2017

E-Waste: Prevention Intervention Strategies Meeting 2017

November 17, 2017 |New Delhi, India *Summary*

Contents

Glossary

CRT:	Cathode Ray Tube
EEE:	Electrical and Electronic Equipment
IT:	Information Technology
LMIC:	Low and Middle-Income Country
PBDE:	Polybrominated Diphenyl Ethers
PPE:	Personal Protective Equipment
PAH:	Polycyclic Aromatic Hydrocarbon
POP:	Persistent Organic Pollutants
PRO:	Producer Responsibility Organization
WEEE:	Waste Electrical and Electronic Equipment[1]

Basel Convention: The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal

Stockholm Convention: The Stockholm Convention on Persistent Organic Pollutants

Participants from Africa, South America, Asia and the U.S. posed for a pre-meeting photo [Courtesy Kwadwo Ansong Asante]

[1] In this summary, WEEE, EEE and e-waste are used interchangeably based on the presenter. Formal meaning in national policies can vary.

Welcome

Michelle Heacock, Ph.D. and Brittany Trottier, M.P.H. (NIEHS)

NIEHS shared a video that was created about E-Waste to open the meeting.

Michelle Heacock welcomed attendees and provided an overview of the day's agenda. Brittany Trottier welcomed attendees and provide some housekeeping announcements. Attendees were provided a list of resources (citations) that speakers provided prior to the meeting and were invited to share additional resources.

NIEHS staff members welcomed attendees

A meeting report will be shared for comment by the end of December; comments are requested by January 31. Attendees were asked to volunteer to speak on a webinar.

The meeting book, attendees and a resource document provided to attendees is attached in the Appendix.

Session 1:

Aimin Chen, Ph.D. (University of Cincinnati) and Indah Salami, Ph.D. (Intitut Teknologi Banduang) introduced speakers in the first session.

"Reducing Exposures to Products of E-Waste Combustion at Agbogbloshie"

-Julius Fobil, Ph.D. (University of Ghana)

The Agbogbloshie E-Waste site is located in the Central Business District of Accra, Ghana. In 1994, the site was a small area for people fleeing violence in the North of the country. It has now become a massive waste recycling site. "Looking at the site today, the site is 'complete visual confusion'. It is hot, heat from the sun and it is a 'totally chaotic environment'."

Methods used to recycle equipment at the site include open burning, manual dismantling with a chisel and hammer and fabrication/molding into local stoves. Researchers have recorded multiple exposures to organics and metals.

Observed health outcomes near the site include: Respiratory tract infections, lower back pain, dizziness, and renal problems in children.

There are three different types of interventions that have been implemented at the site to reduce exposures:

1) Interventions to Reduce Exposures
    a. A cable stripping machine: The goal of the machine is to replace or substitute open burning with use of machines to strip off rubber coatings to allow copper wire to be cleaned.

b. The ”Best of 2 Worlds” Initiative, led by a German private company that focused on sustainable recycling of lead batteries
c. An internationally funded health intervention: A health post is being established to help address worker ailments and to provide safety training.
d. German-Ghana government partnership for institutional strengthening, which led to the Government of Ghana passing an E-Waste bill that aligns with the BASEL convention.

“Model methods are the ‘ideal’ for an intervention. Clean, safe e-waste recycling that is not harmful and that generates less products that effect environmental health are the goal.”

2) Interventions to Engage Stakeholders and Community

The research team at the University of Ghana and partners have begun an effort to engage the workers and surrounding community at Agbogbloshie to understand their concerns and needs and involve them in interventions and research. The partners brought in social scientists who helped engage the community. The goal was that the community sees the researchers as part of themselves, and as “people who will allow them (workers) to keep doing their work in a peaceful environment, so we (researchers) can keep doing our work.” Even among the stakeholders the research team heard many different views.

Having the community help inform research questions is important and can help inform future studies, particularly when bilateral donors ask ”what don’t we know about e-waste?”

“Clean, safe e-waste recycling that is not harmful and that generates less products that affect environmental health are the goal.”

3) Research Studies

The final intervention type remains research. The University of Ghana, with funding from the National Institute of Environmental Health Sciences, Fogarty International Center (FIC), and Canada’s International Development Research Center (IDRC) has partnered with the University of Michigan and McGill University, have established a GeoHealth Hub in Ghana that focuses on E-Waste. The research team works in both English and French ”which reflects the dynamic of the West Africa sub-region.”

The team has a cohort of e-waste recycling workers at Agbogbloshie and controls in the Accra suburbs and will conduct a longitudinal study with exposure monitoring to find evidence of exposure and associations related to e-waste recycling. The group aims to understand job-specific exposures and health risks, including lifetime cancer risks. The study will include seasonal (3 month and 6 month) and annual whole blood and urine sampling to screen for metals and organics, and personal air monitoring. The participants were issued a questionnaire about smoking, previous jobs etc.

"Hazardous Organic Pollutants Associated with Informal E-waste Recycling: An Emerging Issue for Environment and Public Health in India" – Paromita Chakraborty, Ph.D. (SRM Institute of Science and Technology and Water Advanced Research Innovation Fellow, University of Nebraska Lincoln)

PCBs are decreasing in US and Europe but increasing in developing nations and are compounds capable of long range atmospheric transport. India has a number of major e-waste recycling sites, many of which are processing domestically created waste. An estimated 20,000 workers in India work in the informal e-waste sector, and there has been limited research on bioavailability and risks to health from e-waste sites specifically in India.

There are multiple steps in the informal e-waste recycling process in Indian cities. Exposures vary by steps in the process, and understanding the process is critical to research. These steps include:

1. Dismantling: Shredding and crushing of items: leads to PCBs
2. Segregation: de-soldering of materials, separation of CRTs; leads to toxic metal exposure, PCB and PAH exposure
3. Pyrolysis process (burning); fine particulate exposure and fumes
4. Precious metal recovery: often includes the use of acids to recover gold and copper
5. Disposal/dumping: often includes burning of plastics and waste; leads to toxic metals, PCBs, and other exposures

Surveillance of informal sites is important because there are very few studies of bioavailability of chemicals and the risks to health from Indian e-waste sites. There are multiple types of studies and sampling methods being used to study contaminated sites including:

Air: There are two kinds of air sampling tools often used:

1) A high volume active air sampler
2) A simple, passive air sampler.

An early study of PCB's along coastal areas in India found that there are many urban sources of PCBs, but additionally high levels are found on the west coast of the country near ship-breaking industries.

A recent study from her group found that the maximum PCBs levels were in the informal recycling sites and open dumpsites of major cities in India. A follow up measurement of PBDE's found similar results, including a few notable urban "hot spots."

When analyzed for the type of recycling "phase" in the informal e-waste recycling sites, precious metal recovery sites had higher levels of PCBs, particularly highly toxic dioxin-like PCBs, compared to dismantling and shredding sites. Follow-up studies that aimed to understand if black carbon emissions

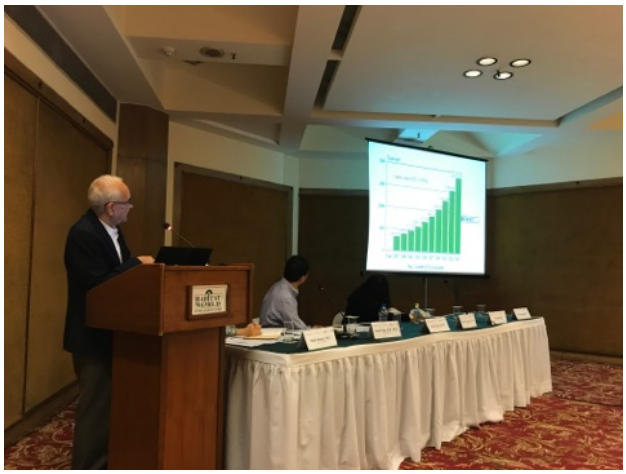
were to blame for elevated PAHs or if atmospheric movement was a factor showed that in fact the source of pollution at the sites was local. In addition, black carbon did not show any correlation with any of the analytes, thereby indicating emission of toxicants associated with e-waste recycling activity a.

Dust: A recent study from her group that included dust sampling, conducted at informal sites of Chennai, found that dust particle sizes in the metal recovery sites were less than 2.5µ, and were heavily loaded with toxic metals and PCBs. The most heavily contaminated dust was found in the informal e-waste recycling workshops compared to neighborhoods or industrial sites.

Soil: Soil studies from her group have found that informal recycling sites have high rates of PCBs, including dioxins. Metal recovery sites (where burning happens), are highly associated with PCBs and dioxins. Because plastic exterior components often make it to these sites and are then burned, high levels of BPA were also found.

Apart from surveillance of toxicants in different environmental matrices in India, Chakraborty's research group at SRM University has started a collaboration with industry called "wealth from waste." The goal is to create a profitable business that uses components of e-waste that would be burned. With her industry partner, Elvis Dsouza, from EDPC polymer industries, Chakraborty has published a patent on a polymer pencil made of reprocessed plastic.

"The Status of E-Waste Management in India" *–T.K. Joshi, M.B.B.S. (Faculty of Occupational Medicine, Royal College of Physicians, London)*



There have been many improvements and developments in environmental health in the past 5 years, but fewer in occupational health. There remains very little information on informal e-waste hazards. The past 10 years have seen changes in how e-waste enters each country. In India, e-waste mainly enters from Europe and North America, often via Delhi, leading to an abundance of informal recyclers in or near Delhi. There has been a rise in old mobile phones and computers and waste and thus an increase in e-waste generated in India. Maharashtra state and Tamil Nadu are the IT capitals of India and generate the most tons of waste per year. Estimates have found that only 3% of e-waste in India is processed by authorized recycling facilities.

New e-waste management rules were introduced in India in 2016. A major change was that compact fluorescent lamps were added to regulations, as they contain mercury. These rules are supposed to help stop diversion of e-waste to the informal sector. Many major recyclers are working under capacity and there is still diversion to the informal sector. These new rules are supposed to make manufacturers responsible for collecting the e-waste generated by their products and are aimed at preventing environmental contamination. Unfortunately, the Ministry of Environment and Climate Change has no jurisdiction over workers, and thus the new rule may not adequately address worker safety. The

Ministry of Labor has the power to declare hazards and thus require worker protection, but there are currently no occupational health and safety (OHS) regulations of recycling in the informal sector in India.

Recently, a formal Indian e-waste recycler was able to obtain both ISO 14001:2004 and OHSAS 18001:2007 certifications, and is a good example of "doing it right." The program includes training and biological monitoring for lead exposure in workers and is a model for the type of future the industry needs.

E-waste can be a profitable business and yet there is no other product that has all the heavy metals on the periodic table. Exposure can be classified into three sectors:

1. Formal
2. Informal
    1. Dismantlers: Those who unload, break, and separate equipment: at risk for dust, heat, and smoke
    2. Recyclers: Those who conduct furnace and chemical-related work to extract materials of value: Often at risk for chemical exposures, smoke, and fumes
3. Exposure to compounds remaining in the environment

Panel Discussion

Discussion

Interventions vary based on the setting, and care must be taken if assuming one intervention will work for every region or population. Recycling practices vary contextually, roles in the sector vary and the equipment being handled vary. It is critical that any intervention include the recyclers themselves because in the end "It is their livelihoods," and any proposed substitutes or alternative practices or methods must be a viable economic alternative to them. When considering replacement methods to reduce exposures the intervention must both reduce exposure and be acceptable to the recycler both for the cost to use/acquire. Improving health but not considering the economics or weaknesses of each intervention will not help because in the end, "recyclers are rational people" and will keep doing what they need to do to put food on the table.

Interventions must consider health, social factors, and economics, so economists, social scientists, and health professionals must all be involved in e-waste recycling change or even research. Social scientists can help understand community need, habits, different roles in the recycling industry, and how intervention teams can gain trust from communities. Inspectors and regulators even have a role in interventions as they can educate communities and help convey best practices. Community interventions should also include parents of children as they are often motivated to protect health and may be able to reduce children's exposure by limiting their time at recycling sites. Consumers too have a role as safe recycling practices and consumer driven demand for products influences waste.

Session 2:

William Suk, Ph.D. (NIEHS) and Poornima Prabhakaran, Ph.D. (PHFI) introduced speakers in the second session.

"E-waste Exposure in Uruguay: A Review. Update of Interventions and Environmental Challenges"

-Antonio Pascale, M.D. (University of the Oriental Republic of Uruguay)

E-waste in Latin America and Uruguay is a continuing problem. Brazil generates the most e-waste, but Chile and Uruguay generate the most per-capita. Uruguay has no specific legislation for e-waste, but there is a public framework for waste management.

There is a lack of adequate technology to manage e-waste in Uruguay. In 2007 Uruguay announced "Plan Ceibal": an effort to support technology in education programs which put one computer per child in schools. Through this effort, nearly 300,000 computers were delivered. This, however, led to high rates of disposal and waste, much of which was exported to USA, Belgium, Hong Kong, and Dubai.

Much of the informal e-waste recycling in Uruguay takes place in "asentamientos" (roughly meaning "Urban Settlements"), which have vulnerable populations, are filled with waste, and are high in lead pollution. In these areas, informal recycling activities take place in homes, streets, and common areas with "lots of dust." The settlements are scattered and difficult to measure in square Kilometers due to their small scale in multiple locations. They are "Microtoxic" spots and often include contaminated backyards, street corners etc. from the open burning. Common exposure scenarios include direct exposure from burning and dismantling, as well as indirect exposure from living in or around the contaminated soil, water, and trash. The main sources of lead in Uruguay are smelting, landfills, and informal e-waste recycling.

A team from the University of the Oriental Republic of Uruguay is leading a cohort study of lead exposure. The team has found interesting results, including:

- More than 45 cases in areas with a soil lead level exceeding 400mg/kg.
- 46% of studied children had blood lead levels above those recommended by CDC levels [5ug/dl]
    - Many of the highest levels were in the youngest children
- Research team found that open burning of cables is an important source of lead exposure
- Indirect exposure to e-waste is being found.

The team also published a study in 2016 that further explored cable burning and blood lead levels in children. The team found high soil lead levels and again, higher blood lead levels in younger people, indicating an indirect exposure to the e-waste.

A second study was organized by a team from GAHP, EU, UNDO, PureEarth, the Montevideo City Council, and the Pediatric Environmental Unit. The team looked at 135 settlements along the Pantanoso River Basin, which is home to more than 40,000 inhabitants in Montevideo. Many of the "microtoxic" e-waste sites are located along the Pantanoso. The team identified and remediated informal settlements and measured blood lead in children before and after the remediation. The average blood lead level in children on the sites was reduced by 3.18 ug/dl.

Environmental interventions seem effective in micro settlements and strategies to remediate them should continue. Some of the best practices include:

- Community engagement to raise awareness in vulnerable populations.
- The use of biomarkers for monitoring exposures is limited because there needs to be a study of the mixtures and not individual elements alone.
- Any intervention needs to address the social and economic situation of exposed populations.
    - Time and money are barriers to interventions.
    - In the "microsites" for informal recycling in Uruguay, something like a wire stripping machine is not practical because individual sites are doing multiple types of jobs.
    - The focus at small sites needs to be safer methods.
- It is important to remember that if we introduce safer methods, there must also be social benefits to the population beyond money. "If the only benefit is money, the people will stay there and maintain the unsafe activities."

"E-Waste Exposure in Children in Thailand And National Integrated E-waste Strategic Plan"

-Panida Navasumirit, PhD. (Chulabhorn Research Institute)

Trends of waste in Thailand reflect many global trends. The Pollution Control Department in Thailand has collected data on e-waste and projects a 10-20% increase in the coming years.

Major sources of e-waste in Thailand include industries, illegal importation of broken equipment, and household e-waste. Studies have found that the majority of Thai people discard electronics into the municipal waste stream. Another survey found that more than 50% of Thai people sell electronics to "junk shops," which leads to informal recycling.

The Pollution Control Department created the National Integrated WEE-Strategic Plan (2007-2011). The plan includes technology development, capacity building, law enforcement, etc. It acknowledges that waste management and recycling stops need to be improved. Efforts to address plan activities included a pilot "take-back program" to collect used electronics. Challenges to implementing the plan include a lack of awareness of hazardous substances, no separate collection system for electronic waste in local areas, low interest in private investment, and improper separation of e-waste. Phase II of the strategic plan covered 2012-2016 and included the establishment of an e-waste collection system, promotion of eco-design of products, development of an e-waste database for reporting and data collection as well as e-waste storage, collection, segregation, and transport for local governments. One element of the plan

included promoting public awareness of e-waste. A number of additional activities were proposed, including further support for green products, registration of importers of e-waste, and pilot projects related to collection, dismantling, and recycling of e-waste.

The Thailand Department of Disease Control estimates that there are more than 100 waste recycling communities in Thailand (Bangkok, Northeastern parts of Thailand). They use primitive methods.

A recent cohort study by CRI set out to understand children's exposure to e-waste. The study followed 50 students, aged 3-5 in two neighborhoods; One e-waste community in Bangkok and children attending a daycare surrounded by informal e-waste recycling were included. The control was another Bangkok community. All participants were given a questionnaire of socioeconomic status (SES), health conditions, and diet. Researchers took air samples and biological samples (nail, urine, saliva).

Study findings included increased PBDEs and PAHs in air at e-waste sites. Children in the e-waste area had elevated exposure to PAHs, and higher metal levels were seen (for all metals) in toenails and urine of e-waste children as well as increased oxidative DNA damage in urine and saliva of e-waste children.

"Consumers' Awareness and Disposal Behaviour of E-waste in the City of Bangalore"

-Anwesha Borthakur (Jawaharlal Nehru University)

E-waste research and handling in India is unique because SES and cultural factors all impact attitudes and practices. There is little reliable data in India about the amount of e-waste produced annually in the country. While the traditional definition of e-waste is that of the EU (to include multiple types of appliances etc.), the definition used in India only includes IT and telecommunication equipment and limited consumer equipment. This narrower definition makes comparing statistics with other countries challenging. Per capita generation of e-waste is low in India, but "we have a large population, so even if our per capita is low, the absolute total remains high."

A review of existing studies of e-waste specifically focused on India found a lack of studies on the public perception and awareness of e-waste and how socio-cultural factors shape perceptions and actions, with particular attention on disposal behavior. Year over year, the overall number of publications have increased, however the number of papers focused on awareness and disposal are low – only 1.6% of all those published.

A research project conducted by Borthakur into consumer perception of e-waste in Bangalore, India, found a number of useful and insightful responses. The study was a qualitative survey of both individual consumers and bulk consumers, including IT workers.

The study was conducted in Bangalore, India's IT hub, home to more than 1200 technology firms and the third largest producer of e-waste in India. Bangalore also has centers that handle domestically produced E-waste. Notable findings were that households in Bangalore had more unused mobile devices

in the home than actively used devices and that often the cost of repairs was cited as a reason to buy a new device. Many responders were willing to repair or recycle, but they didn't know where to formally recycle in Bangalore, despite Bangalore being a "pioneering" city in having authorized recycling centers. This shows a lack of information dissemination mechanism in the city toward ensuring responsible e-waste management practices.

Contrary to the popular belief or perception, individual respondents noted no significant desire for fancy brands and new gadgets as a reason to replace devices, while bulk purchasers noted that older hardware sometimes is not compatible (or large enough) to comply with storage/operating needs as updates are released. Disposal habits varied among respondents, with 32% reporting that they give their old devices to children, 19% sell to scrap dealers called "kabadiwalas" for financial gain, and some reported keeping products for their emotional attachment to them. Bulk Consumers/purchasers noted that un-released trial phones have to be disposed of to avoid duplication by a competitor. Firms that develop this type of technology destroy these devices.

These study findings are important because they help emphasize that "You can't copy and paste western regulations and put into the India context." Local specific e-waste policies are needed because of the national diversity in economic and cultural thoughts.

Panel Discussion:

The intervention discussed in Uruguay had an impressive decrease in blood lead levels due in part to indoor and outdoor remediation. Can it be sustainable to keep recycling in that environment?

> Outdoor remediation methods included cleanup activities removing contaminated soil and backfilling with clean fill. Other measures included education about hygienic clean up, dust removal, and encouraging families to spend time outside home. In some cases, the recommendation was to move the family, and if they didn't want to move, they were educated about hygienic measures mentioned below. Where there were improved blood lead levels, the family recycling activities were banned. While the study shows that a little environmental intervention could be effective, "We know that just physiologically, blood lead levels will decrease if you end exposures."

The group noted that thinking about the recycling of emerging devices such as car and large home batteries that are still new is very important because the devices will end up being recycled. A process to formalize recycling of these could be developed before the end of life of the device.

Improving Health Aspects of the E-Waste Recycling Chain

Deepali Sinha Khetriwal (Sofies)

Many recyclers don't make the connection between their job and health, but neither do the physicians and healthcare provides who may treat them. A survey from Sofies found anecdotal evidence of health impacts from informal recycling "hotspots" that included reports of dizziness, rash, poor diet, and injuries.

There are many steps in the recycling chain, and even before waste gets to recyclers it is handled by last mile collectors, aggregators, and dismantlers before actual recycling (material recovery). With each link in the chain, the hazards faced in completing the job increases.

Interventions can be at the policy level and local level. Moving policy making from the environment ministries to include policies in the health and labor ministries is an important step in changing high-level policy, while engagement with formal sector recyclers to encourage training, treatment, monitoring, and health programs can address local level behaviors. Increasing awareness in informal recyclers and targeted engagement with health providers, particularly in "hotspots" for informal recycling can help improve diagnosis and treatment of e-waste-related ailments.

Within India there are many relevant efforts that can and should include e-waste research or solutions. The Swaach Bharat and Smart City campaigns could be opportunities to tap into waste management funds as could the GIZ Programme on Resource Efficiency. UNIDO/GEF's Waste and Chemicals funding for POP prevention is provided as part of the Stockholm Convention but could be used to address POP exposures form e-waste recycling.

Behind all needed policies are data and harmonized research. A first step to harmonization includes identifying available information and indicators that can be used for monitoring, and evaluation of e-waste exposures and related health impacts. That can be followed by developing tools and building capacity for harmonized collection and reporting of e-waste exposure and health impacts, therefore building the basis for a model system for surveillance based on health facilities.

Session 3:

David Carpenter, M.D. (University at Albany) and Antonio Pascale, Ph.D. (University of the Oriental Republic of Uruguay) introduced speakers in the third session.

"E-waste Recycling and Exposure Reduction Intervention in the Philippines"

-Aimin Chen, Ph.D. (University of Cincinnati College of Medicine)

The Philippines per capita e-waste is low but increasing. Cellphones create the majority of domestically generated waste while Japan and Korea are major sources of imported e-waste. The Japan and Philippine Economic Partnership Agreement (JPEPA) allows Japanese export of e-waste.

The majority of recyclers in the Philippines are informal, and there are very few formal recyclers in the country. The Department of Environment and Natural Resources oversees existing guidelines on "Environmentally sound management of waste electrical and electronic equipment." Regulation began in 2013, however most recycling remains in the informal sector.

A significant difference between formal and informal sectors is the use of open burning and manual stripping in the informal sectors. These methods have a high environmental impact and often increase exposures. Multiple studies have found that open burning of

e-waste increases PAHs in soil. Very few studies however, have been conducted with recycling communities in the Philippines.

Medecins du Monde (MDM), a partner on a University of Cincinnati grant, and the team began a pilot intervention project in Manila in 2011. The project started with a needs assessment survey among recyclers to understand their knowledge of toxicants, PPE, and risks to pregnant women and children. They found very limited knowledge of all topics. MDM began the intervention in 2012 in four different urban areas covering approximately 800 informal e-waste dismantlers. The intervention also included training healthcare providers to understand related health issues, risks, and treatments.

The team found that some interventions were effective while others were not:

Effective interventions to reducing exposures included KAP interventions, site visits bringing informal recyclers to formal recycling sites, and disposal facilities and community clean-up drives. Healthcare providers gained ability to recognize poisoning cases and increased understanding of where to refer complex cases through a series of successful trainings. Less effective interventions included providing PPE because it created discomfort in hot climates. An attempt at introducing "safe dismantling areas" was not effective because the areas were reported to be "too isolated" from the recyclers' homes and community.

The team identified multiple opportunities for improving health and the environment related to e-waste in the Philippines. Reductions in exposure need to be measured and studied for clinical effectiveness as well as for duration of effectiveness; this an opportunity for researchers to be involved. Increased awareness is effective, and a future intervention using other NGO's, the government, and local engineers is possible. Local engineers can help engineer resources for pollution control and can help improve working conditions. Long-term interventions may include formalizing recycling centers, increasing local capacity to recycle cell phones, and continued clean-up of contaminated sites.

"Electronic Waste in Ghana and Interventions to Reduce its Impact on Human Health and Environment"

-Kwadwo Ansong Asante, D.Sc., (CSIR Water Research Institute, Ghana)

In Africa, Ghana and Nigeria are the "heavyweights" for e-waste recycling activities. The secondhand electronic import business is a booming informal economy with the majority of electronic equipment for recycling coming from North America and Europe. International aid sometimes includes electronic gifts (computers to schools, etc.) ,which adds to domestic waste at the end of their life.

The demand for EEE in Ghana continues to grow, and Ghana has a weak import scheme. Until recently, Ghana had no regulations on e-waste recycling. In 2016, a bill was passed on hazardous waste including e-waste activities that aims to internally align Ghana's policies with the Basel Cconvention. There is hope that the bill will allow further regulations and restrictions on hazardous waste in Ghana.

The most infamous recycling area in Ghana is the Agbogbloshie recycling area in Accra. The site is a 10+ block area with neighborhoods, vegetable markets, and local restaurants within the environs of the e-waste site. Free range cattle that roam the site will eventually end up very nearby, and occasional cattle roam the site before being sold as meat on the markets for food. Many phases of the recycling process take place at the site, including collection of materials, manual dismantling, burning, and disposal of burned materials.

In 2013, Agbogbloshie was listed among the top 10 most polluted places in the world. In Ghana, e-waste recyclers use primitive methods to remove plastic insulation from copper cables. This approach releases highly toxic metals, dioxins, and furans into the environment as revealed by some studies from Agbogbloshie. As a result of this, some attempts have been made to reduce the exposure. An effort by the Blacksmith Institute (now Pure Earth), with funding from the Nordic Fund, GIZ, and others aimed to eliminate burning, formalize business operations at the site, and enhance the value of copper recovery. Workers from the site were invited to a forum to help them understand the project goals and structure. Invited participants included members of the Greater Accra Scrap Dealers Association (GASDA). Part of the effort includes introducing new wire stripping equipment that can take the place of burning. GASDA members were taught how to operate the equipment and maintain it. The importance of feedback by end users was emphasized when local recyclers noted that while the equipment was effective in stripping the rubber and exposing copper, it was almost too effective: the usual practice of bending wire on the ground for final stripping (thus picking up dirt) was not needed, whichactually reduced the weight of wire (reimbursement for recovered wire is done by weight). Other users noted the machines were a bit slower than burning.

A new effort between GreenAd, Pure Earth, and GASDA included a health and safety awareness training that focused on raising awareness of the health effects of smoke and burning. Awareness activities include posters, T-shirts, a site walk-through, and free PPE.

GIZ has established a health post near the site to address issues and injuries recyclers receive while working. In another intervention at the site, a local consultant has started training mobile phone repairers on the proper dismantling and disposal of phones. It is expected that the passage of the Hazardous and Electronic Waste Control and Management Bill, 2016 (ACT 917), will lead to the establishment of a coordinated and formalized e-waste recycling/management system in Ghana.

"Prevention-Intervention Strategies to Reduce Exposure to E-Waste in Myanmar"

-Ohnmar May Tin Hlaing (Environmental Health Consultant, Myanmar)

E-waste is a daunting task, and Myanmar is at an early stage of addressing it, but is facing an increased need to do so, due to a growing middle class and increased new gadget use. Data on e-waste in Myanmar is limited, but data from the Step Initiative indicated that E-waste generation is estimated to be 0.4 kg/capita, and total generation is 29,000 tons per year in 2014. Most waste is from households (large appliances like a refrigerators), IT, and consumer equipment.

E-waste now is mostly unregulated, recycled in small workshops. There are not licensed recyclers; informal recyclers use burning, acids, and dismantling.

The National Environmental Policy is based on a 1994 policy and includes a national waste management strategy, policy framework, and action plans. The strategy has 5 goals that include extending sound waste management to eliminate uncontrolled treatment, reducing disposal and open burning, to establish resource circular society through 3R (reduce, reuse and recycle), an analysis of financing, awareness building, compliance, and enforcement. Currently the Ministry of Natural Resources and Environmental Conservation along with multiple stakeholders, including the UN Environment and the IGES (Institute for Global Environmental Strategies) are working on an updated National and City Level Waste Management Strategy and Action Plan which will include e-waste. Furthermore, a master plan for hazardous waste management is being developed by Myanmar - Norwegian Cooperation (NEA & SINTEF).

To inform the plan, a team is taking a baseline measurement of recycling sites in Yangon and seeking to understand e-waste issues to address. The team counted e-waste shops and types of devices they recycle in the greater Yangon area. They found 43 in the area, with a note about specific devices recycled or repaired, the metals recovered, and quantity of plastic/fiber and waste. Teams noted that air conditioner recyclers pick out iron and copper and dispose of circuit boards, while refrigerator and washing machine recyclers only dispose of unwanted foam. The team noted that many sites are located in homes or store back yards.

The team noted that research capacity for e-waste research is important but identified a number of challenges in Myanmar, including the instruments to measure many exposures may be limited and that many health professionals still need awareness on environmental health. An additional study of e-waste workers and physicians found that workers didn't know their disease could be related to waste, and doctors didn't know the connection. Information alone is unable to change the community's attitude and norms.

To address some of these challenges, the team has developed a primary school curriculum that includes discussions of waste management. The goal of the combined efforts described are to increase a precautionary approach toward exposure, especially in children, consideration for end-of-life management of devices, and improved health. Unprotected exposure to e-waste is not advisable for any individual as well.

"Profiling Potential Exposures and Health Risks in E-Waste Processing in Tamil Nadu: Updates on the Proposed Study"

-S.Sankar Ph.D. (Sri Ramachandra University)

E-waste is a modern hazard. The e-waste management plan for India was implemented in 2016. The legal framework for e-waste is complicated as is the structure of management of e-waste (e.g. transport from home to dump etc.). There are many gaps in current Indian regulations. Hazardous batteries are not covered in e-waste rules, and there are separate battery rules in the country; this however makes stakeholders confused as to which type of waste goes where. All mobile phones have batteries, so some people are unclear where they are supposed to be handled.

Transboundary rules are not strongly enforced for hazardous waste, and customs forms or importers are not always accurate. To formally import hazardous waste, the Ministry of Environment and Climate Change must grant permission. In addition, exposure monitoring for safety is intimidating to workers in the sector, and very few laboratories in the country have the capacity to handle samples.

To understand and change the sector, the many different stakeholders must be involved, but the complexity of the situation makes even stakeholder mapping challenging. Different buyers purchase and transport different materials, and the addition of informal scrap buyers and internet-based sellers with unclear or unsafe handling practices adds to the challenge.

To address some of these challenges, Sankar presented a framework that includes 4 elements. He noted that a multi-pronged approach is needed to address all the elements of the framework.

1. Anticipation: Many risks can be anticipated including the types of chemical exposures, characteristics of emissions, and exposure pathways and routes.
2. Recognition: Recognition of threats can be achieved by walkthroughs of sites and categorization of waste types. Interviews can help understand job profiles, and observations of conditions provide a wealth of knowledge of hazards.
3. Exposure Assessments such as taking air samples, measuring VOCs and PAHs, and collection of biological markers.
4. Control Strategies from the Hierarchy of Controls (Engineering, administrative, PPE, Training)

There exist hazard/risk/control tables that address job risks specific to the textile sector, and these could be applied to e-waste. Understanding the specific risks of each position with the recycling chain is important to addressing all the health and safety issues. He noted that any effort must include local stakeholders, be in a local language, and be created for the whole job chain, including supervisors, and employers, not just employees.

A team at Sri Ramachandra University is working with WHO to set up biological mercury in the country, and they hope to adapt the technology to the e-waste sector.

Panel Discussion

PPE distribution and proper use remains a challenge because workers find it uncomfortable, and burdensome, and it can slow the process of recovering materials. Consulting with workers to understand the features of PPE and types (gloves vs. masks) that are more or less usable was reported by attendees as one way to help improve PPE use.

Chair Re-Cap

Session 1 Recap

Aimin Chen, Ph.D. (University of Cincinnati) and Indah Salami, Ph.D. (Intitut Teknologi Banduang)

The e-waste experience in India is complex. There is formal recycling in the south, but it is underused in some areas, and there remain major occupational health issues and threats. Regulations, specifically for occupational safety in e-waste, are lacking

Based on examples from panelists, interventions for e-waste should:

- Include an emphasis on children's health
- Introduce sustainable technology that is environmentally friendly and economically viable
- Include efforts to formalize recycling
- Include education
- Involve industry collaboration for training, product design, and improvement and encouragement of PPE use
- Standardize analytical technology across research projects
- Address needed laws, regulations, and rules in each country
- Regulators should inform and advise the informal sector without invoking fear

Recommendations for community engagement and compliance with Interventions should:

- Involve social scientists and can even use social media
- Address consumer knowledge about hazards and practices for recycling e-waste
- Inform the community of chronic exposure risks and the potential impacts of mixture risks

Session 2 Recap

William Suk, Ph.D. (NIEHS) and Poornima Prabhakaran, Ph.D.(PHFI)

- There needs to be a better understanding of exposures linking to ill health/disease
    - This is hard to do, particularly with the chronic lag in exposures from e-waste
- Health should be the driving force in interventions, even when other forces (finance) are at work
- There needs to be a better link or "marriage" between those organizations and ministries that deal with the environment and those that deal with health.
- In some countries, there is a relationship between research and policy that leads to education and/or intervention. But policy has to have "teeth." Every country must have policies and regulations, and they need to be enforced.
- Studying the mixture of sources of e-waste exposure can help lead to a better understanding of mixtures and their health consequences.
- Where remediation its already happening, there needs to be cleaning of soil, and we need to get the tools to go in and remediate and mitigate the chemicals that are in the soil and groundwater in order to prevent further exposure.

- Electronic toys are becoming more and more popular, and more and more electronic. Is that because there is an assumption that because it's a small number of items, that children are not exposed?
- Sometimes when talking about vulnerability the discussion needs to be about more than children. It's a good idea to pose children and the larger. vulnerable populations to policymakers, as well as in economic modeling. Numbers mean a lot to policy makers.
- We don't have many health impact assessments They are difficult, but we need them.

Session 3 Recap

Antonio Pascale, M.D. (University of the Oriental Republic of Uruguay)

There are many complexities of trade and in getting e-waste to countries. The core of the exposures is in the informal sector, and there is a high prevalence of open burning of cables/wires for copper and manual dismantling.

In order to prevent exposures and predict health risks, there needs to be an understanding of the different activities in recycling and their risks.

- Manual dismantling -> hand injuries
- Open cable burning ->burns
- Chemical exposures ->burns and chronic disease
- Manual CRT crushing is a high-risk activity for exposures

Exposures, both biological and environmental, have been documented in many countries, and in each case, interventions need to include information, education, and communication (ICE) to raise awareness. Workshops, training, materials, and community engagement all must include children and pregnant women.

Clean-up activities include remediation but also the use of wire stripping machines and PPE.

Monitoring effectiveness of interventions is a challenge in most situations. Biomarkers have a great potential for showing change in exposure, but they are costly. There is a need to explore other methods of screening with a lower cost. Indicators of effectiveness should be considered by the research community as projects begin. These indicators should include community buy-in and engagement but there is a need to standardize these measures.

Discussion

"We know the adverse effects of mis-management (of e-waste) on health. But at the end of the day, the people involved in these activities need solutions. We have to start assessing the effectiveness of the interventions so that countries can implement them. When we have literature, we can start implementing it at our community level."

Harmonization of e-waste research

This meeting is an opportunity to join forces. The studies shared are somewhat similar, the situations are somewhat similar: Many researchers are looking at exposures and outcomes, but is the same set of chemicals being measured with similar methods? The questions used to measure effectiveness could be similar across different sites. If everyone starts with a similar tool, there can be cross-country comparisons. There could be a pilot intervention in the different countries, and some good practices have already been established and could be expanded as we have seen preliminary success. Some of the existing methods are already the same, for example lab protocols are the same in analyzing for organics in blood, urine, and soil. We have methods to screen lead in soil at low costs. But the challenge is in measuring and estimating exposures.

A few potential harmonized projects that lead to a larger harmonization effort include:

- A baseline Knowledge, Attitude, Practice survey with a structured questionnaire across countries.
- Development of a protocol to bring in communication with workers and communities into all research projects.
- A baseline survey in each site and country that includes similar measurements of similar devices
- A pilot test that starts at a small, manageable site.
    - "The first step is to find *the* site in each place that is manageable. Then we look at the anthropology, at who's there, at what exposures you see, look at the chemistry of it, the soil, the air, the water."

Involving the formal sector in creating change

There are good and bad examples from the formal sector that should be considered. The formal sector has plenty of problems, as "the growing informal sector is a symptom of the failure of the formal sector." But there are models that work in the formal sector that can help inform change in the informal sector. The education and protection of some industries could be modeled for e-waste.

Addressing the high costs in the formal sector may make recycling more prevalent

The informal sector exists often because it is costly to recycle in formal sectors. The gap can be bridged. Large companies could use R&D funds to research better methods or products. Manufacturing units themselves are starting to be involved in the recycling business, in that when they sell the product, they can be contacted for recycling. Encouragingly, many companies are looking into it, but they need a push to move faster.

"Given the situation now, what do we do to reduce exposures?"

There is a need to consider opportunities to fundraise and train and provide equipment in the informal sector. Recyclers in this sector need to be included in research and work with the formal sector. Upgrading them slowly is important as they are "recyclers and environmentalists."

All interventions should include the following basic concepts:

- No open, uncontrolled burning
  - Such as wire burning to extract metals
- No exposure of vulnerable persons to dismantling and recycling activities
  - Pregnant women and young children in particular
- No unsafe and environmentally unsound dismantling
  - Such as manual breaking of CRTs

"If we wait until each government considers the international agreements, we are wasting time."

Engagement of government to make or obey the international agreements is important. But we can work on a community level, to start to display what that policy or actions looks like, and perhaps it's a useful educational tool. We need recommendations, such as bringing the informal sector under the umbrella of labor complaints, addressing enforcement, etc.

It is also important to move work and education outside the environment ministry to the health ministry, the labor ministry, and to education.

Bringing everyone to the table

This problem and this research are at the intersection of social, economic, and political causes and solutions and is complicated. The solution requires anthropology, and sociology, and implementation science. Social scientists and community members themselves must be part of any research effort and of interventions and in solutions.

To understand this problem globally and in each country, there may be value in bringing in social scientists and stakeholders to inform a policy analysis. The United Nations University StEP program has web tools that help map this for different countries, and they should be utilized.

Conclusion

Michelle Heacock, Ph.D. and Brittany Trottier, M.P.H. (NIEHS)

Michelle and Brittany thanked all attendees. They reminded everyone that a meeting report will be

"The informal sector is quick and efficient and it can be better than the formal sector, but the informal sector, they want to be formalized, to have the license, but they face barriers; the documentation is overwhelming and costly and many informal recyclers have no education. There are social drivers; for many e-waste is a family business, so the children work with parents (not always because they have to, but they join before school) and the family can see recycling as a better route to a livelihood than education. They do know it has negative health effects. They sometimes have home remedies to relieve symptoms. It's a very social issue, it's a very Muslim community job in India, culturally recyclers want to be entrepreneurial and don't always want to be employed in a large company. Even though formal sector is not great, there are leakages and it has to be plugged."

~Informal Sector Consultant (Translated by Deepali Sinha)

Appendix 1: Attendee List

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E-waste: Prevention Intervention Strategies Meeting 2017

November 17, 2017 |New Delhi, India

*Workshop **Program Book***

The Workshop is convened by the US National Institute of Environmental Health Sciences (NIEHS), in collaboration with The Public Health Foundation of India, and the Pacific Basin Consortium at the East West Center. The Workshop is with the financial support from NIEHS.

BACKGROUND

As the demand for electronics increases, the amount of electronic waste (e-waste) steadily accumulates at a rapid pace. E-waste is composed of an alarming combination of several hazardous substances. A systematic review led by WHO and WHO Collaborating Centres looking at health outcomes related to e-waste exposure, showed that increases in spontaneous abortions, stillbirths, and premature births, and reduced birth weights and birth lengths are associated with exposure to e-waste. Direct and indirect exposures are a threat to human health and vulnerable groups such as fetuses, children, pregnant women, the disabled and workers in the informal sector need specific protection. The majority of e-waste recycling is done informally, by migrant workers using primitive techniques such as burning with little or no safeguards in place for human and environmental health.

AIM OF THE WORKSHOP:

The workshop builds from previous workshops convened in Depok, Indonesia, and Geneva, Switzerland and a recent NIEHS Global Environmental Health webinar. The goals are to develop prevention and intervention strategies to reduce exposures to e-waste to humans and the environment, provide the community sector with tools that can allow developing better surveillance, monitoring, and technologies with which to build capacity for better diagnosis and prevention and risk communication to workers and their families. To contrast and compare e-waste recycling practices from a variety of geographic areas and situations, the workshop will include updates from previous case studies, and introduce case studies from new members brought into the e-waste network. These case studies presented will lay out best practices, lessons learned, and importantly provide recommendations for and to help frame a prevention/intervention pilot study.

OBJECTIVES

1. To exchange information on current projects, tools, and best practices from different perspectives (i.e., geographic areas, and locales)
2. To discuss the feasibility of surveillance mechanisms that can be used to non-invasively, identify informal e-waste recycling groups
3. To identify available technologies, and discuss ways to inform communities affected by exposure to e-waste of these available technologies
4. To improve communication and information strategies to reach the e-waste workers and their families
5. To use this information to inform and vet a framework for a pilot prevention/intervention study

Abstracts

Session 1 - Updates from the field

Pollution control at Agbogbloshie informal electronic waste recycling site: Designing the most effective intervention strategies and getting the agenda right

By: Julius N. Fobil, John Arko-Mensah, Niladri Basu, Stuart Batterman & Thomas G. Robins

Agbogbloshie has seen a considerable transformation in physical character since the 1980s when it was primarily a place of shelter for refugees from the Konkomba-Nanumba war and marketing of yam. Today, the area has gained notoriety as one of the most polluted slums in the world by hosting one of the largest electronic waste dump and recycling sites in Africa. At the peak of the day's activities, the area bustles with a mix of commercial activities; both formal and informal, from onion selling through banking to dismantling, recovering, weighing and reselling parts and metals extracted from the scrapped devices and from the heaps of electronic waste. Agbogbloshie is arguably the top 3 largest e-waste recycling sites in the world in respect of the volume of materials recycled per day and the number of recyclers per unit space. It is famous for its high concentration of recycling activities per unit land space. However, what distinguishes it quite distinctly from other similar recycling sites around the globe is the co-occurrence of many other informal level activities as well as formal sector activities within the same space. This abstract outlines ongoing initiatives in the area which are aimed to reduce exposures associated with the recycling activities in the hope of minimizing adverse health impacts on the environment and human health. Our abstract highlights three key areas: viz, a) research, b) low-cost, unsophisticated, easy-to-operate intervention solutions and c) constant community engagement as strategic pillars on which to launch successful pollution control programs, while laying emphasis on the role of each pillar in shaping decisions on intervention.

Hazardous organic pollutants associated with Informal e-waste recycling: An emerging issue for environment and public health in India

By: Paromita Chakraborty

Following a trajectory of rapid economic development, an increasing demand for electronic equipment in India inevitably generates large amounts of domestic electronic waste (e-waste). The quantity of e-waste generated in India is further compounded by dumped e-waste from developed nations. E-waste contains precious and toxic metals and halogenated compounds. Inappropriate recycling processes of e-waste are a challenging issue since it may result in the release of harmful toxicants into the environment. Dangerous recycling practices of e-waste can pose a threat not only to the areas where primary emission is taking place but also can effect human health via various exposure pathways. This paper gives an overview of the investigations on the organic pollutants observed in soil from such informal e-waste recycling workshops in Indian cities. Further

atmospheric emission and transport of such contaminants has been explained using HYSPLIT and FLEXPART Models. Processes that involve the burning of e-wastes are of particular concern, because some substances in e-waste are releasing incomplete combustion products such as highly toxic PCB congener, PCB-126, chlorinated dioxins and furans, polycyclic aromatic hydrocarbons and phthalates with maximum loading in the sites engaged in precious metal recovery. It has been speculated that these compounds resulted from the burning of cables and plastic casings during the precious metal recovery processes. Child, female and male workers engaged in such informal e-waste recycling workshops are suspected to be at maximum risk. Given the fact that the quantity of e-waste generation is increasing across the globe there is substantial increase in the business of informal recyclers in the developing world since laws are not so stringent. Hence the informal sectors located mostly within the city or in the suburbs of Indian cities are prime factors for prolonged exposure to these toxicants. Such hazardous substances can pose adverse health impact not only to the workers but also to the surrounding community dwellers.

Coming Soon!

Session 2 - Updates from the field

E-waste exposure in Uruguay: a review. Update of interventions and environmental challenges.

By: Antonio Pascale

Uruguay is the second Latin American country with highest amount of e-waste per-capita. Despite a public framework for waste management where several public institutions are engaged in recycling and WEEE disposal, specific legislation for e-waste is still on course. Private enterprises are dedicated to the final e-waste disposal, and in some cases e-waste is exported to other countries. In Uruguay, as other Latin American countries, informal recycling activities are reported in informal settlements located in the capital of Uruguay, Montevideo, particularly in suburban residential areas, where many generations of families live for decades in landfills with industrial and domestic waste. These activities, including open burning activities and manual dismantling, represent the largest source of family financial support for economically disadvantaged families. Contaminated sites are also called “micro toxic hotspots”. Children are often exposed living in or near e-waste recycling houses or playing where the activities are performed (indirect exposure). Adults and adolescents involved recycling activities are directly exposed (direct exposure). Studies showed that e-waste is a main source of lead exposure in Uruguay. Since 2010, interventions have been performed in order to reduce this exposure: community education and surveillance, as well as remediation and clean-up activities of contaminated sites. After these interventions, a reduction of blood lead levels in a small cohort of children was reported in two different studies. Despite these actions, social vulnerability is still a threat to reduce e-waste exposure. Local and national policies targeted to formalize these activities are needed.

E-Waste exposure in children in Thailand and National integrated e-waste strategic plan

By: Panida Navasumrit, Krittinee Chaisatra, and Mathuros Ruchirawat

Electronic waste (E-waste) is one of the rapidly growing environmental concerns worldwide because of the sharply increasing annual global volume of e-waste. Thailand is one of the developing countries facing e-waste problem as a consequences of the illegal importation of e-waste from aboard and an

increasing e-waste generation from household. Pollution Control Division (PCD) estimated that the amount of e-waste generated is increasing approximately 368,000 ton per year. Informal e-waste recycling is a major contributing factor of toxic substance generation. E-waste contains a large number of hazardous substances including heavy metals, flame retardants such as polybrominated diphenyl ethers (PBDEs), and polycyclic aromatic hydrocarbons (PAHs). A high volume of informal recycling has been reported in Thailand. Growing evidence indicates health hazard of exposure to toxic substance from e-waste recycling. Children's exposure to environmental pollutants is a public health concern as children are especially vulnerable to toxic chemicals. Chulabhorn Research Institute (CRI) has conducted a project to assess exposure to toxic substances from e-waste recycling and their health risk in young children (3-5 years old) living nearby e-waste recycling areas. The control group was recruited from another community which had no e-waste recycling activities. A significant increase in the ambient levels of PBDE, PAHs and toxic metals such as MN, Ni and Pb were found in the e-waste recycling community. Elevated levels of individual PAHs exposure and its urinary metabolite, 1-hydrorypyriene, and metals in toenails were significantly higher in the exposed children. More importantly, exposed children had higher levels of oxidative and nitrative DNA damage measured as 8-hydroxydeoxyguanosine and 8-nitroguanine, respectively which indicated greater risk of disease development. Therefore, management and regulation of e-waste must become a priority at the national level. PCD drafted the National Integrated Strategy for a proper management of e-waste and raising public awareness in order to prevent and reduce the health effects of e-waste exposure, especially in children and vulnerable populations.

E-Waste in Banglaore, India

By: Anwesha Borthakur

Environment and resource friendly management of Electronic waste (E-waste) is a major challenge for contemporary India. Considering the ever-increasing complexities of E-waste in Indian cities, this paper aims to evaluate the current trends, opportunities and challenges associated with consumption of electronic items and disposal of E-waste in urban India. Bangalore, a city popularly known as the 'Silicon Valley of India', is considered as a case study in order to evaluate the public awareness, household's consumption and E-waste disposal behaviours in urban India. The city profile of Bangalore expresses that it has a rapidly emerging market for electronics and thus, has the potential to act as a 'model' for evaluating the issues concerning E-waste in metropolitan India. Questionnaires were distributed originally among 300 households with an effective response rate of 63.33%. The results indicate that majority of the households (59.3%) still keep their obsolete electronics stored due to lack of knowledge about proper E-waste management. High Awareness on E-waste and high willingness to recycle/repair their E-waste (above 80% in both cases) are yet to be translated into responsible disposal/recycling behaviour as 95.8% households have no knowledge about any formal recycling centre present in the city. We argue that consumers' disposal behaviour and awareness are central to any successful E-waste management interventions without which no reuse/recycling efforts would be fully functional and satisfactory, no pollution abatement initiatives would be entirely successful, no policy instruments could be satisfactorily implemented, no detrimental health/environmental consequences of E-waste could be addressed sufficiently and chaotic dubious E-waste management processes would progress towards an erratic fate. Therefore we suggest that it is imperative to address the ongoing E-waste problem in urban India in an adequate detail from its roots by establishing appropriate and convenient E-waste collection/recycling facilities, ensuring responsible households disposal behaviour, implementing effective laws and legislations and organizing mass E-waste awareness campaigns.

Session 3 – Updates from the field

E-waste recycling and pilot interventions in the Philippines

By: Aimin Chen

E-waste recycling in the Metro Manila, Philippines, occurs in communities around the metropolitan area. It is operated by self-organized recyclers with connection to >2000 junkshops that collect recycled materials. Type of e-waste collected and recycled include CRT TVs, monitors, computers, cell phones, refrigerators, fans, and microwave ovens. The recycling activities occur in front of the house, on the street, in the backyard, or along the river by thousands of recyclers. The recycling activities include manual dismantling, crushing CRTs, burning power cords, and heating circuit boards. There is a lack of pollution control methods to reduce exposure. Limited research in Metro Manila informal e-waste recycling sites suggest increased levels of Cd, Co, Cu, Mn, Ni, Pb, and Zn in soil samples, similar to other large recycling sites in Asia. Open burning of e-waste also increases PAH exposure in soil samples. A study in a Metro Manila waste dumping site identified slightly higher PBDE concentrations in breast milk compared with a control site. In 2012-2017, Médecins du Monde (MdM, or Doctors of the World in English), a large NGO based in Paris, France, conducted pilot interventions to reduce exposures to e-waste toxicants among informal sector workers. MdM has mobilized hundreds of informal e-waste recyclers in 4 communities in Metro Manila to form their own Recycler Organizations and conducted multi-prong interventions to mitigate environmental and health hazards. More research is needed to determine the effectiveness of the intervention for chemical hazards reduction.

Electronic Waste in Ghana and Interventions to reduce its Impact on Human Health and Environment

By: Kwadwo Ansong Asante and Yaw Amoyaw-Osei

Informal metal recycling started at Agbogbloshie in the mid 1990s and in 2013, Agbogbloshie was listed among the top 10 most polluted places in the world. In Ghana, e-waste recyclers use primitive methods to remove plastic insulation from copper cables. This approach releases highly toxic metals, dioxins and furans into the environment as revealed by some studies from Agbogbloshie.

As a result of this, some attempts have been made to reduce exposure. Since 2009, Blacksmith in collaboration with Green Advocacy, Ghana, has been working in Agbogbloshie with the support of Environmental Protection Agency and the Ghana Health Service to investigate reports of the extent of pollution at the site and also focus on training local recyclers on methods to prevent lead and toxics pollution. Through education initiatives and proper access to wire stripping technologies, workers began to understand the risks of their activities. Various wire stripping equipment improvements gave an alternative method for workers to strip products instead of burning. Others partners/funders including GIZ (Germany), Ericsson and Boliden (Sweden) and a NORDIC Fund Project have all been to the Agbogbloshie site. A recycling centre was established at Agbogbloshie in 2014 with four wire stripping equipment capable of stripping telecoms and electrical cables of varying sizes. A new wire stripper and granulator equipment was launched and demonstrated on the 4th of August 2016. In October, 2017, a Ghanaian consultant also organized a training for some mobile phone and computer repairers in Accra.

It is expected that the implementation of the Hazardous and Electronic Waste Control and Management Act, 2016 (ACT 917), will lead to the establishment of a coordinated and formalized e-waste recycling/management system in Ghana.

E-Waste in Tamil Nadu, India

By: Sankar Sambandam

Production, use and disposal of electric and electronic wastes has increased exponentially in 20th century. Managing e-wastes are currently governed by the Hazardous Waste (Management, handling and Transboundary Rules 2008) and E-Waste (Management) Rules, 2016. In spite of the current regulatory requirements on waste disposal, unauthorized recycling and illegal export and import of these wastes to developing countries pose a greater threat to environment and health of the people through exposure of these wastes and remain a greater challenge in the absence of state of art disposal methods. Collectors, dismantlers and recyclers are found to be an important stakeholder of e-wastes. The processes of e-waste recycling in informal sectors are well studied and profiled, but much needs to be studied on the type of chemical exposures among personnel processing these wastes. Poor hygiene, unsafe practice and lack of using appropriate disposal technology concerns much seriously on the exposure of personnel involved in this process and people living in the vicinity of such facilities who are affected by exposure to emissions and effluent discharges. Currently, seven Collection Centers, ten Dismantling and four Recycling Units located across Tamil Nadu are authorized by Tamil Nadu Pollution Control Board. The proposed study will profile the hazards and health risk in selected collection centers, dismantling and recycling units with the support from Tamil Nadu Pollution Control Board. The hazards would be identified through interviews and observations at workplace to arrive at an exposure assessment strategy. A questionnaire will be administered in parallel to recognize the health problems commonly seen in these sectors. A typical industrial hygiene approach will be used to assess the exposure of chemicals such as selected heavy metals, Volatile Organic Compounds and Polycyclic Aromatic Hydrocarbons (PAH) in the workplace environment. The department has been involved in the Development of Mercury Exposure Profile among Pregnant Mothers in Chennai funded by WHO Europe and SEARO and have build the capacity on biomarker assessment. We would be performing biomarker analysis for heavy metals in urine, blood and hair samples and PAH in urine samples to corroborate with specific exposures. The methods of analysis of environmental and biological samples will be discussed.

The existing e waste issue in Myanmar

By: Ohmar May Tin Hlaing

Myanmar has been facing considerable challenges in the management of solid waste like other developing countries. In this regard, the country's national and city level waste management strategy along with action plans as well as the master plan for hazardous waste management have been virtually finalized; however, e waste issue is still needed to be comprehensively scrutinized. These strategies and action plans will be shared in brief and then the existing situation of e waste informal sectors being carried out *w*ith improper recycling practice and disposal in Yangon, the commercial hub of Myanmar will be revealed. Subsequently, engagement with vulnerable populations being exposed to the hazardous substances of E-Waste concerning exposure level that can be available in Myanmar, the benefit to combine risk communication using the effective approach identifying the role of not only social media but also other professional ways to raise awareness will be discussed. Finally, how to tackle the exposed population about their latency of health effects potentially caused by e waste exposure will be reviewed together with the participants.

Biosketches

11.1.2017

Name	Institution/Organization
Aimin Chen	University of Cincinnati Dr. Aimin Chen is Associate Professor in Department of Environmental Health, University of Cincinnati. He specializes in perinatal and pediatric environmental epidemiology, studying chemical exposures and adverse pregnancy outcomes, child neurodevelopment, obesity and metabolic disorders. He has conducted epidemiologic research on DDT, isoflavones, lead, mercury, cadmium, tobacco smoke, flame retardants, perfluoroalkyl substances, particulate matter, and polycyclic aromatic hydrocarbons. He also has research interest in child health risk reduction through exposure mitigation and parental and child behavior modification since prenatal period. His main research interests include: 1) Adverse effects of environmental chemicals on perinatal outcomes and brain development: Identifying potential developmental toxicity, including neurotoxicity, of metals, persistent organic pollutants, and endocrine disrupting chemicals using epidemiologic studies; 2) Reducing chemical exposures in vulnerable fetus and young children: Translating research findings into prevention efforts to reduce environmental chemical exposures including lead, flame retardants, e-waste toxicants, etc.; and 3) Preterm birth, infant death, and child obesity: Addressing epidemiologic research gaps and preventable causes of adverse pregnancy outcomes, infant morbidity and mortality, and obesity-related disorders.
Antonio Pascale	Universidad de la República Oriental del Uruguay Antonio Pascale was the medical doctor for the School of Medicine, University of the Republic in Montevideo, Uruguay from 1994-2002. He worked as the assistant Professor of Clinical Toxicology, Department of Toxicology (WHO Collaborating Center in Environmental Human Toxicology) at the School of Medicine University of the Republic in Montevideo, Uruguay from 2004 to 2009. He is currently a specialist in Clinical Toxicologist and Associate Professor of Clinical Toxicology at the University of the Republic, School of Medicine in Montevideo, Uruguay. Antonio Pascale is the Director- Toxicology Service for the Subnational Direction of Health Police Division, Ministry of Interior Montevideo, Uruguay. He is a member of the Board of Directors for the Pacific

	Basin Consortium for Environment and Health, and a member of TIAFT (The International Association of Forensic Toxicologists). Antonio Pascale is author and reviewer of several publications related to environmental toxic issues, and co-author and reviewer of the WHO Training Module for Health Care Practitioners about "E-waste and child health". He has also been a lecturer of several presentations related to environmental toxic issues.
Anwesha Borthakur	Jawaharlal Nehru University Anwesha Borthakur is currently working as a 'research fellow' in a project by the Department of Science and Technology, Government of India at the Centre for Studies in Science Policy, Jawaharlal Nehru University (JNU), New Delhi. She has a master's degree in Environmental Science and an M.Phil in Science, Technology and Innovation Policy Studies. Her PhD research focuses on the management of electronic waste in India with a special focus on consumers' disposal behavior and awareness. She has more than 20 peer-reviewed research publications to her credit included in the Journal of Cleaner Production, Resources Conservation and Recycling, Journal of Hazardous Materials, Current Science and so on. She has presented her research work in various national and international conferences and workshops both in India and abroad. She has been a recipient of various awards and travel grants from universities like the United Nations University (Germany), Sussex University (The UK), KU Leuven (Belgium), Lund University (Sweden), Arizona State University (the USA), etc.
Brittany Trottier	National Institute of Environmental Health Sciences Brittany Trottier received her Master's in Public Health from The George Washington University and her BA in Chemistry from Adrian College. She is currently a Health Specialist with the Superfund Research Program at the NIEHS. For the SRP, she is the lead for the CareerTrac system for SRP trainees, oversees the community engagement cores, and supports the co-lead for the NIEHS WHOCC e-waste focus area.
David Carpenter	University of Albany David O. Carpenter is a public health physician who serves as director of the Institute for Health and the Environment, a Collaborating Center of the World Health Organization, as well as a professor of environmental health sciences at UAlbany's School of Public Health. He previously served as Director of the Wadsworth Center of the New York State Department of Health, and as Dean of the University at Albany School of Public Health. Carpenter, who received his medical degree from Harvard Medical School, has

	more than 370 peer-reviewed publications, 6 books and 50 reviews and book chapters to his credit.
Deepali Sinha Khetriwal	Deepali is an Associate Programme Officer at the United Nations University and heads the Indian office of sustainability consultancy Sofies. Deepali has over 13 years of research and implementation experience specifically in e-waste management, and has published several papers in peer-reviewed journals on the topic. She has worked as an expert consultant in Europe, Asia and Africa for international organizations as well as private sector companies. She was instrumental in setting up the capacity development activities of the StEP Initiative, a UN supported forum on the e-waste problem. She holds a PhD in International Management from the University of St. Gallen, Switzerland and is currently based in Mumbai, India.
Indah Salami	Intitut Teknologi Banduang Currently the member of Environmental Management & Technology Research Group in the Department of Environmental Engineering, Faculty of Civil & Environmental Engineering, Bandung Institute of Technology (ITB), Bandung Indonesia. Doctoral degree from the Univiersity of Newcastle upon Tyne, UK. A lecturer in Environmental Engineering Program in ITB for undergraduate and postgraduate program. Interest field are environmental health, aquatic toxicology, environmental and health risk assessment, occupational health & safety and appropriate technology and management for environmental pollution. E-waste research on the effect of air pollution in e-waste recycling area on children respiratory health.
Inoka Suraweera	Directorate of Environmental and Occupational Health Inoka is the National Programme Manager for Occupational Health at the Ministry of Health in Sri Lanka. She is also a Board Certified Specialist in Community Medicine. She graduated from the Faculty of Medicine, University of Colombo, and hold a master's and doctoral degrees in Community Medicine from the University of Colombo. She completed my post doctoral training at the Monash Centre for Occupational and Environmental Health at Monash University in Melbourne Australia. I am currently working at the Directorate of Environmental and Occupational Health at the Ministry of Health as a Consultant Community Physician.
Julius Fobil	University of Ghana Julius Fobil is an Associate Professor and Head of the Department of Biological, Environmental and Occupational Health. He holds a DrPH from the University of Bielefeld, and a BSc . Phil from the University of Chana. His research focuses on urban environmental health in low-income economies with emphasis on the impact of

	sanitation infrastructure, neighbourhood environmental conditions, environmental change and area-based socioeconomic inequalities on urban mortalities with a major focus on environmental determinants of urban health in general. More recently, my research interest has moved boundaries to include, vaccinology (i.e. from vaccine development through clinical trials, their licensure to their mass deployment in national vaccination programs on the field) and Genome Wide Association Analysis (GWAS) of common neglected tropical diseases e.g. Buruli Ulcer with an emphasis on genetics and environment interaction underlying its transmission and pathogenesis. Though a small working group at its formative stage, we have an ultimate goal to unravel the unintended urban health vulnerabilities associated with complex urban changes such as the growing consequence of urban air pollution and the multiple urban land uses on urban mortalities and urban health in general.
Kwadwo Ansong Asante	CSIR Water Research Institute Dr. Kwadwo Ansong Asante is an Environmental Chemist/Ecotoxicologist and a Senior Research Scientist with the CSIR-Water Research Institute in Ghana. He holds a B.Sc. degree from KNUST in Ghana, M.Sc. degree in Environmental Chemistry and Ecotoxicology, and a Doctor of Science (D.Sc.) degree in Environmental Chemistry, both from Ehime University in Japan. Aside water quality assessment of groundwater, surface and coastal waters; and heavy metals analysis in fish and sediment, Dr. Asante's interest is in the effect of human exposure to polychlorinated biphenyls (PCBs) and brominated flame retardants (BFRs), and the assessment of heavy metals in mine workers and workers involved in e-waste recycling in Ghana. Dr. Asante has a number of publications in international and local journals to his credit and is a reviewer for some journals published by Elsevier. He is also an External Examiner for public universities in Ghana.
Melina Magsumbol	Public Health foundation of India Melina S. Magsumbol-Samaddar is a medical anthropologist studying the impact of environmental pollutants (metals, pesticides, etc.) on birth outcomes. As a researcher for the International Rice Research Institute in the Philippines, she became interested in how pesticides impact the environment and the health of farming communities in South East Asia. She went for a Master's in Medical Anthropology at the University of Memphis in Tennessee and pursued her research interest in pesticide use and health. While at the University of Tennessee Health Science Center (Pediatrics) she managed birth cohort studies that combined GIS, biomonitoring, environmental exposure assessment and socio-economic analysis of factors that influence birth outcomes. She

	received a fellowship from the Oak Ridge Institute for Science and Education (ORISE) and the Centers for Disease Control and Prevention (CDC) in Atlanta and worked as research fellow at the Organic Analytical Toxicology Branch. She was part of the management team that reported data for the National Health and Nutrition Examination Survey (NHANES). Before coming to PHFI, Melina was a Research Scientist at Georgia State University working on a birth cohort study with Emory University regarding late term prematurity and its impact on educational testing scores.
Michelle Heacock	National Institute of Environmental Health Sciences Michelle Heacock, received her doctorate from Texas A&M University for her work on the interplay between DNA repair proteins and telomeres, followed by a postdoc at the NIEHS that concentrated on understanding the causes and outcomes of cellular toxicity in response to DNA damaging agents. She is currently a Program Officer at the NIEHS for the Superfund Research Program (SRP), a grant program with a multidisciplinary approach to understanding the toxicity and risks of hazardous substances on human and environmental health. For the SRP, she also helps to coordinate efforts to disseminate and translate research findings. She is the co-lead for e-waste focus area that is part of the NIEHS-WHO Children's Environmental Health Collaborating Centers and the US Project Collaborator for The West Africa-Michigan Collaborative Health Alliance for Reshaping Training, Education, and Research in Global Environmental and Occupational Health (WAM-CHARTER-GEOHealth).
Ohnmar May Tin Hlaing	Environmental Quality Management Co Dr Ohnmar got her MB, BS degree in Institute of Medicine (I), Yangon, Myanmar. She received certificate in Analytical Toxicology as a WHO fellow and then post graduated in Environmental Toxicology, Technology and Management in the inter university program of Asian Institute of Technology (AIT) and Chulaborn Research Institute (CRI). Since 2012, Dr Ohnmar has been leading an environmental team (Environmental Quality Management, EQM) as an environmental health consultant working on environmental related projects covering air, noise, water and waste management in Myanmar. She is a member of Myanmar Medical Association (MMA), Asian Pacific Association of Medical Toxicology (APAMT) and of IGAC (Monsoon Asia, Oceania Networking Group).

Panida Navasumrit	Chulabhorn Research Institute Panida Navasumrit, Ph.D., is the Senior Research Scientist, Laboratory of Environmental Toxicology Laboratory, at the Chulabhorn Research Institute. Panida Navasumrit is a lecturer for the Post-graduate program in Environmental Toxicology, at the Chulabhorn Graduate Institute and member of the executive committee of Thai Society of Toxicology. Her research interests include, 1) Molecular and cellular changes of early-life exposure to environmental carcinogens (i.e. arsenic exposure); 2) Mechanisms of environmental pollutants-induced human diseases and cancer: Genetic and epigenetic mechanisms; 3) Molecular epidemiology: Application of biomarkers in human biomonitoring; and 4) Environmental and genetic risk factors of cholangiocarcinoma.
Paromita "Paro" Chakraborty	SRM Research Institute Dr. Paromita Chakraborty joined SRM Research Institute and Department of Civil Engineering as Assistant Professor in 2012. Dr. Chakraborty obtained her PhD degree in Natural Sciences with full term scholarship from Chinese Academy of Sciences. Dr. Chakraborty specializes in fate, transport and remediation of organic contaminants. She is leading the "Environmental Science and Technology Laboratory" in SRM Research Institute.
Sankar Sambandam	Sri Ramachandra Medical College Obtained his masters degree in Environmental Toxicology from the Post Graduate Institute of Basic Medical Sciences (Madras University), Chennai. His fields of specialization include environmental and industrial toxicology and industrial hygiene measurements. He is responsible for the co-ordination of data collection and analysis for R&D projects and conduct of academic and short term training programs in occupational safety & health.
Subramanian Annamalai	Annamalai Subramanian is an Environmental Chemist. "I got my M.Sc. degree in Marine Biology and Oceanography from the Centre of Advanced Study in Marine Biology, Annamalai University, India and also a Ph.D. degree from the same Centre in the year 1982. I got a second Ph.D. from the Faculty of Agriculture of Ehime University, Matsuyama, Japan in 1988. Then I worked in Annamalai University, India in different capacities as a research cum teaching staff and moved again to the Center for Marine Environmental Studies (CMES), Ehime University in the year 2003 as a Professor. My field of interest is Environmental Pollution and I worked on several chemicals like heavy metals, organo halogens, polyaromatic hydrocarbons, etc. producing nearly 150 peer reviewed publications, one book and five seminar proceedings and attended about 80 national and international seminars, symposia, workshops, etc. I am working on the e-waste problem for the past more than 10 years in association with e-waste processing

	facilities in India, Vietnam, etc. I have guided many research students. I have operated nearly 30 research projects in different capacities as principal or co-investigator. I did projects and also a consultant for agencies including UGC, Department of Ocean Development, India, UNEP, UNDP and Japanese Ministry of Education, Culture, Sports, Science and Technology, etc. I took care of the international activities of CMES, Ehime University, Japan and so have wide international connections."
TK Joshi	Centre for Occupational and Environmental Health Dr. T.K Joshi MBBS, MS, MSc (Occupational Medicine, London), Cer. OEM (UCSF), DLSHTM (Occ. Health) U.K., FFOM (Royal College of Physicians, London) specializes in occupational and environmental medicine. He trained in Occupational and Environmental Health at TUC Centenary Institute of Occupational Health, London University, and Division of Occupational and Environmental medicine, University of California, San Francisco. Dr. Joshi has been a national consultant to WHO as well as ILO. He has visited large global corporations, and advised several Indian corporations on strengthening occupational health and safety. He was the first Indian Physician to be elected a fellow of Collegium Ramazzini.
William Suk	National Institute of Environmental Health Sciences William Suk, Ph.D., M.P.H., is director of both the Center for Risk & Integrated Sciences (CRIS), and the Superfund Research Program, as well as the chief of the Hazardous Substances Research Branch in the NIEHS Division of Extramural Research and Training. His affiliation with several organizations and committees include: Roundtable on Environmental Health Sciences, Research, and Medicine, Institute of Medicine, National Academy of Sciences; International Advisory Board of the Chulabhorn Research Institute, Bangkok, Thailand; and World Health Organization Consultation on Scientific Principles and Methodologies for Assessing Health Risks in Children Associated with Chemical Exposures. He sits on a member of a number of trans-NIH committees. He also sits on the editorial boards of a number of international journals, including Environmental Health, Toxicology and Environmental Chemistry, International Journal of Occupational Medicine and Environmental Health, and the Central European Journal of Public Health. He is a recipient of several awards including Roy E. Albert Memorial Award for Translational Research in Environmental Health from the University of Cincinnati; the Child Health Advocacy Award from the Children's Environmental Health Network; and more.

Title	Source	Description	Country	Citation	Link	Type
Accumulation Features of Anthropogenic and Naturally Produced Organohalogen Compounds in Human Serum from Indian E-Waste Recycling Workers and Residents Near Coastal Areas	*Organohalogen Compounds*		India	Eguchi A, Nomiyama K, **Subramanian** A, Bulbule KA, Parthasarathy P, Takahashi S, Tanabe S. 2010. Accumulation features of anthropogenic and naturally produced organohalogen compounds in human serum from Indian e-waste recycling workers and residents near coastal areas. *Organohalogen Compounds* 72: 868-871.	Email japansubra@gmail.com for a copy	Article
Accumulation Features of Organohalogens and their Hydroxylated Metabolites in the Blood of Pigs Collected from a Dumping Site for Municipal Wastes in India	*Interdisciplinary Studies on Environmental Chemistry—Environmental Specimen Bank*	This article determines the contamination status and accumulation characteristics of PCBs and the metabolites, OH-PCB, by analyzing the blood samples of pigs collected from municipal dumping sites and control sites in India.	India	Mizukawa H, Nomiyama K, Kunisue T, Watanabe MX, **Subramanian** A, Takahashi S, Tanabe S. 2010. Accumulation features of organohalogens and their hydroxylated metabolites in the blood of pigs collected from a dumping site for municipal wastes in India. In: *Interdisciplinary Studies on Environmental Chemistry—Environmental Specimen Bank: Exploring Possibility of Setting-up ESBs in Developing Countries*. Eds., Isobe T, Nomiyama K, **Subramanian** A, and Tanabe S. pp. 175-181.	Full Text	Article
Astitava : Green Highways (14/10/2017)	*YouTube*		India		Video Link	Video *In Hindi*
Astitva : Poisonous E-waste (21/10/2017)	*YouTube*		India		Video Link	Video *In Hindi*
Contamination by Trace Elements at E-Waste Recycling Sites in Bangalore, India	*Chemosphere*	This study measured contamination by trace elements (TEs) in soil, air dust, and human hair collected from e-waste recycling sites (a recycling facility and backyard recycling units) and	India	Ha NN, Agusa T, Ramu K, Tu NPC, Murata S, Bulbule KA, Parthasaraty P, Takahashi S, **Subramanian** A, Tanabe S. 2009. Contamination by trace elements at e-waste recycling sites in Bangalore, India. *Chemosphere* 76(1): 9-15. doi: 10.1016/j.chemosphere.2009.02.056	Abstract Only	Article

Title	Source	Description	Country	Citation	Link	Type
		reference sites in Bangalore and Chennai in India.				
Different Profiles of Anthropogenic and Naturally Produced Organohalogen Compounds in Serum from Residents Living near a Coastal Area and E-Waste Recycling Workers in India	*Environment International*	Studied contamination status and accumulation profiles of PCBs, PBDEs, and bromophenols in serum from e-waste recycling workers compared to residents living near a coastal area.	India	Eguchi A, Nomiyama K, Devanathan G, **Subramanian** A, Bulbule KA, Parthasarathy P, Takahashi S, Tanabe S. 2012. Different profiles of anthropogenic and naturally produced organohalogen compounds in serum from residents living near a coastal area and e-waste recycling workers in India. *Environment International* 47: 8-16. doi: 10.1016/j.envint.2012.05.003	Abstract Only	Article
Draft Notice of E-Waste (Management) Amendment Rules	*Government of India/ The Gazette of India*	The Ministry of Environment, Forest and Climate Change (MoEF&CC) has proposed to amend the E-Waste (Management) Rules, 2016 and has invited objections and suggestions to the proposal contained in the draft notification.	India	The Ministry of Environment, Forest and Climate Change (MoEF&CC). 2017. Draft Notice of E-Waste (Management) Amendment Rules. The Gazette of India. No. 890.	Full Text	Draft Notification
E-Waste and Associated Environmental Contamination in the Asia/Pacific Region (Part 2): A Case Study of Dioxins and Furans in E-Waste Recycling/Dump Sites in India	*Persistent Organic Chemicals in the Environment: Status and Trends in the Pacific Basin Countries -- Contamination Status.* (Chapter 7)	This chapter describes using the CALUX bioassay to determine the toxic equivalents (TEQs) for PCDD/Fs from informal e-waste recycling areas of New Delhi, Mumbai and Chennai and compared with the TEQs from the open dumpsites of each of these Indian cities.	India	Chakraborty P, Selvaraj S, Nakamura M, Prithiviraj B, Ko S, Loganathan B. 2016. Chapter 7 - E-Waste and Associated Environmental Contamination in the Asia/Pacific Region (Part 2): A Case Study of Dioxins and Furans in E-Waste Recycling/Dump Sites in India. *Persistent Organic Chemicals in the Environment: Status and Trends in the Pacific Basin Countries -- Contamination Status* 139-154. doi: 10.1021/bk-2016-1243.ch007	Abstract Only	Book Chapter

Title	Source	Description	Country	Citation	Link	Type
Organohalogen and Metabolite Contaminants in Human Serum Samples from Indian E-Waste Recycling Workers	*Interdisciplinary Studies on Environmental Chemistry—Environmental Specimen Bank*	This study measured PCBs, PBDEs, and their hydroxylated metabolites in the serum of workers in an Indian e-waste recycling factory and compared with residents from a rural area (control group).	India	Eguchi A, Nomiyama K, **Subramanian** A, Parthasarathy P, Bulbule KA, Takahashi S, Tanabe S. 2010. Organohalogen and metabolite contaminants in human serum samples from Indian e-waste recycling workers. In: *Interdisciplinary Studies on Environmental Chemistry—Environmental Specimen Bank: Exploring Possibility of Setting-up ESBs in Developing Countries*. Eds., Isobe T, Nomiyama K, **Subramanian** A, and Tanabe S. pp. 167-174.	Full Text	Article
Passive Air Sampling of Polybrominated Diphenyl Ethers in New Delhi, Kolkata, Mumbai and Chennai: Levels, Homologous Profiling and Source Apportionment	*Environmental Pollution*	To compare atmospheric polybrominated diphenyl ethers (PBDEs) levels, polyurethane foam disk passive air sampling (PUF-PAS) was conducted along urban-suburban-rural transects in four quadrilateral cities including New Delhi, Kolkata, Mumbai and Chennai from northern, eastern, western and southern India respectively.	India	Chakraborty P, Zhang G, Cheng H, Bala**Subramanian** P, Li J, Jones KC. 2017. Passive air sampling of polybrominated diphenyl ethers in New Delhi, Kolkata, Mumbai and Chennai: Levels, homologous profiling and source apportionment. *Environmental Pollution* 231(Pt 1):1181-1187. doi: 10.1016/j.envpol.2017.08.044	Abstract Only	Article
Persistent Toxic Substances in India	*Developments in Environmental Science* (Chapter 9)	This review provides information on the history of usage of persistent toxic substances in India, their occurrence in the aquatic and terrestrial environment and in the flora and fauna.	India	**Subramanian** A, Tanabe S. 2007. Chapter 9 - Persistent Toxic Substances in India. *Developments in Environmental Science.* 7: 433–485. doi: 10.1016/S1474-8177(07)07009-X.	Abstract Only	Book Chapter

Title	Source	Description	Country	Citation	Link	Type
Pioneering Study on Trace Elements in E-Waste Recycling Sites in Bangalore, India	*Environmental Chemistry*		India	Ha NN, Agusa T, Tu NPC, Ramu K, Bulbule KA, Takahashi S, Parthasaraty P, **Subramanian** A, Tanabe S. 2009. Pioneering study on trace elements in e-waste recycling sites in Bangalore, India. *Environmental Chemistry* 76: 9-15.	Email japansubra@gmail.com for a copy	Article
Pollution Trends in India – Evidence for the Need of an Environmental Specimen Bank	*Interdisciplinary Studies on Environmental Chemistry—Environmental Specimen Bank*	This article emphasizes the need for an environmental specimen bank for researchers in India.	India	**Subramanian** A, Devanathan G, Takahashi S, Tanabe S. 2010. Pollution trends in India – Evidence for the need of an environmental specimen bank. In: *Interdisciplinary Studies on Environmental Chemistry—Environmental Specimen Bank: Exploring Possibility of Setting-up ESBs in Developing Countries*. Eds., Isobe T, Nomiyama K, **Subramanian** A, and Tanabe S. pp. 111-118.	Full Text	Article
Polychlorinated Biphenyls in Settled Dust from Informal Electronic Waste Recycling Workshops and Nearby Highways in Urban Centers and Suburban Industrial Roadsides of Chennai City, India: Levels, Congener Profiles and Exposure Assessment	*Science of the Total Environment*	Polychlorinated biphenyls (PCBs) were measured in settled dust collected from informal electronic waste (e-waste) recycling workshops in Chennai, India. Major objectives of this study were to: understand the spatial variability and homologue profiling of PCBs; elucidate the distribution pattern of PCB congeners using principal component analysis, characterize the elemental composition, morphology and size of dust particles using FESEM/EDX;	India	Chakraborty P, Prithiviraj B, Selvaraj S, Kumar B. 2016. Polychlorinated biphenyls in settled dust from informal electronic waste recycling workshops and nearby highways in urban centers and suburban industrial roadsides of Chennai city, India: Levels, congener profiles and exposure assessment. *Science of the Total Environment* 573:1413-1421. doi:10.1016/j.scitotenv.2016.07.129.	Abstract Only	Article

Title	Source	Description	Country	Citation	Link	Type
		and estimate the potential risk to human health.				
Public understandings of E-waste and its disposal in urban India: From a review towards a conceptual framework	*Journal of Cleaner Production*	This article features an in-depth literature review of important aspects of E-waste and a review of publics' perceptions of E-waste and the determinants of their consumption and disposal intention with the help of specific theoretical underpinnings.	India	**Borthakur** A, Govind M. 2018. Public understandings of E-waste and its disposal in urban India: From a review towards a conceptual framework. *Journal of Cleaner Production* 172:1053-1066. 10.1016/j.jclepro.2017.10.218	Abstract	Article
Recent Status of Organohalogens, Heavy Metals and PAHs Pollution in Specific Locations in India	*Chemosphere*	This article reviews the status of organohalogen, heavy metal, and PAH pollution in India over the past ten years.	India	**Subramanian** A, Kunisue T, Tanabe S. 2015. Recent status of organohalogens, heavy metals and PAHs pollution in specific locations in India. *Chemosphere* 137:122-134. doi: 10.1016/j.chemosphere.2015.06.065.	Abstract Only	Article
Soil Concentrations, Occurrence, Sources and Estimation of Air–Soil Exchange of Polychlorinated Biphenyls in Indian Cities	*Science of the Total Environment*	This article describes the first attempt to investigate the occurrence of PCBs in surface soil and estimate diffusive air-soil exchange, both on a regional scale as well as at local level within the metropolitan environment of India. This study provides evidence that soil is acting as sink for heavy weight PCB congeners and source for lighter congeners.	India	Chakraborty P, Zhang G, Li J, Selvaraj S, Breivik K, Jones KC. 2016. Soil concentrations, occurrence, sources and estimation of air–soil exchange of polychlorinated biphenyls in Indian cities. *Science of the Total Environment* 562: 928-934. doi:10.1016/j.scitotenv.2016.03.009.	Abstract Only	Article

Title	Source	Description	Country	Citation	Link	Type
Contamination by Brominated Flame Retardants in Soil Samples from Open Dumping Sites of Asian Developing Countries	*Interdisciplinary Studies on Environmental Chemistry—Environmental Research in Asia*	This article measures contamination by brominated flame retardants in soil samples from municipal waste dumping sites in developing Asian countries.	India, Vietnam, Malaysia, Indonesia, Cambodia	Eguchi A, Isobe T, **Subramanian** A, Sudaryanto A, Ramu K, Minh TB, Chakraborty P, Minh NH, Tana TS, Viet PH, Takahashi S, and Tanabe S. 2009. Contamination by Brominated Flame Retardants in Soil Samples from Open Dumping Sites of Asian Developing Countries. In: Interdisciplinary Studies on Environmental Chemistry—Environmental Research in Asia. Eds., Y. Obayashi, T. Isobe, A. **Subramanian**, S. Suzuki and S. Tanabe, pp. 143-151.	Full Text	Article
Emerging trends in consumers' E-waste disposal behaviour and awareness: A worldwide overview with special focus on India	*Resources, Conservation and Recycling*	This article reviews locale specific characteristics of consumers' E-waste disposal behavior and awareness and identifies the measures adopted by the consumers of different countries to dispose of their E-waste.	India, China, Japan, Korea, Thailand, Vietnam, Switzerland, Spain, Germany, The United Kingdom, Nigeria, Ghana, United States, Canada, Brazil, Mexico	**Borthakur** A, Govind M. 2017. Emerging trends in consumers' E-waste disposal behaviour and awareness: A worldwide overview with special focus on India. *Resources, Conservation and Recycling* 117:102-113. doi:10.1016/j.resconrec.2016.11.011	Abstract	Article
Environmental Contamination and Human Exposure to Dioxin-Related Compounds in E-waste Recycling Sites of Developing Countries	*Environmental Science: Processes & Impacts*	This article reviews the potential sources, specific emission patterns, environmental occurrence and current human exposure impact	India, China, Vietnam	Tue NM, Takahashi S, **Subramanian** A, Sakai S, Tanabe S. 2013. Environmental contamination and human exposure to dioxin-related compounds in e-waste recycling sites of developing countries. *Environmental Science Processes & Impacts* 15(7):1326-1331. doi: 10.1039/c3em00086a	Abstract Only	Article

Title	Source	Description	Country	Citation	Link	Type
		assessment of dioxin-related compounds from informal e-waste recycling activities in Asian developing countries.				
E-Waste and Associated Environmental Contamination in the Asia/Pacific Region (Part 1): An Overview	*Persistent Organic Chemicals in the Environment: Status and Trends in the Pacific Basin Countries I Contamination Status.* (Chapter 6)	This chapter provides an overview on e-waste production/import and handling in various South Asian countries including Bangladesh, Sri Lanka, Pakistan, India, Nepal, Bhutan and Myanmar. Recommendations for energy savings and resource conservation are discussed.	India, Bangladesh, Sri Lanka, Pakistan, Nepal, Bhutan and Myanmar	Chakraborty P, Selvaraj S, Nakamura M, Prithiviraj B, Ko S, Loganathan BG. 2016. Chapter 6 - E-Waste and Associated Environmental Contamination in the Asia/Pacific Region (Part 1): An Overview. *Persistent Organic Chemicals in the Environment: Status and Trends in the Pacific Basin Countries I Contamination Status* 127-138. doi: 10.1021/bk-2016-1243.ch006	Abstract Only	Book Chapter
Researches on informal E-waste recycling sector: It's time for a 'Lab to Land' approach.	*Journal of Hazardous Materials*	This article responds to an article on E-waste in Ghana and relates its findings to the context of India.	Ghana, India	**Borthakur** A, Singh P. 2017. Researches on informal E-waste recycling sector: It's time for a 'Lab to Land' approach. *Journal of Hazardous Materials* 323:730-732. 10.1016/j.jhazmat.2016.03.087	Full Text	Article
Bioindicators of POPs: Monitoring in Developing Countries.	*Kyoto University Press, Japan and Trans Pacific Press, Australia*	This book addresses the issue of persistent organic pollutants (POPs) and how poor developing nations remain hesitant to adopt planned monitoring due to the economy and the lack of man-power and facilities	Developing Countries	Tanabe S, **Subramanian** A. 2006. Bioindicators of POPs: Monitoring in Developing Countries. Kyoto, Japan: Kyoto University Press; Melbourne: Trans Pacific Press 190 pages.	Abstract	Book

Title	Source	Description	Country	Citation	Link	Type
		for such evaluations. The Global Environmental Facility (GEF) has recently included POPs into one of its operational programs.				
Contamination by Brominated Flame Retardants in Soil Samples from Asian Developing Countries	*Organohalogen Compounds*		Asia	Eguchi A, Isobe T, **Subramanian** A, Sudaryanto A, Viet PH, Tana TS, Takahashi S, Tanabe S. 2009. Contamination by brominated flame retardants in soil samples from Asian developing countries. *Organohalogen Compounds*.71: 1303-1305.	Email japansubra@gmail.com for a copy	Article
Submitted: Assessment of Human Exposure to PBDEs in Asia: Residue Levels in Breast Milk and their Potential Exposure Sources and Pathways	*Science of the Total Environment*		Asia	Sudaryanto A, Kajiwara N, Takahashi S, **Subramanian** A, Isobe T, Tanabe S. Submitted Assessment of Human Exposure to PBDEs in Asia: Residue Levels in Breast Milk and their Potential Exposure Sources and Pathways. *Science of the Total Environment*	Email japansubra@gmail.com for a copy	Article

A list of additional resources related to E-Waste is available at: https://www.niehs.nih.gov/research/programs/geh/partnerships/index.cfm

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