Metals Recycling - Challenges and Strategies

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Circular Economy: Development of Recycling Industries

Prof. Dr. Liselotte Schebek

Institute IWAR
Technische Universität Darmstadt

Metals Recycling: Substitution of Primary Resources

Steel is the World’s Most Recycled Material

“Metals are infinitely recyclable in principle…”

Source: Reck/Graedel 2012

https://www.steelsustainability.org/recycling
Sustainable Development Goals and Metals Recycling


Energy and Mitigation of Climate Change

- The production of iron, steel and aluminum accounts for **10 % of total manufacturing energy use.**
- Secondary production requires about **74 %** (steel), respectively **90 %** (aluminum) **less energy** than primary production.

Sustainable Development Goals and Metals Recycling

Environment: Water, erosion, biodiversity, toxic substances

- Roughly 70% of mining operations of the world’s six biggest companies are in countries facing water stress.
- Poorly managed mining operations can pollute the environment and damage the biodiversity.

Sustainable Development Goals and Metals Recycling

Livelihood and health

- Up to 100 million people make a living from **artisanal mining**.
- High **health risk** for the workers and the surrounding community.

Recycling Rates of Metals

"Metals are infinitely recyclable in principle…
…but in practice, recycling is often inefficient or essentially nonexistent"

Source: T. E. Graedel et al., UNEP Status Report 2011
Barriers and Challenges

http://www.notebookinfo.de/


Barriers and Challenges: The Waste Management Perspective (I)

Waste flows Europe: Example Batteries, Vehicles, Electronics

Source: Huisman et al. 2017
Barriers and Challenges: The Waste Management Perspective (II)

Waste Management in developing countries

<table>
<thead>
<tr>
<th>Barriers</th>
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<tbody>
<tr>
<td><strong>Technical</strong></td>
<td>• deficient infrastructure</td>
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<td></td>
<td>• difficulty of separation</td>
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<td>• increasing complexity of products</td>
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<td></td>
<td>• lack of effective materials recovery technologies</td>
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<td><strong>Regulatory &amp; Institutional</strong></td>
<td>• lack of effective collection mechanism networks</td>
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<td>• lack of adequate regulations</td>
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<td>• shortfall of professional management</td>
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<td>• accountability</td>
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<td><strong>Socio-economic</strong></td>
<td>• lack of financial incentives</td>
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<td>• lack of knowledge</td>
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<td>• unequal sharing of the costs and benefits of recycling</td>
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Sources: Pollmann et al. 2018, Conke 2018, Tansel 2017

Barriers and Challenges: The Socio-Economic Perspective (I)

Informal waste recycling – Waste picker

- Probably millions of people worldwide earn their living from informal recycling waste
  - E.g. Brazil: over 229,000 waste pickers => responsible for the high recycling rates in Brazil (nearly 92 % aluminium recycled in 2008)
  - Exposure to hazardous materials/inhalation of toxic gases, e.g. burning of wires
  - Child labor is common practice, no social security/no benefits for workers.

Sources: Umair 2015.
http://www.wiegp.org/informal-economy/occupational-groups/waste-pickers#size
Barriers and Challenges: The Socio-Economic Perspective (II)

Material Flows from Collection to Final Processing: example gold recycling from printed wiring boards


<table>
<thead>
<tr>
<th>System</th>
<th>Collection</th>
<th>Pre-processing</th>
<th>Final processing</th>
<th>Net yield</th>
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<tbody>
<tr>
<td>Formal (Europe, UNU 2008, Chancerel et al. 2009)</td>
<td>60% formal take-back system</td>
<td>25% mainly mechanical processes</td>
<td>95% integrated smelter</td>
<td>15%</td>
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<td>Informal (India, Keller 2006)</td>
<td>80% individual collectors</td>
<td>50% manual sorting and dismantling</td>
<td>50% backyard leaching</td>
<td>20%</td>
</tr>
</tbody>
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Source: IRP (2017): Green Technology Choices
Barriers and Challenges: The Material Flow Perspective (I)

Global traceability: example e-waste:
- lack of a universal definition of e-waste
- no international trade data that distinguishes between new and used commodities
- role of illicit trade

Sources: Lepawsky 2015, Tansel 2017
Barriers and Challenges: The Material Flow Perspective (II)

Example Lithium: Recycling-Loops

Scenario A – open-loop recycling: secondary LiC to Basic Demand (except rechargeable and EV-batteries)

Scenario B – closed-loop recycling secondary LiC to rechargeable and EV- Batteries

Source: Ziemann et al. 2018
Barriers and Challenges: The Technical Perspective (I)

Material cycles and dissipative losses:

- Critical raw materials in alloys, but no exact data on amount of critical raw materials in metal scrap
- As to new high-grade steel and other alloys, the scrap metal needs to be well sorted or the materials will be lost to downcycling (Hiebel & Nühlen 2016)
- “metal recycled from old scrap largely serves as an imperfect substitute for primary metal” (McMillan 2012)
Barriers and Challenges: The Technical Perspective (II)

„Product-Centric approach“: recycling targets components of a product, separating and recovering them.

- „Design for Recycling“ vs. **rapidly changing designs** and **more complex products**
  => barrier for recycling (Punkkinen et al. 2017)

- **Only selective recovery** of single elements - e.g. Cobalt from Li-Ion batteries

- novel technological routes for material recovery – „**upcycling““, „**functional recycling““


https://www.mawi.tu-darmstadt.de/media/fm/homepage/presse_2/White_Paper_TUDa UM_magnetic_refrigeration.pdf
Conclusions

Ample evidence of barriers => Challenges:

- **Traceability of material flows**: control of illicit trade; classification schemes and data of material flows as a global knowledge base

- **Waste management in developing countries**: comprehensive solutions covering technical support, inclusion of the informal sector, professional training and incentives

- **Recovery of critical raw materials**: technologies for specific materials and products; establishment of value chains

- **Strategic planning**: much more ambition for „Design for Recycling“: scenarios planning for future material flows
Thank you for your attention!

Contact:

Prof. Dr. Liselotte Schebek

Technische Universität Darmstadt
Institute IWAR - Chair Material Flow Management and Resource Economy
Franziska-Braun-Straße 7, 64287 Darmstadt, Germany
Email: l.schebek@iwar.tu-darmstadt.de
Web: http://www.iwar.tu-darmstadt.de/sur