 mn

The disposal of CRTs from computers or TV sets in landfill must be avoided because the lead they contain is a threat to the environment – a high concentration of acidic leaching of heavy metals to the ground water. Hence landfill is not a very viable option. They must be disposed in areas licensed for hazardous waste. The cost of disposal in such areas is increasing and the total cost also includes transporting tons of material which is costly.

CRTs are one of the few electronic waste components in which globally recycling costs exceed the commodity value.[10] Markets for glass from CRTs are limited. Waste glass from PC and TV monitors will begin to decline as a direct consequence of the emerging flat screen display technology; nevertheless, it seems reasonable to assume that an amount of CRTs from all sources is likely to continue to enter into the waste stream in the coming years. Because of its negative aspects, CRT often gets dumped into developing countries where there are less stringent environment laws and weak implementation.

3.4 CRT in India

In India, CRT market is made up of domestic production and CRT shipments (imported CRTs). Its sales were around 10–million units last year and are expected to reach four–million units next year. CRT TV market is valued at around Rs. 4,000 crore, just one–third of the Rs. 12,000–crore flat panel segment. In 2011, CRT TV shipments in India were 11.6 million units – down 30% from 16.5 million in 2010 (Figure 4). In comparison, the LCD TV shipments have jumped to 6.3 million units – up 90% from the 3.3 million

8 Dixons, 2006. 'The future is flat as Dixons withdraws sale of 'big box' televisions', London Evening Standard, viewed on 16 July 2012- http://www.standard.co.uk/news/the-future-is-flat-as-dixons-withdraws-sale-of-big-box-televisions-7081231.html

9 J.R. Mueller, MW, Boehm, C, Drummond. Direction of CRT waste glass processing: electronics recycling industry communication, 2012.-http://www.eworldrecyclers.com/news/content/ScrapMag8010.pdf

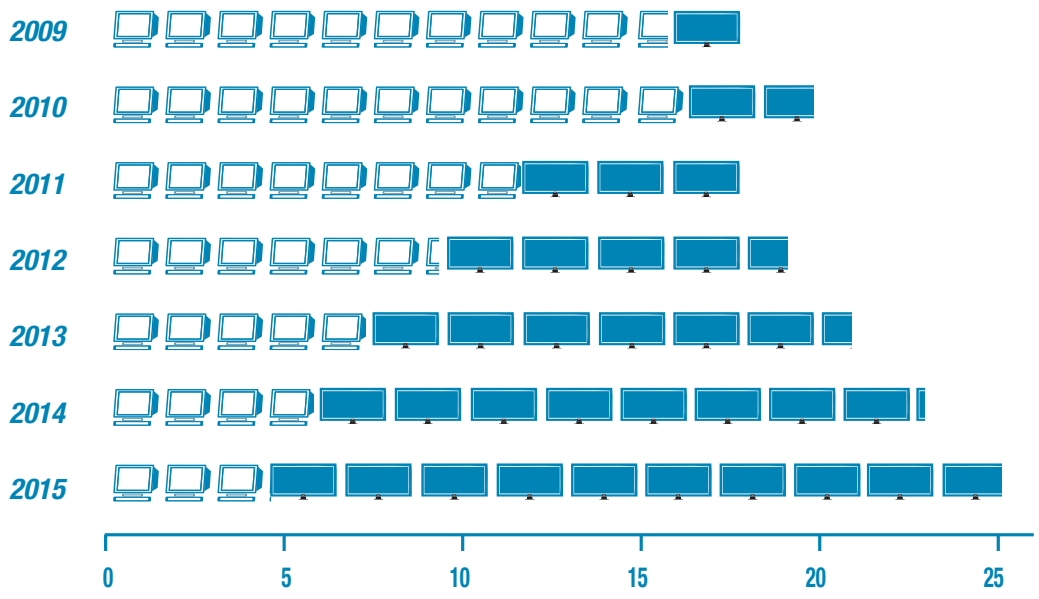
10 http://www.dep.state.fl.us/waste/categories/electronics/pages/lead.htm

in the same period. For the first time in 2012, LCD shipments have pulled ahead with nearly 10 million units as compared to 9.3 million for CRT. By 2015, the CRT shipments are expected to stand at just 4.8 million units versus LCD shipments of 20.3 million.[11]

Big players like Sony, Samsung and LG have stopped producing CRT in India. Interestingly, Indian picture tube manufacturers like Videocon, Oscar and Salora have stopped the production of CRT and are, instead, importing tubes from China, Indonesia, etc.[12]

However, CRT won't completely disappear from India – a country of some 1.2 billion in population and the world's second largest after China. Tremendous diversity in television demand continues to exist in the country. Large swathes of India remain underserved or underpenetrated, with as many as 120 million households having no access to television. For this huge segment, as well as those with limited incomes, CRT TVs will remain a viable option.[13] According to industry estimates, the biggest market for CRT televisions is now in West Bengal, Assam, Bihar, Uttar Pradesh, Rajasthan and Andhra Pradesh.

FIGURE 4: CRT TV vs. LCD shipment forecast (millions of units)



Source: IHS iSuppli Reasearch, July 2012

11 Website of iSuppli. http://www.isuppli.com/Display-Materials-and-Systems/MarketWatch/Pages/LCD-TVs-to-Take-Over-in-India-by-2012-with-Close-to-10-Million-Units.aspx

12 Indian TV market: it's CRT vs. LED', Times of India, 2013, http://articles.timesofindia.indiatimes.com/2013-11-15/hardware/44113001_1_picture-tube-tv-market-lg-india

13 Website of iSuppli. http://www.isuppli.com/Display-Materials-and-Systems/MarketWatch/Pages/LCD-TVs-to-Take-Over-in-India-by-2012-with-Close-to-10-Million-Units.aspx

3.5 Imports

Though CRT markets are dwindling, the import of this component continues in India. According to the information sourced from the Ministry of Commerce, around 64 lakh and 58 lakh CRTs were imported in the year 2010-11 and 2011-12, respectively, even though the quantities came down a little in 2012-13 (47 lakh). Cathode ray tubes are being shipped to India primarily from China, Malaysia and Indonesia. Surprisingly, the quantities saw a sudden jump between 2009 and 2011 even though this was the time when the CRT market was slowing down (Table 1). Interestingly, this was also the phase when most of the developed countries phased out this technology. An important point to note is that the list of importing countries included many European countries as well as USA – none of them, in particular, known for CRT production. These countries have no domestic markets for CRT currently and with their consumers discarding this technology, there are huge piles of CRTs for disposal.

TABLE 1: CRT Imports to India (in Thousands)

Category	HS Code	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14 (Apr- Sept)
Cathode-ray TV picture tubes, including video monitor-cathode ray tubes- color	854011	1224.59	1689.43	2083.74	2223.82	3089.56	4617.49	4058.20	4780.73	6470.18	5837.45	4727.20	2081.49
Other cathode ray tubes	85406000	14.73	25.25	9.65	21.40	9.28	37.47	10.85	20.82	15.60	12.87	16.21	4.74

Source: Government of India, Ministry of Commerce & Industry, Department of Commerce (http://commerce.nic.in/eidb/default.asp)

The import data also reveals an unusual trend. Though the cathode ray tubes imported from China (PRC) or Indonesia cost between 1700–2500 rupees per unit, the prices from some of the other countries is significantly higher – at times up to sixty times (Table 2). This certainly raises a doubt about the legality and nature of these imports.

TABLE 2: Import or dumping?

Country	HS code	Year	Quantity (in thousands)	Price (INR in lakh)	Per unit cost (in Rupees)
China (PRC)	854011	2012-13	1195.36	27,112.03	2,268
Indonesia	854011	2012-13	2277.46	39,645.59	1,747
USA	854011	2012-13	0.04	15.93	39,825
Germany	854011	2012-13	<0.01	4.91	46,333
China (PRC)	85406000	2012-13	15.35	325.52	2,120
Russia	85406000	2012-13	0.20	71.91	35,955
Germany	85406000	2012-13	0.09	112.75	1,25,277
UK	85406000	2012-13	<0.01	7.22	80,222
USA	85406000	2012-13	0.16	23.51	14,693

Because of the environmental and occupational risks and costs involved in handling the leaded glass and the collapsing market for manufacturing new CRTs in the US, Europe and Japan, non–working CRTs are shipped to developing nations (BAN, 2004). Although data on the actual quantity of CRT imports are unavailable, India is still the destination for large proportion of CRT shipments from developed countries. This is in violation of the existing international laws and Indian regulations. There have been various reports and studies over the years highlighting e-waste dumping in India. Availability of cheap labor and lax environmental controls in the country are the major reasons for tons of illegal shipments landing in the ports of the country. Recently the UN warned about the US exports of CRT ending up in India in future, as the only other glass-to-glass furnace in the world (in China and Malaysia) are scheduled to close by 2013. This would mean most of the world's CRT is being dumped in India and the country gets burdened with a large quantity of leaded glass. Unfortunately, it is this inability to manage such wastes safely that results in causing human health and environmental impacts amongst workers and communities.

Key Concerns

- ***Quantity:*** The increasing quantities of waste CRT is an issue of concern. The coming of High Definition Television (HDTV) technologies, since the past decade, has replaced the Standard Definition Television (SDTV) sets, especially in developed countries and this has resulted in CRTs becoming redundant.
- ***Toxicity:*** There is an issue of hazardous materials contents of CRTs especially lead. CRTs have consistently failed tests used in the characterization of solid wastes as toxic.
- ***Trade:*** There is an issue of trans–boundary movement of large quantities of CRT containing devices into developing countries.
- ***Technological advancement:*** With Liquid Crystal Display (LCD) and plasma display panel screens replacing CRT screens, there is a subsequent reduction in production of CRTs. The quantity of recovered CRT glass, from the discarded CRTs, used in manufacturing of new CRTs has also therefore reduced.

4. Recycling CRT in India

India generates around 70 million tons of Municipal solid waste annually. Around 1% of this waste is glass, i.e. around 7 million tons of glass waste annually. Though the quantity is huge, glass is not considered as a major burden on the landfills, primarily because it is 100% recyclable. It is an ideal material for recycling and manufacturing new products as it can be recycled infinitely without losing its strength, purity or quality. Glass recycling is a common practice in India and is carried out in both formal as well as informal sector. It is an energy intensive process and requires furnace to melt the glass so as to mold it into a new product.

The concern with glass recycling comes in when the glass is contaminated and may contain toxic material; CRT glass is one such glass. It contains large quantities of lead, which raises concern about its recycling and further use. The current study to understand CRT glass recycling process is based in Delhi and the surrounding areas, as Delhi is one of the biggest e-waste processing centers and a large number of picture tubes or cathode ray tubes land up in the city as discards.

4.1 CRT Flow

In India, monitors and TVs are much sought after by the scarp dealers as they contain quality copper in the yoke, besides PWBs and CRTs. To understand the flow of CRT glass, it is vital to know the entire supply chain. Through secondary research and field visits; we found that CRT monitor and glass flows through the following mentioned channel (Figure 5).

FIGURE 5: Flow of CRT glass

At times through door-to-door collectors (*kabadiwalas*) or small scrap collectors (local scrap shops), the discarded CRT monitor reaches the e-waste scrap dealers. Though the *kabadiwalas* and collectors are spread across the city, the dealers are primarily based out of e-waste hubs in the city, like Shastri Park or Seelampur. The interactions in the field suggest that the e-waste dealers also receive imported e-waste which includes discarded CRT monitors or televisions.

The scrap dealer usually employs workers to assess the condition of the equipment. CRT monitors, which are in working condition, are sold in the market for reuse. The damaged or non–reusable monitors are broken and segregated into different components. Primitive technologies, such as physical dismantling by using tools such as hammers, chisels, screw drivers and bare hands are adopted to separate different materials. Copper and other valuable fractions are sold to dealers who deal with those materials. The dismantlers assess if CRT or the picture tubes are still in working condition. These are then sold to dealers or to shops that use it to make low quality televisions. A large number of CRTs, which may not be functional but are not damaged, are sold to the regunners, where it is refurbished and put back into the market. This is more profitable as a dealer usually buys a monitor for around 600 rupees and a working monitor can be sold for up to 1000-1200 rupees. The broken components fetch much less revenue; especially glass (see 4.4. Financial Mechanism).

CRT waste making their way to India through ports

Electron gun is removed from the defective CRTs, which cannot be reused, through machines. This gun is further processed to recover valuables. The remaining part is then broken manually to recover iron frames from the funnel and what remains is

the broken glass. The panel and funnel glass together with fluorescent materials are mixed and then sold further. This broken glass is picked up by glass dealers, who, after segregation (according to quality, colour, etc.), sells it to glass recyclers or manufacturers. The recycled glass then takes new forms to make new products to be sold in the market.

According to some sources in the field, this glass also finds some use in bakeries where it is used to maintain high temperature.

4.2 CRT Processing Areas in Delhi

In Delhi, CRT monitors, along with other e-waste, are collected from households/ offices by Kabadiwalas and scrap collectors or bought from the ports by scrap dealers. The areas known for trading in display monitor scrap in the city are Yamuna Vihar, Seelampur, and Mustafabad (Figure 6). The lanes and the by lanes of these localities are loaded with myriads of shops and units dealing with computer scrap trading and dismantling, especially computer monitors and picture tubes.

As mentioned earlier, the functional waste CRTs are sold for regunning. Regunning of CRT has a huge market in Delhi and the major hubs for this process are Yamuna Vihar, Amar Colony, Gokulpuri, Mustafabad and Meet Nagar. After regunning, CRTs are sold to Delhi's biggest electronic markets in Lajpat Rai and Nehru Place and are primarily used for the manufacture of TVs for local brands and at times for video games screens. These regunning markets also receive manufacturing waste or scrap from CRT companies directly.

FIGURE 6: CRT dismantling and regunning areas in Delhi

Glass Dealers

In Yamuna Vihar, Seelampur and Mustafabad, electron gun is removed from the damaged or unusable CRTs and then broken down for recovering the iron frame. Broken glass pieces from the funnel and the panel are sold to the glass dealers. During our study we found that there were very few glass dealers who dealt with this glass and one of the big ones was located in Noida. There was another unit in Mandoli, which was dealing with all types of glass, including CRT glass. CRT glass is the lowest grade of available glass that appears grayish black in color, has limited usage and, hence, is sold separately.

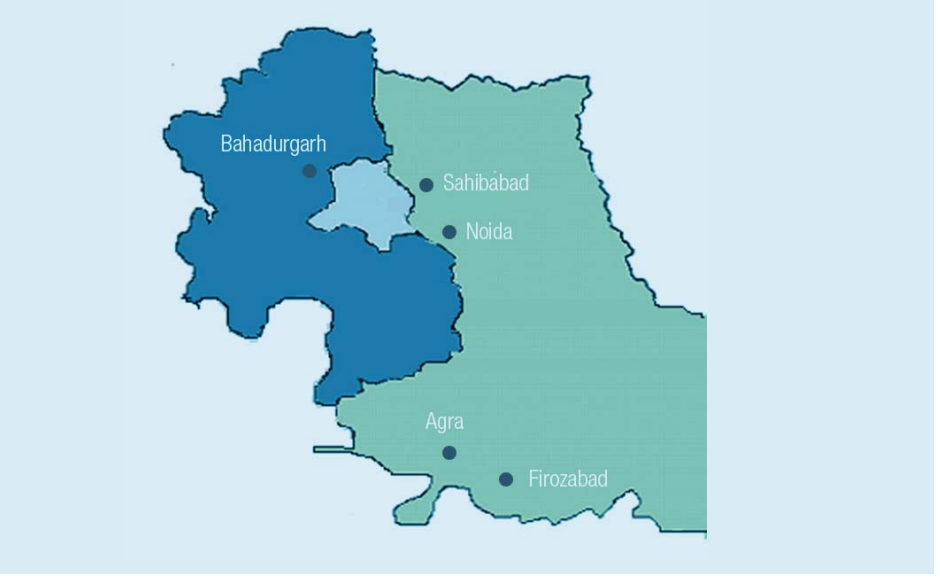
Recycling Glass around Delhi

Due to restriction in the type of industries in Delhi, glass recycling units are mostly located outside the city boundaries. CRT glass is picked up by factories in Noida, Firozabad, and Agra. A small number is located in areas like Bahadurgarh, Sahibabad, etc. Though the unit in Noida deals only with CRT glass, the other units deal with all types of glass.

Informal CRT Market in Delhi

Informal sector caters to the major segments of this market. There are a few formal recycling units around Delhi that use CRT glass. The informal market is spread in and around Delhi, which constitutes a huge market. There are around 15–20 refurbishment units in Delhi, employing around 5–15 workers per unit on an average depending on the size of the unit.

FIGURE 7: Glass recycling hotspots around Delhi



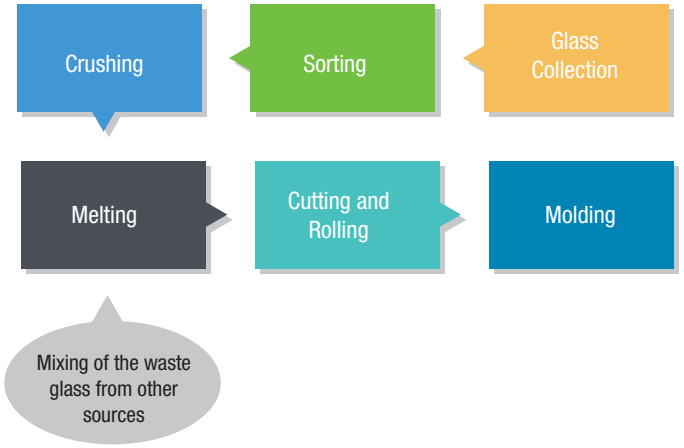
Glass recycling units are mainly concentrated around Firozabad and Agra (Figure 7). These areas are well known for glass activities especially in the making of bangles and marbles. There are very few units – around 5–10, working on CRT glass.

During the visit, casual discussions with the workers in these units revealed that the demand of CRT glass is very low in the market. Mostly these glasses are used for making marbles as the landed cost (cost including all expenditure) comes around Rs. 1.50 – 2.00 per kilogram which is extremely cheap compared to any other glass.

4.3 Recycling Process

In glass recycling units, CRT glass is crushed and broken into small pieces to form cullet (Figure 8).

FIGURE 8: Glass recycling process



After crushing and grinding, the glass cullet are fed into the furnace having a temperature of around 1400–1800°C. Glass waste from bangle manufacturing and other glass industry is mixed in CRT glass during the melting process. At such high temperatures, glass turns into molten phase. Then these are passed through a roller which turns at regular interval to give it a round shape. Once the desired shape is reached, they are cut with the help of a sharp blade and slowly cooled to strengthen the glass product.

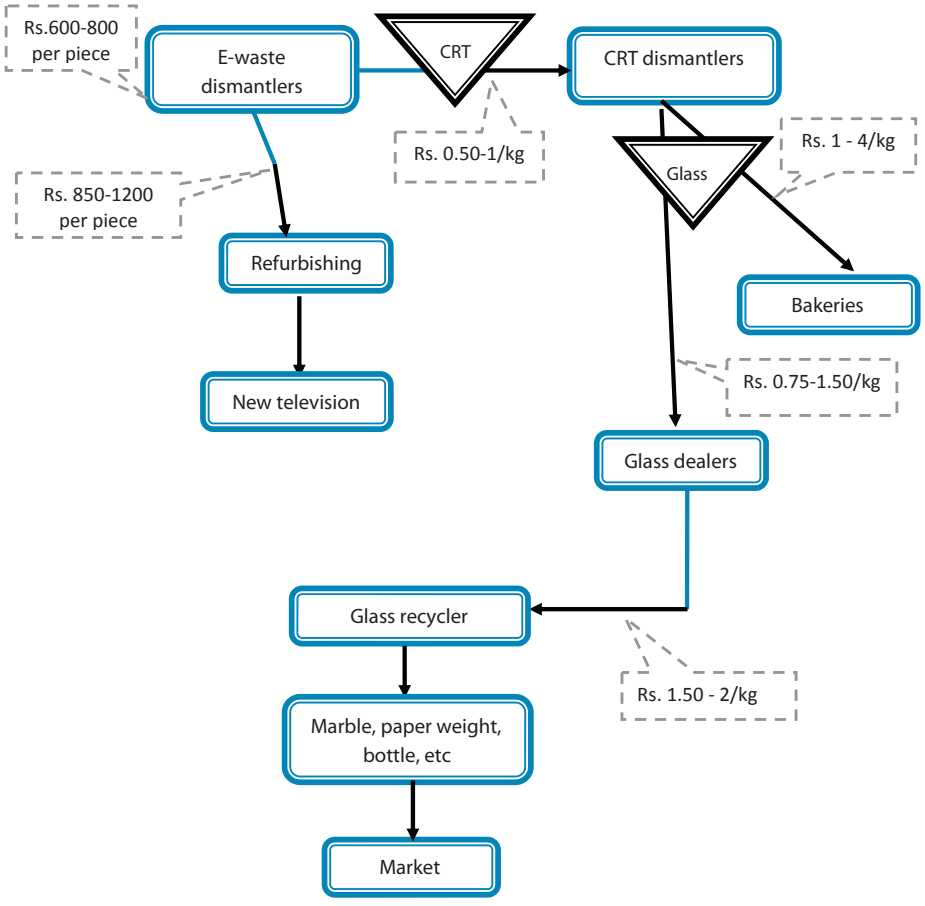
CRT glass has very limited reusability. Though earlier a lot of CRT glass waste was sourced back to new CRT manufacturing plant for use, these have few takers now. Besides making new CRT glass, it is used to form marbles, bangles, bottles, decorative items and table tops. Due to the low quality of CRT glass, it is usually mixed with other glass to form these products. The basic manufacturing process remains the same with slight modifications as per the demand of the products. Thus the CRT glass passes to the consumers, but as a recycled product and in a different form.

4.4 Financial Mechanism

The decreasing demand for CRT in the market has resulted in lesser demand for CRT glass. Due to limited reusability, CRT glass was previously being used to make new CRTs. Currently, this glass is being picked up by the glass dealers at the rate of Rs. 0.50 – 1.00 per kilogram and sold further to the glass recyclers at 50% profit.

Due to the low demand for CRT glass, they are either sold to marble, bangle, other decorative items manufacturing units or bought by bakeries. Landing cost of CRT glass to the glass manufacturers is Rs. 1.50–2.00 per kilogram. But these units mix CRT glass with other waste glass to make marbles or bangles which results in their manufacturing cost being low. Ultimately the products are sold in the market for Rs. 7–70 per kilogram, thus making a huge profit. The bakeries usually buy the glass at the rate of Rs. 1–4 per kg (Figure 9).

FIGURE 9: CRT glass-economics



These treatment methods are seen as “cost–efficient”, because non–skilled manual labor is used and there is disregard for any hazards to environment or health.

4.5 Concerns

Issue of Cross Contamination

Most materials that we use in modern times have additives for various reasons – at times for color or for stability or for adding/enhancing certain properties. These products, even at the end of their useful life or after having joined the waste stream, still retain these additives affecting their recyclability. The concern arises when the additives are toxic in nature and the material is used to make different products, thus leading to "cross contamination". Subsequently a toxic additive which was added to a material may now contaminate the entire chain as new products are usually made with a mix of virgin and recycled material. It may also be present in a product where it is not required or where it may get released or leached. CRT glass is one such material for concern as it contains lead. Such contamination needs to be avoided.

CRT glass is mainly handled by informal sector

In the current study, we tried to map the CRT glass flow and understand if there were any possibilities of cross contamination. For India, though, cross contamination in recycled products has hardly been looked into. Nonetheless it is a very crucial matter as CRT glasses are one of the most hazardous components of e-waste.

Most of the CRT glass is handled by the informal sector which has little or no knowledge about the composition and effects of handling CRT glass. For them, it's just some low quality glass which can be used for making certain products.

The field study reveals that this glass being low in quality is mostly used for manufacturing playing marbles. Other products made from these are bangles, paper weight, decorative items, bottles and table top. The recycling process does not include any intermediate decontamination step to remove lead from glass. Thus, the lead contaminated glass is crushed, melted, molded and comes back to the consumers in the form of new products, without any warning that the product may contain lead in any form.

Products like marbles, used by children who handle it bare handed and also at times take it into their mouth, may have an exposure to risk. Other products made from this recycled glass, like bottles, may also have the risk of leaching and may cause unintentional exposure. Since, during the process of creating new products, glasses from other streams are also added, additional glass material is left contaminated at the end. Though this study clearly points out that there is cross contamination, it is also important to understand if lead is released or leached from these new products.

Though there are no existing studies on lead leaching from products made from CRT glass (it is not allowed in most countries because of the high lead content), there are many studies which clearly elucidate that lead leaches from glass over time. The corrosion of Lead (Pb) – containing glass by acid has been extensively studied since lead crystal glass is often used for tableware and the dissolution of Pb is harmful. The

results of previous studies show that Pb is preferentially dissolved into acid solution from glass and that the time dependence of the dissolution indicates a diffusion–controlled mechanism in the first stage. The leaching rate becomes proportional to time after a certain period because of the formation and dissolution of a silica–gel layer. In contrast, there have been few studies on Pb glass corrosion under neutral or basic conditions. It is known that conventional silicate glass is subject to significant corrosion by basic solutions as the Si–O–Si bond is attacked and broken by OH.[14] Hence, the leaching of Pb caused by glass network dissolution under basic conditions also needs to be studied.

Impact on Marginalized Section

Marginalized sections of the society are usually the most impacted by environmental and health risks. Lack of knowledge and money push them towards unhygienic working environment. They are forced to work in pitiful conditions to earn their daily bread. CRT glass, which is primarily collected and processed in the informal sector, could also be adding to the woes of this weaker section of the society. Glass manufacturing industries, which are categorized as hazardous, employ a large number of women laborers. Women tend to make a major portion of this sector accounting for around 60%.

Workers are forced to work in pitiful conditions to earn their daily bread

Using CRT glass affects this section in two ways:

i. Informal sector workers continuously face issues related to occupational health and safety. During the crushing process, workers use crude methods which expose them to high levels of dust. This glass dust may contain lead oxide, phosphor, etc. The working conditions are also very bad and the workers are not even provided with basic protective gears like mask and gloves.

ii. Many a times, products made from these glasses have low quality and are used to make cheaper products which are mainly used by the poor section of the society.

iii. When used as linings in the bakeries, workers may get exposed to the lead dust or fumes since the glass is subjected to high temperature.

4.6 CRT Glass Recycling- International Practices

CRT monitors contain large quantities of lead and hence have been declared "hazardous" and subsequently "banned" from land–fills and incinerators in most developed countries. With a large shift in technology, most countries including many in Asia have shifted to new projection systems (LCD, Plasma), thereby creating a huge pile of this hazardous waste. Though other materials were recovered and put back into the market, CRT glass always presented a challenge. In contrast to the recycling of plastic, metal and other

14 Masaru Yamashitaa, Anucha Wannagona, Sachiko Matsumotoa, Tomoko Akaia, Hajime Sugitac, Yukari Imoto, Takeshi Komaic, Hirofumi Sakanakura. Leaching behavior of CRT funnel glass.

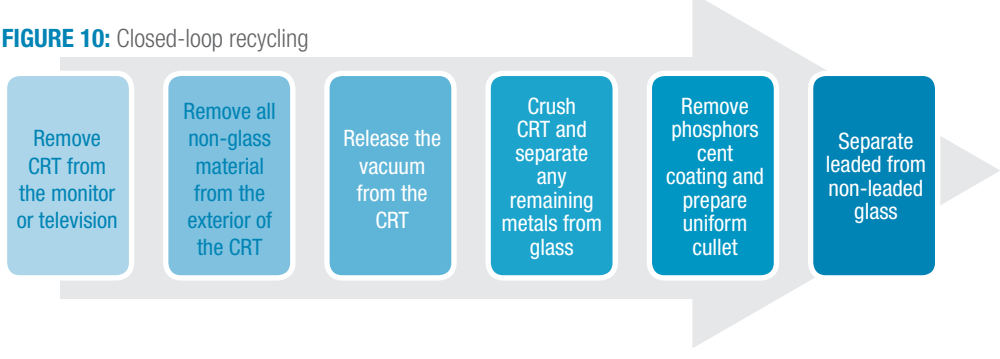
components in e-waste, the recycling of CRT glass is quite difficult. This is due to the fact that CRTs are normally made of several glass components and each is chemically different. Glasses as funnel and neck contain principally lead, whereas panel glass contains other heavy metals (Ba, Sr, etc.) that forbid their recycling in the glass industry for the production of containers, domestic glassware and glass fiber.

Generally, closed–loop recycling (manufacturing new CRT glass) and open–loop recycling (manufacturing glass for other applications) are two principal ways of recycling CRT glass. Under EPA's regulations, the CRT glass can currently be recycled in two ways: sent to a lead smelter (to reclaim the lead and use the silica as a flux agent) or sent to glass-to-glass recycling for making new CRTs. The glass-to-glass recycling is now operating in only a handful of countries in the world because of the decreasing demand. Another viable use for end-of-life CRT glass is as fluxing agents in smelter.[15] But now there is more focus on finding other technologies. Cleaning the glass and using it further is one such option. But lead removal process from CRT glass is costly[16] and economically non–viable. Though there have been efforts in researching appropriate techniques for removing lead from CRT glass so that it can be reused for various purposes, till date most of the options are at the experimental stage and haven't been tried on a large scale.

Glass-to-Glass Recycling

Conventionally, this waste glass was recycled and used as raw material to produce new CRTs. The reuse of recovered CRT glass can save energy, substitute raw materials, and decrease pollution. However, due to the significant declining market for new CRTs, the manufacturers no longer have the capacity to utilize the increasing amount of waste CRT glass. Need for such recycling has slowly reduced, leaving the decision makers to find alternative technologies for the burden of the toxic waste pile accumulated. In closed–loop recycling process, the recovered glass is used as a raw material for new CRTs. In the recycling process, the whole glass is ground into cullet without separation of panel and funnel glass and the recycled glass (the cullet) is used in new CRT production.

FIGURE 10: Closed-loop recycling



15 Management of electronic waste in the United States: Approach 1', United States Environmental Protection Agency, 2007.

16 http://www.ecsrefining.com/services-and-markets/products-and-services/crt-recycling

In this process, the TVs and monitors are disassembled manually or through automated systems (Figure 10).The vacuum of CRT is reduced before it is crushed. The glass and non–glass materials are separated and then processed to meet specifications. The glass-to-glass process is labor intensive, involving hand dismantling and de-processing (separation) of CRT glasses. The funnel and panel glasses of CRTs are hard to de-process. The methods in glass-to-glass recycling of waste CRT outlined by Materials for the Future Foundation (MFF, 2001) are:

- The separation of leaded from non–leaded glass can be achieved by using sensor–guided automatic sorting.
- Alternatively some plants separate the funnel and panel glass by sawing, by heating or by laser cutting prior to crushing. This produces high quality glass cullet for new CRTs.

CRT glass-to-glass recycling has been identified as an environmentally and economically sound approach to managing end-of-life CRTs because this option offers significant potential to reduce lead in landfills and incinerators without increasing the risk for significant lead releases in the environment. Furthermore this option recovers the resource value of specialty glasses and leads, reduces waste management costs, diminishes the demand for new lead in CRT glass manufacturing and lowers the energy consumption of CRT glass manufacturers. There are presently no cost–effective recycling procedures for the phosphorescent coatings which are usually washed–off. Consequently, they are disposed as hazardous waste.[17]

There are very few CRT furnace operators worldwide

There are very few CRT furnace operators worldwide: Samsung–Corning in Malaysia and Videocon in India. These furnace operators re–melt the leaded glass in a furnace and mold new funnels – either for their own assembly process or for sale to other CRT manufacturers.[18] Nevertheless, due to decreasing demand of CRT in near future, no company would be using it for manufacturing process anymore because of the following factors:

- The sheer quantity of glass is already higher than demand.
- The introduction of flat screen technology is creating a declining market for CRTs, leaving a glut of leaded glass that needs to be treated.

Open-Loop Recycling

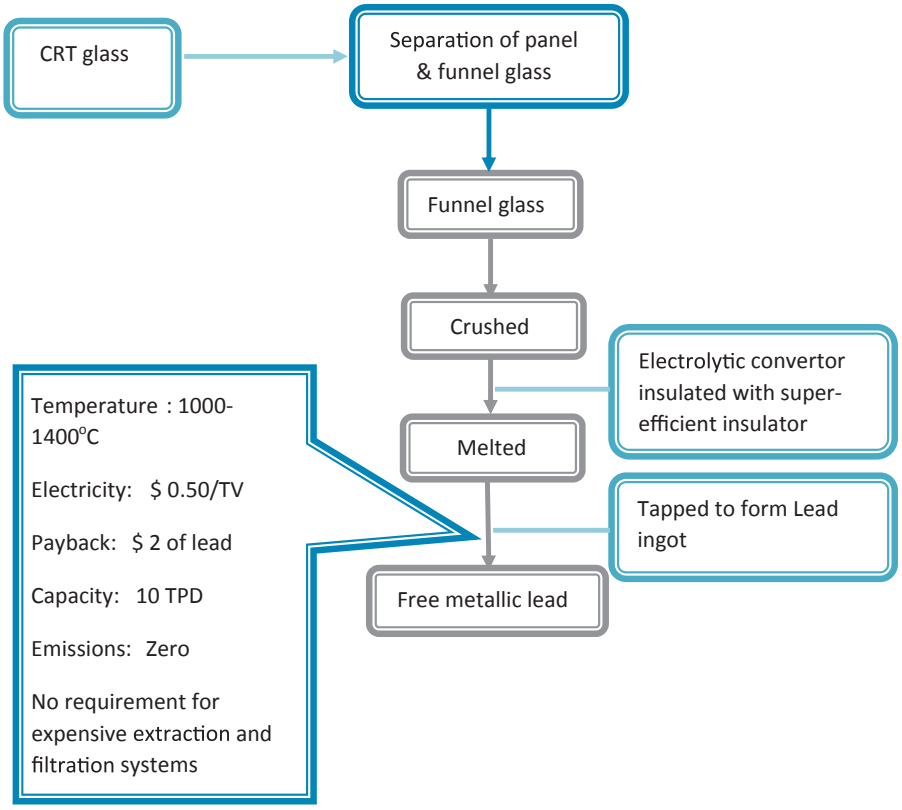
This recycling route uses CRT glass in materials or processes other than CRT manufacturing.

17 IC, Nnoroma,*, O, Osibanjob,1, MOC, Ogwuegbua. Global disposal strategies for waste cathode ray tubes.

18 Rodgers, M, 2010. CRT glass: What's all the fuss about, ECS Refining, viewed on 20 July 2012.

In most cases, the glass materials are used in primary or secondary lead smelters as a substitute for raw materials or fluxing agents. A typical example in this recycling option is where CRT glass is re–melted for its silica and lead content during some lead manufacturing processes. In this glass-to-lead recycling process, metallic lead and copper are separated and recovered from CRT glass through a smelting process. CRT glasses behave as a fluxing agent in this. Many lead extraction methods, such as pyro–vacuum process, mechanical activation, etc. has not been industrialized yet.

FIGURE 11: Flow diagram of CRT glass recycling



Industrial open–loop glass recycling is complicated because CRT glass chemistry varies by manufacturer and time period. The compositional information of CRTs is still treated as a trade secret. This makes it difficult to provide raw glass of tightly controlled quality. Though there are industrial glasses that share many of the same oxides as CRT glass, none of them share all the same oxides thus limiting the potential to reuse applications. Presence of lead can also ruin a non–leaded glass furnace.[19]

A recent entrant in this field with facility in the UK and the US[20] claims to have developed a solution to separate lead from funnel glass using a highly efficient electric furnace and

19 Julia R, Mueller, Michael W, Boehm, Charles Drummond. Direction of CRT waste glass processing: Electronics recycling industry communication.

20 http://www.nulifeglass.com/

a combination of chemicals that produces both clean glass and lead. According to the company, the process has no emissions and creates no waste. The flow diagram of the process employed by them is as shown in Figure 11.

The company claims to recover 98%+ pure lead with the recovered glass having been approved by UK Environment Agency as a recovered product. It claims to be the most advanced CRT recycling plant in the world and the only active industrial scale process to recycle leaded glass.

Another company in the UK[21] has developed and applied a process for the removal of lead from funnel glass. In the facility, a furnace that works at 1200°C recovers lead from glass, with a capacity of 10 tons of funnel glass per day. Consequently, through smelting at high temperatures, lead is separated from glass and the glass recycled for different uses in the glass and ceramic industries.[22]

There have also been experiments to use the leaded glass in glass ceramics manufacture and in re–using lead–containing glass in the manufacturing of clay bricks and roof tiles. However, some of these potential applications that have been proposed are quite problematic or less attractive from a social–economic and environmental point of view.

21 http://www.sweepkuusakoski.co.uk/

22 Laura Rocchetti, Francesca Beolchini. Environmental burdens in the management of end-of-life cathode ray tubes, 2014.

5. Legal Framework

5.1 International Framework

Discarded CRT televisions and personal computer displays represent as much as 22% of Waste Electrical and Electronic Equipment (WEEE) by weight in Europe and 58% of regulated e-waste by weight in the United States.[23] Acknowledging the problem emerging from e-waste, various initiatives have been taken all over the world. The countries that have already implemented e-waste management, have done so based on a reverse logistic system or an Extended Producer Responsibility (EPR). EPR is defined by the Organization for Economic Cooperation and Development (OECD) as an environmental policy approach in which a producer's responsibility for a product is extended to the post–consumer stage. EPR is also defined as a policy principle extending the manufacturer's responsibilities to all phases of the product's lifecycle, especially to the take–back, recovery and final disposal. A policy based on the EPR principle has two main purposes – to transfer the responsibility of managing the waste from municipalities to industries, and to encourage the development of more sustainable products and more cost–effective recovery processes because producers will try to reduce the cost of this waste management.

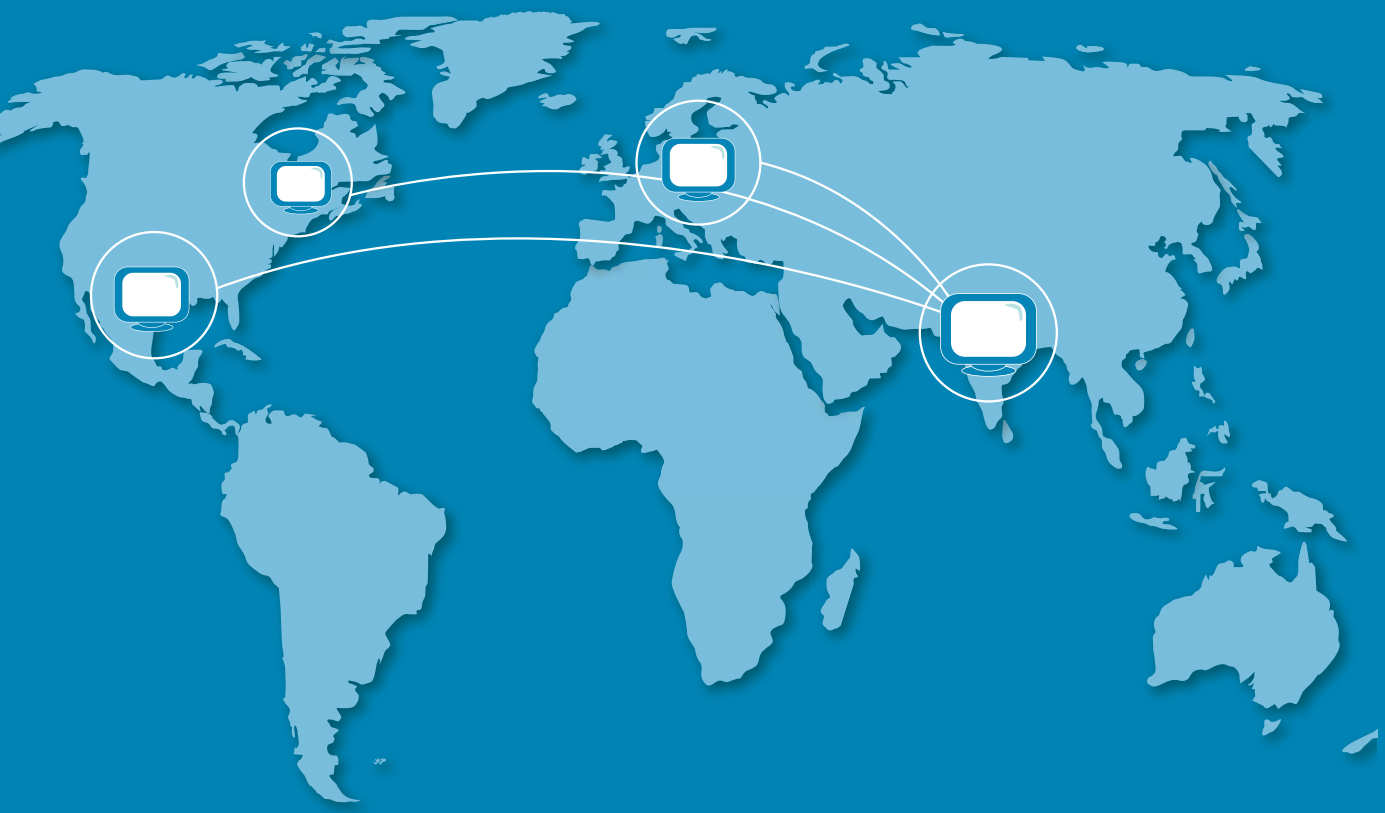
In the legal frameworks, the one by European Union (EU) probably is one of the most significant one. European Union came out with two directives – one regarding end-of-life management of WEEE (WEEE Directive) and the other restricting the use of hazardous substances in EEE (RoHS Directive). Under WEEE Directive, the established target recycling rate for CRTs is 70.[24] Some of the other global legal initiatives are as follows:

- In response to the threats posed by CRT funnel glass waste stream, several states in the US including California, Florida, Minnesota and Massachusetts have established regulations to categorize CRT funnel glass as hazardous waste. States like Massachusetts, California and Florida, etc. have banned the disposal of CRTs in the landfill and their incineration.
- Japan has two laws in place to alleviate the issue of landfill and e-waste. The first law is called as the Law for the Promotion of Effective Utilization of Resources (LPUR) which encourages manufacturers to voluntarily help recycle goods and reduce the generation of waste. The second law, called the Law for the Recycling of Specified Kinds of Home Appliances (LRHA), imposes more requirements on the recycling efforts of both consumers and manufacturers of home appliances. For CRTs, Japan achieved 78% recycling rate in 2004.[25]

23 WY, Yuan, JH, Li, QW, Zhang, F, Saito, Innovated application of mechanical activation to separate lead from scrap cathode ray tube funnel glass, 2012.

24 Nnorom, IC, Osibanjo, O, Ogwuegbu, MOC, 2010. 'Global Disposal Strategies for Waste Cathode Ray Tubes', Elsevier, pp. 275-290.

25 Sasaki, K, 2004. 'Examining the Waste from Electrical and Electronic Equipment Management Systems', Lunds University.



India

is still the destination for large proportion of CRT shipments from developed countries.

Trans-Boundary Movement of CRT and Basel Convention

An international treaty, known as the Basel Convention on the Control of Trans–boundary Movement of Hazardous Wastes and Their Disposal, came into force on May 5, 1992. In 1994 a total ban was agreed upon, which prohibited the export of all hazardous waste from rich to poor countries for any purpose, including recycling. The signing countries were also obligated to deal with their e-waste problems within national borders, regardless of the level of waste management technology in the importing country (Basel Convention, 2011). However, the USA being the world's largest e-waste producer has not approved either the Basel Convention or the Basel Ban Amendment, whereby the export of e-waste is very much a part of their disposal strategy. Currently, it is legal under the US law to export all forms of e-waste (including color CRTs, which are listed as hazardous waste by the USEPA) as long as recycling, and not disposal, is the objective.

... it is legal under US law to export all forms of e-waste

CRT and leaded glass cullet are specifically listed in the Basel Convention as globally regulated waste. Practice of export of CRT is illegal under the Basel Convention. Ironically, e-waste management in developed countries includes transporting these wastes into the developing nations and reports suggest that CRTs are regularly exported.

The increase in policies and legislation around the globe restricting or banning some disposal options (especially land filling) for CRT waste have increased the disposal cost significantly. This has also been driving the trans–boundary movement of this category of hazardous wastes.

5.2 Indian Framework

In 2011, India came out with E-waste (Management & Handling) Rules which became effective in May 2012. As per the rules, e-waste should be handled in environmentally sound ways with the producers being made responsible for managing the waste arising from their products (EPR). All units, which process e-waste, need to seek authorization from the State Pollution Control Board where the units are located. CRT comes under the purview of the rules as television and computer are both covered under Schedule I of the aforementioned rules.

CRT is also covered under the Hazardous Waste (Management and Handling Rules, 2008) Schedule IV, where hazardous waste requiring registering for recycling or reprocessing is listed along with "glass cullet from cathode ray tubes".

Schedule III, which lists down hazardous waste applicable for Import with Prior Informed Consent (taken from Annex VIII IX of Basel Convention) also includes activated glass cullet from cathode ray tube (A1180). India is a signatory to the Basel Convention.

6. Conclusion

With rapid advancement in technology, demand for CRT has been reducing drastically. Shift to new display technologies has also driven the increase in CRT device retirement. These coupled trends directly question the ongoing viability of the environmentally preferred material recovery pathway –the reuse of CRT cullet into making new CRTs. Managing discarded CRT has become a daunting task as it is one of the most challenging factions of e-waste. Though CRT was one of the most innovative inventions of its time, its disposal has been subject of many researches and a cause of concern for policymakers around the world. Globally there are at least 1.9 billion CRTs still in use so this is a waste stream that is going to remain an issue for many years to come[26] and, hence, needs to be addressed.

The CRT mixed glass is used to make new products like bottles, marbles, and decorative pieces, hence reaching us without any warning.

Due to heavy metal content like lead, strontium and phosphor, CRTs, especially the glass, are considered to be extremely hazardous. CRT glass, if it goes into landfill, would lead to leaching of lead and in turn pollute the ground water and soil. Presence of lead in water or soil could lead to contamination of the food chain and, hence, affect the human health. Lead, as is well known, interferes with a variety of body processes and is toxic to many organs and tissues including the heart, bones, intestines, kidneys, and reproductive and nervous systems. It affects development of the nervous system and is therefore particularly toxic to children, potentially causing permanent learning and behavior disorders. CRT glass thus poses a serious threat to not only the environment but also to human health.

CRT glass can be categorized into leaded glass and non–leaded glass. Sometimes this is referred to as “funnel glass” and “panel glass”, but such classifications can be misleading since a portion of panel glass also contains lead. The ability to effectively identify, separate, characterize, and process CRT glass will be critical to future management options.

In India, the use of CRT is on the decline thereby creating mounts of this toxic waste. With the closed–loop recycling of CRT glass losing its market, managing CRT glass in a sound manner is becoming a challenge. Increasing imports are adding to the pressure of environmentally safe management of CRTs in a country like India, where the recycling practices are not very streamlined. The flow of e-waste to the developing countries are motivated by the economic dynamics of market forces. The people of poorer regions are being subjected to a life of poverty as well as being exposed to

26 http://www.nulifeglass.com/uk-crt-tv-television-computer-screen-recycling-process/safely-recycling-crts-tv-screen-computer-monitors.htm

poisonous substances. The import data as well as several reports indicate that India is being burdened with this toxic glass from all over the world. With no proper technology in sight, CRT glass ends up being processed in crude ways.

Like most other e-waste processing in India, end-of-life CRT is also managed by a well networked unorganized sector. The workers handling CRT glass are completely ignorant of the material hazard and the risk of exposure. Their work environment is very unhygienic and they don't even use basic protective gears like gloves and mask. Our study did indicate that during crushing, grinding and melting, lead could be released in different forms which directly or indirectly could affect their health.

Apart from the occupational hazard and environmental pollution, the study points towards an often ignored issue in the country – the problems of cross contamination. This study shows that CRT glass, a major part of which is lead, gets mixed with other clean glass thereby contaminating the glass chain. The mixed glass is used to make new products like bottles, marbles, and decorative pieces, hence reaching us without any warning.

CRT glass recycling in India is a grave issue requiring immediate attention. Though it is covered under the E-waste Rules and Hazardous waste Rules, considerable efforts need to be done to ensure that it is managed safely and does not end up poisoning us.

6.1 Future Scope of the Study and Key Recommendations

The report does suggest the need to conduct more extensive study to understand the flow of CRT glass, recycling issues and workers engagement in the whole process. The issue of cross contamination needs to be studied in depth, especially to understand the risk of leaching and exposure from the recycled glass products.

Case studies of various countries need to be considered for best practices in the form of technology innovation so that it can be replicated in India. This is extremely important as the most favored option till date – closed-loop recycling – is no longer a viable option.

There is also an urgent need for the global fraternity to look at the reality of the trans–boundary movement of this hazardous waste and its implications. Stricter monitoring is required to ensure that the toxic waste burden is not shifted to countries where it ends up causing greater damage.

Key Recommendations

- ***Policy:*** CRTs, coming from computers and televisions, are covered under the E-waste Management and Handling Rules, 2011, whereby the Producers or the brands are responsible for managing the waste from their products. But a large faction of CRT waste might be falling under the definitions of orphaned or historical waste. The government may need to come up with defined systems to manage these.
- ***Research:*** Facilitation of research studies by government departments and institutions need to come up on CRT glass recycling and its effects on the environment as well as the health and safety of workers.
- ***Infrastructure:*** There is an urgent need to research and bring in technology to separate lead from glass and understand the economic viability of doing so. This will ensure that our landfills are not filled with leaded glass and our products are safer.
- ***Channels:*** Downstream monitoring, proper recycling and monitoring channels need to ensure that there is no cross contamination of CRT glass with normal glass. The government also needs to play a major role in ensuring this. Recycling companies and the Producers can be asked to provide in depth information of the downstream management of CRT glass.
- ***Standards:*** Glass products should be mandated to have low lead levels.
- ***Imports:*** There must be stricter monitoring of the import of CRTs to the country to ensure that India is not left with all the leaded CRT glass of the world.

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