Sustainability of Materials Used in Consumer Electronics

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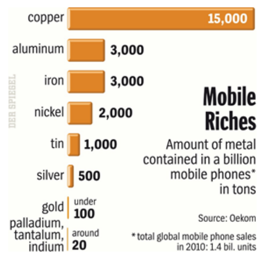
Objectives

- Identify substances of concern that are in consumer electronic products *(e.g., desktops, laptops, tablets, and smart phones)*
  - Metals
    - Aluminum
    - Stainless Steel
    - Nickel

  My focus area


copper 15,000
aluminum 3,000
iron 3,000
nickel 2,000
tin 1,000
silver 500
gold under 100
palladium, tantalum, indium around 20
DER SPIEGEL
Mobile Riches
Amount of metal contained in a billion mobile phones* in tons
Source: Oekom
* total global mobile phone sales in 2010: 1.4 bil. units

- Identify environmental and human health hazards associated with each material by reviewing studies based on alternatives assessment and life cycle assessment
- Develop a tool to be used in the consumer electronics materials selection process to identify and mitigate the potential impacts of each material

Methods

- Background Research
  - Determined what materials are commonly used in consumer electronics.

Elements Detected* in Samples

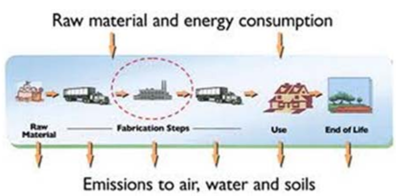
Element	Components Detected*	Percentage of Samples
P	293	27%
S	452	41%
Cl	543	49%
K	653	59%
Ca	718	65%
Ti	903	82%
V	376	34%
Cr	746	68%
Mn	617	56%
Fe	890	81%
Co	474	43%
Ni	599	54%
Cu	779	70%
Zn	559	51%
As	142	13%
Se	249	23%
Br	184	17%
Rb	0	0%
Sr	698	63%
Zr	0	0%
Nb	0	0%
Mo	0	0%
Ag	292	26%
Cd	173	16%
Sn	862	78%
Sb	401	36%
I	0	0%
Ba	494	45%
Hf	0	0%
Ta	0	0%
W	0	0%
Re	0	0%
Au	453	41%
Hg	406	37%
Pb	305	28%
Bi	450	41%

*Number of components in phones with elements detected above threshold screening levels devloped by HealthyStuff.org.

Primary Rating Elements
Secondary Rating Elements

Methods

- Background Research
  - Familiarized myself with
    - **Life Cycle Assessment (LCA)** - a technique to assess environmental impacts associated with all the stages of a product's life



- **Alternatives Assessment (AA)** - a process for identifying and comparing potential chemical and non-chemical alternatives that can be used as substitutes to replace chemicals or technologies of high concern

Methods

- Literature Review
  - Organized findings in results literature framework

Number	Text Citation	APA Citation	URL	Keywords
Example	Cambria & Pierangeli, 2011	Cambria, D., & Pierangeli, D. (2011). A life cycle assessment case study for walnut tree (Juglans regia L.) Seedlings production. The International Journal of Life Cycle Assessment, 1-10.		Industrial plantations, Juglans regia, LCA, Life cycle assessment, Timber, Wood
1		Berkeley Green Chemistry, 2012. Identifying substances of concern during informal recycling of electronics.	http://bcgc.berkeley.edu/sites/default/files/E-waste%20GSFinal%20Report%202012.pdf	Informal recycling, green chemistry, substances of concern, end-of-life, electronics
2	Santonen et al., 2010	Santonene, T., Stockmann-Juvala, H., and Zitting, A. (2010). Review on Toxicity of Stainless Steel. Finnish Institute of Occupational Health. Helsinki 2010-11-17.	http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&ved=0CB0QFjAA&url=http%3A%2F%2Fwww.ttl.fi%2Fen%2Fpublications%2Felectronic_publications%2Fdocuments%2Fstainless_steel.pdf&ei=OHugU-gpyv-hBKqngcgG&usg=AFQjCNFBQSjxijA5BykOnLHcdnzGrr4r7A	stainless steel, production, toxicity, human health hazards, classification and labelling, sensitization, respiratory tract toxicity, mutagenicity, carcinogenicity.
3	Weber, 2010	Weber, Douglas (Arcadia, CA, US 2010) NITRIDING STAINLESS STEEL FOR CONSUMER ELECTRONIC PRODUCTS United States APPLE INC. (Cupertino, CA, US) 20100273538	http://www.freepatentsonline.com/y2010/0273538.html	US pattent application, Apple, nitriding stainless steel, consumer electronics
4	Hedberg, 2012	Hedberg, Y. (2012). Stainless Steel in Biological Environments – Relation between Material Characteristics, Surface Chemistry and Toxicity. (Doctoral dissertation). Stockholm: KTH Royal Institute of Technology.	http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-105521	Stainless Steel, 316L, toxicity, surface and particle characteristics, metallurgy and corrosion, protein interaction, metal release, risk assessment, GHS

Stainless Steel Findings

- Stainless steel is used in the parts which require corrosion resistance, machinability, and strength.

- Stainless steel posses risk to humans through exposure during production and use
  - Inhalation of welding fumes and grinding dust
    - Workers may be at risk for the development of lung cancer, kidney damage, and cardiovascular disease (Hedberg 2010)
    - Occupation as a welder has been associated with a 25%–40% increase in lung cancer risk (Mannetje 2012)
  - Dermal contact with AISI 303 and 316L can lead to skin and eye irritation and sensitization (Beach 1999)

Aluminum Findings

- Aluminum is used for structural components in which light weight, durability, and strength are needed.

- Workers are exposed to Aluminum during refining, processing, and welding
  - Aluminum is a respiratory irritant (CCOHS 2010)
  - Occupational exposure leads to adverse respiratory tract effects, asthma, wheezing, dyspnea (shortness of breath), and impaired lung function (Krewski 2007)
  - Occupational exposure was significantly correlated with a variety of neuropsychiatric symptoms including; loss of coordination, loss of memory, and problems with balance (Krewski 2007)
  - Chronic aluminum exposure is associated with Alzheimer's disease
    - aluminum may contribute to the formation of Amyloid proteins in the brain, a marker of Alzheimer's disease (Popović 2014)

Nickel Findings

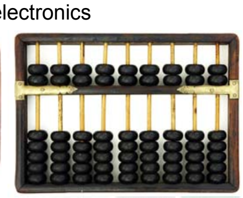
- Nickel is used in the microphone diaphragm, electrical connections, capacitors, batteries and surfaces buttons and features of consumer electronics. It is also a constituent in stainless steel.

- Nickel fume in high concentrations is a respiratory irritant
  - produces cancer of the paranasal sinuses and the lung (International Agency for Research on Cancer)
  - as dust or fume causes sensitization dermatitis (Popović 2014)
- Dermal contact leads to skin and eye irritation and sensitization

Conclusions

- Develop safer mining, processing and refinement techniques
- Use stainless steel with smaller % nickel and chromium
  - avoid austenitic chromium-nickel alloys
- Discontinue use of nickel in consumer electronics

Green Mobile Devices



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