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Electronic waste – an emerging global environmental and health challenge in the 21st century

Diane Purchase
Out with the old ...
E-waste generated per capita in 2014

Source: United Nations University-Institute for the Advanced Study of Sustainability. 2015
Challenges of E-waste

- Chemical nature and global distribution?
- Environmental and health impact?
- Risk management?
- Management strategy?

Recommendations for management approach
The International Union of Pure & Applied Chemistry E-waste Project
Example - Elements typically found in a mobile phone

This periodic table does not take into account in what quantities and concentrations the elements have been used (only the smallest impurities are excluded). Neither does it take into account the form the element in question has been used in.

Source: Ormala E. 2015
Examples of hazardous chemicals in E-waste

- **Heavy metals and metalloids**
  - e.g. barium, mercury, aluminium, chromium, copper
  - e.g. arsenic

- **Brominated flame retardants**
  - e.g. hexabromocyclododecane (HBCDD), polybrominated diphenyl ethers (PBDE)

- **Plastics**
  - e.g. bisphenol-A, polychlorinated biphenyls (PVC)

- **Lead Glass**
  - e.g. Lead
Treatment of E-waste

- Dismantling and pre-processing
- Recycling of metal contained E-waste
- Recycling of E-waste plastics
Example - Trade chain practice in India

Imports

Domestic: Public/private institutions via commercial dealers

Vendor lobby

Scrap dealers

Extraction/crushing/processing/treatment

Dismentlers

Recycling products (e.g. plastics/metal/glass)

Resale

Disposal

Crude products

Modified from Chatterjee D. 2015
Conceptual model of a typical E-waste recycling site in Nigeria
Potential health impacts

Source: http://ewise.co.nz/the-impact-of-ewaste/
Key legal framework

- Basel Convention
- Waste Shipment Regulation (WSR)
- Restriction of Hazardous Substances Directive (RoHS)
- Extended Producer Responsibility (EPR)
- Directive on Waste Electrical/Electronic Equipment (WEEE)
WEEE directive in EU “take-back” regulation

- Member State Collection 4kg per capita/year
- (ReUse), Recycling and Recovery 50 – 80 %

National implementation in MS legislation

- 45% POM (3yrs) collection from households
- (ReUse), Recycling and Recovery 55 – 85 % from 2016 forward

65% POM collection OR 85% waste generated

13th Aug 2005:
- Separate collection in place
- EEE before this is “historical”
- Marking of EEE

Collective financing for “historical” equipment ends 2011 for small equipment 2013 for large equipment

POM (3yrs) = put on market during previous 3 years

Source: Ormala E. 2015.
Challenges in the implementation of regulations and policy

- **Different implementation**
  - harmonized policy ≠ harmonized implementation
  - temporal & cultural dimension about waste
  - political unwillingness to regulate corporations too strictly

- **Difficult implementation**
  - Finding illegal trade = needle in haystack (risk assessment)
  - Requires expertise (not present with all agencies)
  - Limited resources
  - Information with different agencies
  - Different agencies with different goals

- **Prosecution & Sentencing:**
  - demanding investigative work
  - slow prosecution
  - low fines

- **Transnational trade**: different jurisdictions, awareness, economics
The known legal flow of E-waste

**UNFAIR FLOW**

Most electronic waste from developed countries ends up in poor nations that lack regulation. China processed around 70% of the world’s e-waste in 2012; the rest goes to India and other countries in eastern Asia and Africa, including Nigeria.

- **42 MILLION TONNES**
  - E-waste generated each year
  - **WORLD**: 41.8 million tonnes
  - **ASIA**: 16 million
  - **AMERICAS**: 11.7 million
  - **EUROPE**: 11.6 million
  - **AFRICA**: 1.9 million
  - **OCEANIA**: 0.6 million

1. The United States produces the largest total amount of e-waste per year, at 7.1 million tonnes.
2. Norway generates the most e-waste per person, at 28.3 kg per capita.
3. African nations produce little e-waste, with Equatorial Guinea creating most (10.8 kg per capita).
4. China ranks second for total e-waste generation (6 million tonnes), but low relative to its population size (4.4 kg per capita).

... and the illegal dark trade

Source: http://www.sustainelectronics.illinois.edu/policy/international.cfm [accessed 7th September, 2016]
E-waste as a criminogenic market?

- Case of Ghana:
  - Different priorities/concerns (no legislation on e-waste)
  - Massive informal collection & recycling
  - Local consumption of new/second hand products

‘You can make money by “recycling” e-waste in poorer environmental and social conditions, since this provides you the precious metals with lower labour costs’ (Corporate respondent 13).

There’s more to governance than government

- Cross border circulation is a key for a successful business
- Harmonized rules are needed to facilitate economically sustainable solutions
- The differences in waste from various product groups should be respected
- Rules should be well defined and justified and nor be used as trade barriers
- A formal global protocol on E-waste trading
- Strengthen domestic regulations
- Encourage transfer of knowledge on processing and recycling technology from developed to developing countries
- Producers’ and Consumers’ responsibilities
Making E-waste management sustainable

- Less wasteful consumption
- Circular economy
- Cleaner production & smaller material footprint
- Reverse logistics credits
- Life cycle analysis to identify environmentally sound end-of-life option
- Better treatment and disposals
- e-waste valorization
Example: Improve recycling behaviour-mobile phones

Source: Ormala E. 2015
Examples of E-waste recycling costs

EU Recycling scheme:
Average cost 4 cents / sold phone

Canada:
Recycle My Cell – program.
Average cost: \(0.1\)€ / phone

MEA:
Several initiatives,
Future cost estimated to be 1-3€ / sold phone

Thailand:
Proposed green tax 1.56€ / sold phone

Australia:
Levy for Mobile Muster program
Annual fee around 0.3€ / sold phone

SA: proposed fee level was 4.5 EUR per phone (was cancelled)

Source: Ormala E. 2015
Examples - Advances in material science for cleaner production

- Synthesis of heteroarchitectures formed by graphene oxide, conductive polymers and manganese dioxide for low cost high performance supercapacitors
- High performance supercapacitors - polypyrrole nanotubes coated with Ni(OH)$_2$ for
- Hybrid Materials for Hybrid Energy Storage – supercapacitor and batteries in one
# Examples - Advances in recycling technologies for metals recovery

<table>
<thead>
<tr>
<th>Recycling technology</th>
<th>State of recovery metals</th>
<th>Species and effect of recovery metals</th>
<th>Advantages of environmental and technological aspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrometallurgy</td>
<td>pure solid metals</td>
<td>almost all metals; high recovery rate</td>
<td>totally-commercial; owing some dust chamber and exhaust gas treatment plant</td>
</tr>
<tr>
<td>Mild extraction</td>
<td>solution</td>
<td>almost all metals; recovery rate related to the reagents and reaction condition</td>
<td>low toxicity; simple and easy accessibility; relative low environment damage</td>
</tr>
<tr>
<td>Biometallurgy</td>
<td>Solution</td>
<td>only for a few specific metals; considerable recovery rate for Cu, Zn, Au etc</td>
<td>environment-friendly; low cost of investment</td>
</tr>
<tr>
<td>Electrochemical</td>
<td>pure solid metals</td>
<td>only for specific metals; high recovery rate</td>
<td>high recovery efficiency; low cost of investment; mature technology</td>
</tr>
<tr>
<td>Supercritical</td>
<td>solid mixture of metals</td>
<td>almost all metals; high recovery rate</td>
<td>high recovery efficiency; low cost of investment; low environment damage</td>
</tr>
<tr>
<td>Vacuum metallurgy</td>
<td>solid single metal</td>
<td>only for high vapor pressure metals; high recovery rate</td>
<td>environment-friendly; short technological process</td>
</tr>
</tbody>
</table>

Source: Ermolin M.S. and Fedotov P.S. 2017
‘There is no such thing as waste …’

- Also contains rare earth minerals
- From cathode-ray-tube funnel glass to zeolites
- Indium from LCD display
- From old printed circuit boards to Cu-Sn nanoparticles

http://www.electronicspecifier.com/around-the-industry/do-you-have-a-goldmine-in-your-pocket
Conclusion
The IUPAC e-waste task group

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THANK YOU