Urban Mining – Changes, Challenges and Opportunities
towards an integrated perspective with primary & secondary resources

Applied mineralogy II, 2015 (May, 11th)

Back in 1883...

Expo 1883: Swiss national exhibition
1. official map on mineral resources in Switzerland

Source: www.flickr.com-
Where the minerals are – the urban mining approach
Raw material groups → categories → actual situation & trends

Direct application
- e.g. gravel, sand, building stones, gypsum

Manufacturing (major technical process)
- e.g. cement, bricks, ceramics

Actual & future (secondary materials)
- e.g. reuse, recycling, recovery, waste to resource

Ore mining
- e.g. ore, energy resources, industrial minerals

Massnahmenplan zur Abfall- und Ressourcenwirtschaft 2011···2014
AWEL Amt für Abfall, Wasser, Energie und Luft

Past (in Switzerland)

Circular Economy (Kreislaufwirtschaft)

Towards the Circular Economy: Accelerating the scaling up of global supply chains

Why circular economy:
- Geological resources
- Energy demand
- Loss of material
- Anthropogenic stock

The five capitals model
1. Geology and environment (ecological domain)
2. Material properties and technology (technological domain)
3. Financial consideration (economic domain)
4. Social considerations (social domain)
5. International and national and stakeholder policy (governance domain)

Regierungsrat Markus Kägi, Baudirektor

Massnahmenplan zur Abfall- und Ressourcenwirtschaft 2011···2014
11. Februar 2011

http://www.srf.ch/sendungen/myschool/urban-mining
Success as a combination of:

- Data / basic information
- System / understanding
- Collaboration / team play
- Technology

- Knowledge and skills
- Efficient & effective
- Optimised disposal security
- Protection of the environment and population

Potential for waste and resource management

- Urban mining: Example canton Zürich

Framework for the waste and resource management

- Urban mining: some hands-on experience


Source: Journal -> Umwelt Perspektiven 1/13 (2013)
Highlights, keywords & numbers

- Material Flow Analysis (mass flows, substance flow analysis...)
- Concentrations in each step
- Comprehensive resp. holistic approach
- ZAR – technology, knowledge, network (development center for sustainable management of recyclable waste and resources)
- Located at KEZO (Kehrichtverbrennung Zürcher Oberland), a state of the art municipal waste incineration (MWI) plant
- Incineration and waste treatment as an integrated part of the Swiss policy of waste and resource management

ZAR – www.zar-ch.ch

Thermo-re
Includes all relevant steps:
- Pretreatment
- Thermal disintegration (exposure)
- Extraction of metals and minerals
- Beneficiation of metals (and minerals)
- In combination with generation of energy (e.g. greenhouse, glasshouse)

Numbers (quantities)
2011 –> 40'000 t bottom ash (slag)
- Fe-content (ca. 10%) –> 4'000 t
- Non-ferrous metal content –> 900 t
Al > Cu > Zn > Ag ....
Including approx. 10 kg gold (ca. 0.3 - 0.5 Mio sFr !)

Example MWI (municipal waste incineration; German – KVA Kehrichtverbrennungsanlage)
Input
Element concentration in municipal waste (input), MWI, Hinwil

Distribution
Element content (distribution) in specific fractions of municipal waste, MWI, Hinwil


Element-Flow
Estimated annual flow of selected precious metals, REE and other metals in the waste input, MWI (SWI), Hinwil ZH
81 kg/y –> Recovery rate approx. 15% (2012) –> 10-12 kg/y

Example MWI (municipal waste incineration; German – KVA Kehrichtverbrennungsanlage)
Gold and other (precious) metals

Estimated annual flow of selected precious metals, REE and other metals in the waste input, MWI (SWI), Hinwil ZH 2014ff

81 kg/y –> approx. 15% (2012) –> 10-12 kg/y
KEZO –> all SWI in CH –> potential economic value (best guess) –> up to 60-70 Mio sFr...

Example MWI (municipal waste incineration; german -> KVA Kehrichtverbrennungsanlage)

shift in system boundaries -> enhanced recovery rates?

GEOLOGY?

Primary: Reserves – Environment – Restrictions
Secondary: Quality – Availability – Processing

How much?

Common language?
• a walk through the material cycle...
• classic way of geological thinking vs. open minded recognition/comparison of primary and secondary mineral cycles
• ore minerals, ore grade, extractability, occurrence, disseminations, dissolution,...
• –> establishing of analogies

Primary resources: ore deposits & systems & typical elements

Global types of ore deposits, classified after 3 main geological processes.
Selective element enrichment, due to geodynamics and plate tectonics (including climate and atmosphere)

Primary Resources: Goldschmidt classification of the elements

The Goldschmidt classification, developed by Victor Goldschmidt, is a geochemical classification which groups the chemical elements according to their preferred host phases into lithophile, siderophile, chalcophile and atmophile or volatile.

siderophile (iron-loving), lithophile (silica(rock)-loving), chalcophile (sulphur- or ore-loving)


Secondary resources/waste: some typical elements in selected technologies
Neither reserves nor resources represent a fixed quantity! They predominantly reflect the intensity of geological exploration activities, driven by economic development and technical progress, which results in a continuous transformation from resources to reserves.
F&E-Programm Wirtschaftsstrategische Rohstoffe

- Full entlang Verkaufshaupte an energetischen mineralischen Rohstoffe
- Schwerpunkt auf Entwicklung von der Rohstoffe an vermehrungsfähigem Rohstoffen (minerale und Erdöl-
  und Erdgasrohstoffe)
- Vorgangliche Forschung bei den Demonstrationen, Verknüpfung mit Wirtschaftsforschung
- Capiet ca. 20 Mio. € (310 Mio. €)

Research needs Switzerland

The number of researchers in CH companies has been significantly reduced. “… this could be a future problem for Switzerland...”

EU, CH: Building materials industry

- Gravel & sand
  - EU: biggest sector within category «mineral resources»
    - tonnage
    - number of companies
    - number of employees
    - largest turnover
    - largest added value (net product)
  - CH: Demand
    - ca. 4-5 m³/year (6-8 t)
    - 50-65 Mio. t/year total
    - 3.1 – 2.3 Mrd CHF turnover
    - hidden amount of materials ca. 0.5 kg/kg imported gravel

Recycling and re-use of construction materials
Application of secondary raw material
- e.g. concrete, pavements, gravel, ash ...

Development of the gravel demand vs. deconstruction material production – Situation Switzerland

Structural engineering
Civil engineering
Increasing amount of secondary materials
- building up of a stock on resources decreasing demand of primary gravel

The number of researchers in CH companies has been significantly reduced. “… this could be a future problem for Switzerland...”
Urban mining: Example canton Zürich – Aggregates

New definition of values: Products have to be evaluated against future requirements without burdening them with the past – not only the aggregates can be discussed...

...it's not that easy!

Characterisation of metal-depleted dry incinerator bottom ash (IBA)

Analysis And Characterisation of Metal-depleted Dry Incinerator Bottom Ash (IBA)

Attempt of A Product Definition For The Cement Industry

Not only the aggregates have to be discussed...

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Characterisation of Metal-depleted dry incinerator bottom ash

Master thesis Anja Pestalozzi 2011 (DERDW, SGTK, ZAR, JCF)
Characterisation of metal-depleted dry incinerator bottom ash

Analytical methods for IBA

- Grain size analysis
  - Impact of transport and homogenising
- Chemical analysis
  - X-ray fluorescence (XRF)

Results of lab experiments

- Significantly worse strength with IBA
- Volume expansion within 28 days:
  - 1% - 5%
  - 10% - 15%
  - 40% - 64%

... and, finally, ;-) ... the end