Promoção da resilience urbana através da gestão de stocks de recursos urbanos

The material stocks
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Metals in-use stocks

Metals have the potential for almost infinite recovery and reuse.

(Gordon, R.B., Bertram, M. e Graedel, T.E. 2005)

Metals incorporated in products can be considered “mines” of secondary resources.

(RECALDE, K., WANG, J. e GRAEDEL, T.E. 2008)
Copper

- The increase of copper’s demand is a potentially large constraint on the future availability of virgin copper.
- Most of the copper processed during the last few decades still resides in society, mostly in non-dissipative uses.


![Copper in-use stock in New Haven, USA (2000)](image1)

- 144 kg/capita
- 11% Infrastructure
- 13% Buildings
- 35% Equipment
- 41% Transportation

(Drakopoulos, et al., 2006)

![Copper in-use stock in the State of Connecticut, USA (2000)](image2)

- 157 kg/capita
- 15% Infrastructure
- 13% Buildings
- 19% Equipment
- 53% Transportation

(Rauch, et al., 2007)
Copper in Connecticut, 2000

- Buildings – 83.9 kg/capita
  - Wiring → 38.8 kg/capita
  - Plumbing → 35 kg/capita

- Infrastructure – 30 kg/capita
  - Water distribution system’s service lines → 13.9 kg/capita
  - Electricity transmission & distribution → 8.9 kg/capita

- Equipment – 23.7 kg/capita
  - Industrial machinery & appliances → 12.9 kg/capita
  - Electric & electronic → 6.4 kg/capita

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Copper in Stockholm, 1995

Iron

- Iron is by far the most widely used metal, comprising >90% of the metal tonnage produced worldwide.
- At the global scale, anthropogenic iron stocks are less significant compared with natural ores but their relative importance is increasing.
- In 2004, 50% of US steel was produced in electric arc furnaces, which use scrap almost exclusively as an iron source.

**Historic US iron stocks in products in use, per capita**

**Historic iron flows in obsolete products generated in the US**

Iron in Connecticut, 2000

- **Buildings**
  - Industrial buildings → 2539 kg/capita
  - Commercial buildings → 1764 kg/capita
  - Residential buildings → 1226 kg/capita

- **Transportation**
  - Automobiles → 1656 kg/capita

- **Infrastructures**
  - Water supply and distributions mains → 487 kg/capita

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Aluminium

- The energy required to produce aluminium from scrap metal is approximately 5% of that required for primary production.

- The lifetimes of aluminium in buildings and infrastructure is estimated to be 40-50 years, in transportation facilities 10-30 years and in packaging only several months.

Aluminium in-use stock in Connecticut, USA (2000)

363 kg/capita

3% Transportation
0% Infrastructure & Building
37% Equipment
60% Packaging

(Recalde, et al., 2008)

Aluminium in Connecticut, 2000

- Infrastructures & Buildings
  - Residential buildings → 92.8 kg/capita
  - Commercial buildings → 97.7 kg/capita

- Transportation
  - Light vehicles → 81.7 kg/capita
  - Marine vessels → 32.7 kg/capita
  - Aircraft → 80% Al content

Landfill mining

“Landfill mining” is a process of excavating a landfill using conventional surface mining technology to recover e.g. metals, glass, plastics, soils and the land resource itself.

(Van der Zee, D.J., Achterkamp, M.C. e Visser, B.J. 2004)

The composition of waste recovered is dependent on the type of landfill, particular practices of deposition and the level of decomposition of waste, and the type and quantity of industrial waste and/or trade in them were deposited.

(Anacleto, S. 2008)
Landfill mining - Advantage

- Conservation of landfill space
- Reduction in landfill area
- Elimination of a potential source of contamination
- Mitigation of an existing contamination source
- Energy recovery
- Recycling of recovered materials
- Reduction in management system cost
- Site redevelopment

Landfill mining - Advantage

Reuse of such substances as:

- Soil cover material
- Material for energy recovery
- Wood for the production of woodchips
- Stones, bricks and mortar for road construction
- Concrete for crushing into coarse material
- Metals as iron, copper and aluminium for industry

Landfill mining in Moita, 2007

A mineração da lixeira permite:

- Reciclar 380 mil ton de finos como material de cobertura
- Utilizar 150 mil ton de fracção combustível para produção de CDR
- Obter 9.4 mil ton de materiais ferrosos
- Obter 2.7 mil ton de materiais não ferrosos
- Libertar até 91% do volume da lixeira

A estimativa do tempo necessário para o processamento de todos os materiais é de pelo menos 13 anos
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The material stocks
The in-use stocks

“In-use” refers to material that are currently providing services to people.

(Eckelman, M., Rauch, J. e Gordon, R. 2007)

The “material stock” is composed out of all the products that contain materials and have a life span longer than 1 year.

(Elshkaki, et al., 2004)

Three types of products:

*In stable use* → products with predictable life spans and potential for recycling

*In hibernating use* → products with a predictable life span but with low commercial value at end of life

*In dissipative use* → products with short lifetimes and low recycling potential

(Mao, J., e Graedel, T.E., 2009)
Heavy metal stocks in Stockholm, 1995

Lead

- In 2000, the lead in-use stock in Portugal was about 12.9 kg/capita.

Toxicity of lead

- The replacement of lead pipes in water supply infrastructure
- The use of lead-free electrical components in consumer applications
- The development of lead-free solders

Decline in lead demand and, over time, in lead in-use stocks

- The future availability of lead for recycling will exceed its demand.

68% Batteries
20% Pipes and sheets
8% Others
4% Alloys

The 20,000 ton of lead water pipes have a re-use potential to produce 1.6 million traditional car batteries.

Infrastructure density and lead stocks in Vienna in kg Pb per 1000 m²

Lead in Stockholm, 1995

Zinc

- To provide comparable services with existing technology to a large part of the world’s population, current technologies would require the entire zinc ore resource.

- Between 1850 and 1990, in the U.S., 73Tg of zinc placed in service, 23Tg remains in use, only 4Tg were recycled and 46Tg (63%) were lost in waste repositories or were dissipated.

The important uses of zinc are inherently dissipative, as in galvanizing and brass in brake linings.

Zinc in Stockholm, 1995

Nickel

A major use of nickel is as a component of stainless steel

- Buildings & Infrastructures
  - Chimney liners, smokestacks, bank vaults, kitchen sinks
- Transportation
  - Passenger vehicles, buses, large and specially trucks, rails
- Industrial machinery
  - Machinery (industrial and construction), manufacturing machinery
- Household appliances and electronics
  - Computers, refrigerators/freezers, stereos/radios, stoves
- Metal goods and other end uses
  - Cookware, kegs, restaurant equipment, fasteners

Nickel in New Haven, 2000

The nickel in-use stock in New Haven is about 2.6kg/capita.

Landfill mining in Sweden, 1996

Landfill mining in Moita, 2007

Composição física média dos resíduos depositados na lixeira da Moita – 673 233 ton

Composição do material combustível dos resíduos depositados na lixeira da Moita

Traditional and urban mines

- Mineral ores change very slowly over time, anthropogenic stocks change rapidly and therefore require better monitoring;

- Mining production of mineral ores can readily be adjusted to changes in demand provided that necessary reserves, capital and labour are available, whereas urban mining faces physical limitations because it is restricted to products in use becoming obsolete;

- The material in urban mines in generally of higher quality than mineral ores because already processed and purified material often requires less energy and technology to re-employ;

- There is extensive knowledge about the size and chemical and physical properties of geological ores but there is very little understanding of anthropogenic material stocks and their dynamics.