Mercury in e-waste

Environmentally unsound disposal

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The generation of electric and electronic waste (e-waste) has been increasing because of the heavy worldwide use of information technology. Much of this e-waste is transferred from developed countries to developing countries as second-hand products. While the recycling industry in developing countries is very active, there also exists an informal recycling industry, which focuses on e-waste and other wastes. Unfortunately some of this e-waste contains mercury or mercury compounds. This mercury is released into the environment because of the crude, environmentally unsound processing methods of the informal sector. In addition, the recyclers themselves face the possibility of mercury exposure. Environmentally sound management for e-waste implies that developing countries should involve the informal recycling industry because the latter plays an important part in waste management.

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Introduction

There are several definitions of "waste". The most common definition refers to unwanted materials or substances that are left after people have used the main product. However, the implication and recognition of this definition are different in diferent countries, depending on whether they are developing or developed countries.

People in developing countries tend to distinguish wastes acording to whether or not a product, material or substance is still possible to be reused or recycled. On the other hand, people in developed countries tend to distinguish wastes according to whether or not a product, material or substance properly functions or has become obsolete. This difference in perception of waste between developing and developed countries is one of the factors that cause a trans-boundary movement of recyclable and reusable waste from developed countries to developing countries. One of the main wastes, which are considered wastes in developed countries and not considered wastes in developing countries, is electric and electronic waste (e-waste).

Informal recycling industry

The recycling industry has a long history and plays an important part in waste management in both developed

and developing countries. It tends to gravitate to small business in developing countries but to large business in developed countries. In developed countries the recycling industry tends to be legalized or controlled by a public sector. In many others, particularly developing countries, however, it is still not controlled by any legal system and instead is fully established as an informal sector. This fact can no longer be ignored as these countries strive to develop environmentally sound management systems.

The informal recycling sector deals with various kinds of hazardous wastes and other wastes in an environmentally unsound manner. Every process of collection, treatment and disposal is likely to cause adverse effects on human health and the environment, as a result of such wastes, especially due to chemicals contained in new or obsolete products. Of these wastes, e-waste is one of the main wastes to which the informal sector is attracted.

The current information technology society has given a momentum to the recycling industry, particularly the informal recycling industry in developing countries. The reasons are that electric and electronic equipment (EEE) has reusable and recyclable potential even after its first (or even second) life has ended.

Also, used EEE is a main product for most people living in developing countries because they cannot afford to buy new EEE. In addition, obsolete EEE, particularly used computers in developed countries, attracts the informal recycling industry, because a past life span as brand-new computers is relatively short, such as 2-5 years, in developed countries and these computers are still capable of working properly.

Furthermore, the recycling cost of obsolete EEE in developing countries is much less than that in developed countries (about one tenth). This is why an international movement of used EEE is very active from developed countries to developing countries.

Generally, many informal sectors exist in developing countries. There are several informal recycling sectors in Guiyu (China), Mumbai (India), Delhi (India), Dhaka (Bangladesh) and Karachi (Pakistan) in Asia.[1] Of these cities, the total population of Mumbai, Delhi, Dhaka and Karachi each exceeds 10 million.[2] It is said that about 20-50 per cent of the total population in each of these megacities live in unauthorized colonies or slum settlements.[3, 4, 5]

Although people living in those areas are a significant part of the urban working population in their cities, some of them work as the informal recycling sectors in their dwelling areas and establish informal recycling complexes by gathering a number of small recycling workshops, such as Dharavi in Mumbai. Thus, many informal recycling industries are in slums where hygiene and living conditions are poor.

E-waste and mercury

EEE consists of various kinds of chemical materials, including hazardous and non-hazardous chemicals. EEE using mercury accounts for 26 categories at least and includes audio equipment, laptops or notebook computers, telephones, DVD players, fax machines, photocopiers, products containing liquid crystal display (LCD), and so on.[6]

Mercury in the EEE is contained in LCD backlights, lamp components, display panels and so on. Although the amount of mercury contained in each unit of EEE is at a low level (about 2-10 mg per equipment), it is estimated that all the mercury annually used in EEE accounts for about 22 per cent of the world mercury consumption, thanks to current lifestyles that excessively use EEE.[7]

In many countries, particularly developed countries, mercury usage in EEE is tending to be phased out due to the current environmental awareness against hazardous chemicals used in EEE. Producers of EEE try to technically reduce the amount of mercury in EEE as low as possible, or to use alternatives instead of mercury to manufacture EEE. In addition, they promote consumers to buy environmentally friendly EEE, which is free of hazardous chemicals. This implies, however, that the amount of obsolete EEE containing trace quantities of mercury would keep increasing.

In developing countries, producers of EEE containing mercury seem to do very little to reduce the amount of mercury in the EEE, or to phase out the mercury used in the EEE, because there is less opportunity for them to know that mercury has the potential to cause adverse effects to human health and the environment.

Some EEE containing mercury, such as fluorescent lamps, has practically no mercury-free alternatives. Some countries, mainly developed countries, set the maximum level that mercury can be used in EEE and allow some EEE to contain as little mercury as possible. Nevertheless, the amount of e-waste containing mercury tends to increase in both developed and developing countries as a consequences of the current EEE containing mercury.[8]

The mercury contained in EEE in terms of its chemical properties (Box 1) holds the potential to cause adverse effects on human health and the environment if the EEE is dealt with in an environmentally unsound manner. According to reports,[9, 10] several workshops in the informal recycling industry deal with used parts, such as LCD backlight and lighting products, dissembled from used EEE and similar products, including fluorescent lamps, and the working conditions in the workshops are environmentally unsound. For example, a workshop dealing with used fluorescent lamps is not equipped with a ventilation system, including windows, despite the fact that broken fluorescent lamps are scattered on the floor. It can be concluded that mercury contained in the used EEE in the informal recycling industry escapes to the environment.

This article explains the current situation and the environmental and health concerns of e-waste containing mercury in the informal recycling sector. It also discusses an ESM of e-waste in the informal recycling industry.

Current issues to deal with

Overall issue of e-waste

E-waste and other waste management in most developing countries tends to

Box 1: General information on Mercury (UNEP 2002[27]; WHO 1991[14]; 2003[15])

Mercury is a metallic element that occurs naturally in the environment. It has been used by various industries for many years to manufacture chemicals or as a catalyst for chemical processes because of its unique characteristics. Some of the parts of EEE function by utilizing some characteristics of mercury.

There are three primary categories of mercury and its compounds: elemental mercury, which may occur in both liquid and gaseous states; inorganic mercury compounds, including mercurous chloride, mercuric chloride, mercuric acetate, and mercuric sulphide; and organic mercury compounds. The characteristics of mercury are unique that mercury exists as liquid at normal temperature and pressure and transforms into the vapour at 0.3 Pa, 25°C. Elemental mercury is the most volatile form of mercury. Mercury vapours are colourless and odourless. The higher the temperature, the more vapours are released from liquid elemental mercury.

heavily rely on the informal sector, even though a legal framework and management system may exist. The reasons are that a legal system is not fully implemented by the authorities; and scavenging waste is work that people in poor communities can easily start. Usable or recyclable wastes attract these people to collect, repair, refurbish and remodel for reselling as second-hand products, which are main consumer products in many developing countries.

The informal sector is generally recognized as a key and legitimate actor in e-waste and other waste management in many developing countries. A collection system of e-waste and other wastes, particularly reusable and recyclable wastes, is well established among informal collectors throughout communities, cities or countries; and the informal collectors are supposed to bring these wastes to informal recyclers, repair or second-hand shops.[11] In this collection mechanism, the collectors are also "traders", because they buy reusable and recyclable wastes from end-users and sell the goods to recyclers. They also go to end-users' homes on request, and frequently roam around communities, to collect wastes, and thus provide a convenience for end-users to discharge or sell obsolete EEE.

These countries hardly have recyclers or environmentally sound facilities. Here "environmentally sound" may refer to the disposal of non-reusable and recyclable wastes into landfill or open dumping sites because no other treatment method exists. Recyclers deal with obsolete EEE by reusing and recycling as much obsolete EEE as possible. This, however, is absolutely an environmentally unsound manner in terms of environmental and health concerns, disposal into landfills and open dumping sites, and other environments, such as river banks.

Issue of e-waste with mercury

Obsolete EEE containing mercury, such as fluorescent lamps, is one type of e-waste which informal collectors in developing countries target, despite the fact that earnings are less than for obsolete EEE such as used computers and TV sets. EEE containing mercury is collected by local collectors who collect various kinds of wastes throughout a country and sent to such recyclers, together with other wastes for further processing.

Fluorescent lamps, for example, are processed for reuse as follows:

- The end-caps of fluorescent lamps are removed;
- The glass tubes are washed with water and then dried;
- The removed end-caps are repaired if possible;
- New fluorescent lamps are remodelled by using washed glass tubes and the repaired or new end-caps; and
- A gas containing low pressure mercury vapour is filled in the fluorescent lamps. Although their recycling processes are the same as those of recyclers who operate in an environmentally sound manner under a regulation, they rely only on their skills to dismantle and remodel EEE and do not have any environmentally sound methods.

Obsolete EEE containing mercury which can no longer be reused or recycled is disposed of as any other municipal solid waste and mixed with other wastes in most developing countries,[12] because of the lack of awareness and the lack of a separation collection system, or the lack of facilities for EEE containing mercury. Such EEE ends up at landfill sites or open dumping sites, or is treated by incinerators or open burning. As a result, the mercury in the EEE is released into the environment. Mercury pollution is suspected around those sites because of mercury emission from EEE and other mercury wastes.[13, 14, 15]

Environment and health concerns

When EEE is disposed of in an environmentally unsound manner, the mercury contained in it is released into the environment because of its chemical properties. A gas containing low pressure mercury vapour in fluorescent lamps, for instance, escapes into the environment when fluorescent lamps are broken. The other occasions on which mercury leaks is when obsolete EEE is disposed of into landfills, or incinerated, or openly dumped into illegal dumping sites in an environmentally unsound manner.

Once mercury is released into the environment, it remains there permanently, changing its chemical forms depending on the environment (Figure 1). Mercury cannot be converted to a non-mercury compound. Thus, it can be hypothesized that mercury released from informal recycling sectors in an environmentally unsound manner is diffused throughout the environment.

If people inhale mercury vapour, approximately 80 per cent of it crosses the alveolar membrane and is rapidly absorbed into the blood.[16] Due to the high lipophilicity, elemental mercury vapour passes the blood-brain barrier and the placenta.[16] The WHO air quality guideline for mercury is 0.001 mg×Hg/m^3 (annual average).[17] The threshold limit value (TLV) for mercury vapour is 0.025 mg×Hg/m^3 for long-term exposure as the time weighted

average (TWA), which means the time weighted average concentration for a normal 8 hour-day and 40 hour-work-week.[18] The acute exposure limit for mercury vapour is 0.1 mg×Hg/m^3.[18]

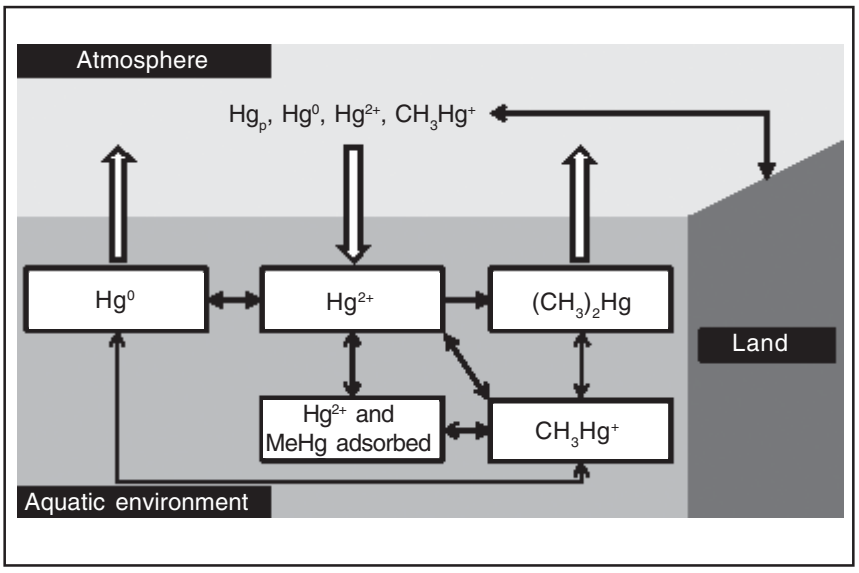
There is scientific evidence that mercury vapour in the fluorescent lamp industry has adverse effects on human health. For example, Feitosa-Santana *et al* reported that the urinary mercury concentrations of workers at a fluorescent lamp manufacturing unit during working (4-24.5) years ranged from 1.2 to 134.7 mg×Hg/g×creatinine. In contrast, the corresponding figure for the same workers after up to 1 year away from working ranged from <1 to 4.3 mg×Hg/g×creatinine).[19]

These concentrations can be calculated to 0.001-0.110 mg×Hg/m^3 as a mercury vapour concentration in a room, based on a ratio reported by Roels *et al*.[20] The workers showed health problems such as colour discrimination losses.[19] Similar research works reported other health problems, such as long-term effects on information processing and psychomotor function with increased depression and anxiety,[21] and deficits in short-term memory and mood.[22]

Another report describes the adverse effects to human health due to a domestic mercury exposure.[23] A 23-month-old toddler showed acrodynia, which is a type of mercury poisoning in children, characterized by pain and pink discoloration of the hands and feet. The toddler and family were exposed to mercury vapour because a carton of unopened 8-ft fluorescent lamps was broken in a potting shed adjacent to the main nursery where the children continued to play even after the accident. Mercury levels in the air in their rooms exceeded 0.025 mg×Hg/m^3, and mercury levels in the urine of the toddler and family ranged from 39 to 137 ng/ml, against an average of less than 10 ng/ml for the general population (Ministry of the Environment in Japan 2004).

Interestingly, only the toddler showed the acrodynia and no other family members showed symptoms at all, because early child development is sensitive to mercury vapour exposure. Although this is a very rare case, it warns us that children, particularly newborns and infants, are particularly under threat of mercury vapour exposure if they live near the informal recycling industry.

Figure 1: Dynamic interactions between various mercury species in the environment[2, 6, 11]



Note: MeHg: methylmercury; Hg_p: particle-bound mercury

Treuesdale *et al* estimated that mercury emissions from a fluorescent lamp after breakage were about 6.8 per cent of the total mercury content of each fluorescent lamp.[24] Another report describes mercury emissions from a fluorescent lamp after breakage to be from 1 to 1.2 per cent.[25] A workshop in the informal recycling sector uses a ratio of mercury emission due to breakage of a fluorescent lamp. Mercury concentration, *M*, immediately after breakage of fluorescent lamps is calculated by the following equation:

$$M = \frac{(Hg \times U) \times P}{V}$$

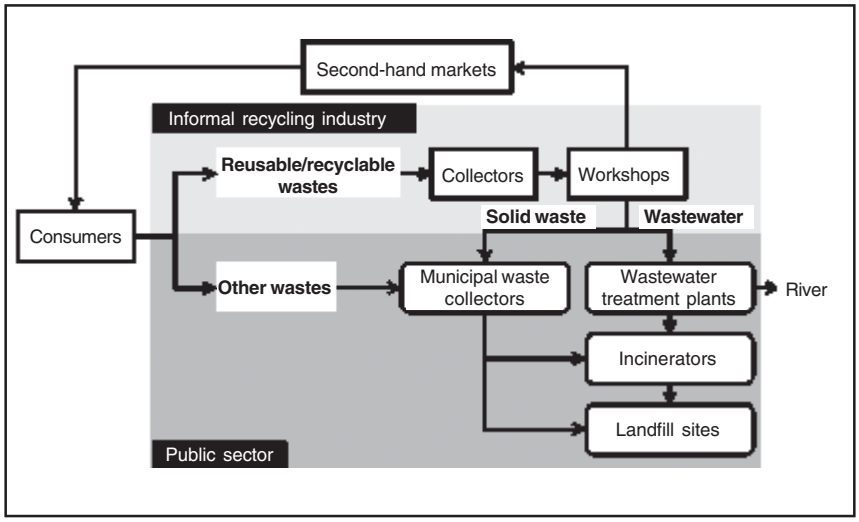
where *Hg* is mercury content in a fluorescent lamp, *U* is the number of fluorescent lamp units that are dealt with simultaneously or continuously, *P* is the percentage of mercury emissions from a fluorescent lamp, and *V* is the workshop volume. Taking into consideration a worst-possible-scenario in the informal recycling industry, a hypothesis used for calculation is that a workshop (100 m^3) with no ventilation (no windows) deals with used fluorescent lamps (20 mg×Hg/unit) for reusing, with a mercury emission percentage of 6.8. If two fluorescent lamps are dealt with simultaneously and the mercury vapour in the lamps escapes into the air, the concentration of mercury vapour is 0.027 mg×Hg/m^3, which slightly exceeds the TLV. Furthermore, it is reported that one-third of the mercury contained in a fluorescent lamp would be released during the first 8 hours after breakage.[26] Therefore, if ventilation is poor in a workshop dealing with used fluorescent lamps, recyclers and their family members inside the workshop would inhale mercury vapour and face possible occupational exposure to mercury vapour.

Solutions

E-waste in informal recycling

One of the ideal solutions is to follow the several success stories of how developed countries implement an environmentally sound management for e-waste. This is through the development of a public-private partnership under a legal framework as well as through investment in environmentally sound technologies. Another solution would be the technology transfer of environmentally sound technologies into countries where these technologies are lacking.

Figure 2: One of ideal frameworks to deal with e-waste involving the informal recycling sector



The most important factor, however, is awareness among people. Unfortunately, there is very little opportunity for the people working in the informal recycling industry to know that their environmentally unsound techniques might cause adverse effects to their health and environment. It is noted that access to education is very low for those people. This makes it more difficult to find educational opportunities or other jobs for family members. In addition, it is difficult for them to access social services, such as health care. Thus, on the one hand, people are susceptible to serious health problems caused by the environmentally unsound manner in which they deal with EEE; and, on the other, themselves cause various kinds of environmental pollution.

An ideal framework to deal with e-waste involves the informal recycling sector, which is a key actor (Figure 2). The informal recycling industry repairs, refurbishes and/or remodels EEE in their small workshops. Meanwhile, a waste collector, such as a municipal waste collector authorized by the public sector, collects other wastes that informal collectors do not collect, as well as wastes discharged from the informal recycling industry.

In addition, a public sector or other organization needs to regularly implement an environmental education programme or other related programmes, such as dissemination of publications and guidebooks, house-to-house visits, and so on, to people working in the informal recycling industry, and provide protective gear to them. Furthermore, the public sector and other organizations need to check the working environment of the informal recycling sector for occupational health concerns and direct the informal sectors to create better working environments. A public sector and/or other organization, such as international organizations and donors, have to invest in environmental infrastructure, such as wastewater treatment plants, landfill sites, and so on.

An informal recycling complex is generally not equipped with any wastewater treatment system and discharges wastewater containing hazardous chemicals directly into a river. It also disposes of wastes containing hazardous chemicals into a nearby environment, such as river banks.

If wastewater treatment facilities and landfill sites are invested in and managed by the authorities concerned, such as a public sector, these would at least prevent any environmental contamination due to discharge of wastewater and solid wastes from the informal recycling complex into the environment.

After this initial step it is time to consider how to develop a legally binding environmentally sound management of e-waste. The most important factor is to assist and support the informal recycling industry in order to utilize their recycling activities in an environmentally sound manner.

E-waste containing mercury

The simplest and easiest way to avoid mercury exposure is to use protective gears, such as masks (particulate respirators), goggles, gloves and protective clothing. The other way is to install a ventilation system or at least open windows during processing. However, it should be noted that mercury vapour would simply be released into the environment in this case. Although ideally there should be an advanced ventilation system, such as a fume hood equipped with an air control system, this would be a first step for the informal recycling industry to become "a formal recycling sector" under a legal framework and subsidized by a public sector.

International projects on mercury waste

As an international activity on mercury waste, the Secretariat of the Basel Convention (SBC), in cooperation with United Nations Environment Programme (UNEP) Chemicals, initiated the project on mercury waste.[27] In its first phase, it drafted technical guidelines on the environmentally sound management of mercury waste.[28] In addition, UNEP Chemicals initiated a voluntary mercury management programme as one of the UNEP global mercury partnership programmes (UNEP 2008).[29]

The issue of mercury waste is recognized globally, and global activities for an environmentally sound management of mercury waste are undertaken by intergovernmental organizations. It might be possible to develop and implement a project or related plan to implement an environmentally sound management of mercury waste and e-waste with intergovernmental organizations and other donors. Further research or projects on mercury and e-waste would be implemented.

Conclusion

With the speculation that mercury contained in e-waste is being released into the environment, the following conclusions have been reached:

- It is highly possible that mercury contained in e-waste is released to the environment because of the current environmentally unsound e-waste management mechanisms in most developing countries; and
- Recyclers in the informal recycling industry, dealing with e-waste containing mercury, seem to face a possibility of mercury vapour exposure due to their environmentally unsound techniques.

For an environmentally sound management of e-waste in the informal recycling industry, the following are suggested:

- Awareness-raising activities should be undertaken before the introduction of environmentally sound management and technologies implemented in other countries;
- It is important to coordinate between the informal recycling industry and a public sector in charge of a legal waste management; and
- A mechanism for waste management involving the informal recycling sector is that a public sector supports and assists the informal recycling industry towards an implementation of an environmentally sound manner, and minimizes various kinds of wastes discharged from the informal sector by the public sector.

Disclaimer

The opinions expressed in this article are the personal views of the authors based on the authors' research and experiences, and do not reflect any official views or policy of the organization for which the authors work.

References

1. Visvanathan, C. (2006). "Reduce, Reuse, Recycle - The 3Rs in South Asia, 3R South Asia Expert Workshop". Available at: http://www.iges.or.jp/en/ltp/pdf/activity08/02_visvanathan.pdf.
2. Institut National de la Statistique et des Études Économiques (2005). "Population des Principales Unités Urbaines du Monde", Available at: http://www.insee.fr/fr/ffc/chifcle_fiche.asp?tab_id=19.
3. Forbes, D., Cutler, C. (2002), Karachi, in "Atras of The Megacities", Wien, Austria, GEOSPACE International GmbH, pp 145-149.
4. The Mega-Cities Project (2001), Mumbai (Bombay), India. Available at: http://www.megacitiesproject.org/network_mumbai.asp.
5. Vedeld, T., Siddham, A. (2002). "Livelihoods and Collective Action among Slum Dwellers in a Mega City (New Delhi)", IASCP Conference 2002, Available at: http://dlc.dlib.indiana.edu/archive/00000938/00/vedldt120402.pdf.
6. Electronic Industries Alliance (2005). "Consumer Product Mercury Information Sheet", Available at: www.eiae.org/chemicals/files/CEI_mercury.pdf.
7. Silicon Valley Toxics Coalition (2002). "Just say no to E-waste: Background Document on Hazards and Waste from Computers", Available at: http://svtc.igc.org/cleancc/pubs/sayno.htm.
8. United Nations University (UNU) (2008). "Review of Directive 2002/96 on Waste Electrical and Electronic Equipment", Available at: http://ec.europa.eu/environment/waste/weee/pdf/final_rep_unu.pdf.
9. McDougall. D. (2007). "Waste Not, Want Not in the £ 700 m slum", Available at: http://www.guardian.co.uk/environment/2007/mar/04/india.recycling.
10. Toguchi, A., Kojima, M. "Fluorescent Lamp Recycling in Dhaka (18 February 2007, Personal Communication)".
11. The Basel Convention Regional Centre in China (2005). "Survey of the Import and the Environmentally Sound Management of Electronic Wastes in the Asia-Pacific Region", Available at: http://www.basel.int/centers/proj_activ/stp_projects/01-02.pdf.
12. Honda, S. (2005). "Study on the Environmentally Sound Management of Hazardous Wastes and Other Wastes in the Asia", Tsinghua University, Beijing, P. R. China, Postdoctoral Dissertation.
13. Ding, Z. H., Tang, Q. H., Liu, C. E., Wang, W. H., Zhuang, M., Lin, Y. M. (2007). "Distribution and ecological effect of mercury in Laogang landfill", Shanghai, China, *Journal of Environmental Sciences* (China), Vol. 19, pp. 200-204.
14. Machado, W., Moscatelli, M., Rezende, L. G., Lacerda, L.D. (2002). "Mercury, Zinc, and Copper Accumulation in Mangrove Sediments Surrounding a Large Landfill in Southeast Brazil", *Environmental Pollution*, Vol. 120, pp. 455-461.
15. United Nations Environment programme (UNEP) (2007). "Environmental Pollution and Impacts on Public Health", Available at: http://www.unep.org/urban_environment/PDFs/DandoraWasteDump-Report Summary.pdf.
16. World Health Organization (WHO) (1991). "Environmental Health Criteria 118, Inorganic Mercury, International Programme on Chemical Safety", Available at: http://www.inchem.org/documents/ehc/ehc/ehc118.htm.
17. World Health Organization (WHO) (2003). "Elemental Mercury and Inorganic Mercury Compounds: Human Health Aspects", Concise International Chemical Assessment Document 50, Available at: http://www.inchem.org/documents/icads/icads/cicad50.htm.
18. International Labour Organization (ILO) (2004). "International Chemical Safety Cards - Mercury", Available at: http://www.ilo.org/public/english/protection/safework/cis/products/icsc/dtasht/_icsc00/icsc0056.pdf.
19. Feitosa-Santana, C., Costa, M. F., Lago, M., Ventura, D. F., (2007). "Long-term Loss of Color Vision after Exposure to Mercury Vapor", *Brazilian Journal of Medical and Biological Research*, Vol. 40, pp. 409-414.
20. Roels, H., Abdeladim, S., Ceulemans, E. (1987). "Relationships between the Concentrations of Mercury in Air and in Blood or Urine in Workers Exposed to Mercury Vapour", *The Annals of Occupational Hygiene*, Vol. 31, pp. 135-145.
21. Zachi, E. C., Ventura, D. F., Faria, M. A. M., Taub, A. (2007). "Neuropsychological Dysfunction related to Earlier Occupational Exposure to Mercury Vapor", *Brazilian Journal of Medical and Biological Research*.

22. Pressinger, R. W. (1997). "Mercury Exposure During Pregnancy", Available at: http://www.chem-tox.com/pregnancy/mercury.htm.
23. Tunnessen, W. W. Jr., Macmahon, K. J., Baser, M. (1987). "Acrodynia: Exposure to Mercury from Fluorescent Light Bulbs", *Pediatrics*, Vol. 79, pp. 786-789.
24. Truesdale, R. S., Beaulieu, S. M., Pierson, T.K. (1992). "Management of Used Fluorescent Lamps - Preliminary Risk Assessment", Available at: www.p2pays.org/ref/23/22634.pdf.
25. U. S. Environmental Protection Agency (US EPA) (1998). "Mercury Emissions from the Disposal of Fluorescent Lamps", Available at: www.p2pays.org/ref per cent5C06/05620.pdf.
26. Aucott, M., Mclinden, M., Winka, M., (2004). "Release of Mercury from Broken Fluorescent Bulbs", Available at: www.state.nj.us/dep/dsr/research/mercury-bulbs.pdf.
27. Secretariat of the Basel Convention (SBC) (2006). "Decision VIII/33 - Report of the Conference of the Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal on its eighth meeting", Available at: http://www.basel.int/meetings/cop/cop8/docs/16eREISSUED.pdf.
28. Secretariat of the Basel Convention (SBC) (2007). "Draft Technical Guidelines on the Environmentally Sound Management of Mercury Waste", Available at: http://www.basel.int/techmatters/mercury/guidelines/301007.doc.
29. United Nations Environment Programme (UNEP) (2008). "Draft Business Plan of the Proposed Mercury Waste Management Partnership Area - UNEP(DTIE)/Hg/Partnership.1/INF.6", Available at: http://www.chem.unep.ch/mercury/UGMP/INF per cent206.doc.
30. Beijer, K., Jernelov, J. (1979). "Methylation of Mercury in Aquatic Environments" in *The Biogeochemistry of Mercury in the Environment. J. O. Nriagu*, Amsterdam, The Netherland, Elsevier, North-Holland Biomedical Press, pp. 176-202.
31. Fitzgerald, W. F., Mason, R. P. (1997). "Biogeochemical Cycling of Mercury in the Marine Environment" in *Metal Ions in Biological Systems*, A. Sigel, Sigel, H. New York, USA, Marcel Dekker, Inc., pp. 53-111.
32. Lamborg, C. H., Fizgerald, W. F., O'Donnell, J., Torgersen, T. (2002). "A Non-Steady-State Compartmental Model of Global-Scale Mercury Biogeochemistry with Interhemispheric Atmospheric Gradients", *Geochimica et Cosmochimica Acta*, Vol. 66, pp. 1105-1118.
33. United Nations Environment Programme (UNEP) (2002). "Global Mercury Assessment", Available at: http://www.chem.unep.ch/mercury/Report/Final per cent20report/final-assessment-report-25nov02.pdf. ❐

Partnership for Action on Computing Equipment

The Basel Convention has launched the Partnership for Action on Computing Equipment (PACE) initiative to tackle the management of obsolete and used computers. The launch of PACE is one of the outcomes of the ninth meeting of the Conference of the Parties to the Basel Convention.

PACE brings together the Secretariat of the Basel Convention, industry (through several industry associations) and civil society to establish methods to divert used and obsolete computers away from land disposal and burning into commercial recovery operations. PACE will also develop technical guidelines for proper repair, refurbishing and recycling, including criteria for testing, labeling of refurbished computing equipment and certification of environmentally sound repair, refurbishment and recycling facilities. The activities undertaken through PACE will offer expert advice, guidance and networking to support and build confidence in sustainable commercial practices with social, economic and environmental benefits to all participants.

PACE provides a forum for governments, industry leaders, non-governmental organizations and academia to improve the current management of used and end-of-life computing equipment through the development of global recycling and refurbishment guidelines on the environmentally sound management of computing equipment, in addition to other tools and activities.

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