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# Urban mining as a contribution to the resource strategy of the Canton of Zurich

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ABSTRACT

Urban mining is increasingly being recognised as an important component of resource strategies of public authorities, not only because it contributes to environmental protection, but also because it is a source of valuable recyclable materials. We demonstrate that the sustainable livelihoods (SL) framework can be used for public policy making in waste management by presenting the approach and experiences of a review study termed '*urban mining potential analysis*' and its application to antimony, copper, gypsum, gold and rare earth elements. This article uses the rare earth element (REE) group to illustrate and present an overview over information and knowledge gaps concerning urban mining. The analysis shows that rare earth element recycling can be more environmentally friendly than primary production, particularly if the latter comes from countries with weak enforcement of environmental legislation. On the other hand REE recycling often cannot compete with large scale primary production because market prices do not reflect the social and environmental impacts of production, and because the avoided impacts of waste decontamination and reduced waste production are not considered. The urban mining potential analysis can be used to support decision making and the setting of priorities for future research and public action. The findings of the study and expert opinions based thereon contribute to the selection of measures and the formulation of public waste management and resource strategies in general.



## 1. General introduction and background

The Canton of Zurich is developing a waste management plan (AWEL, 2015), which accounts for the growing relevance of urban mining as a material source, and for the objective of reducing the environmental footprint of resource consumption. Therefore, projects that aim at recovering valuable materials, such as reclaiming phosphorus from sewage sludge, or extracting ferrous and non-ferrous metals from municipal solid waste incineration slag, are of great importance. Other high priority urban mining projects include recovering heavy metals such as zinc, cadmium and lead from waste incineration filter ash, increasing the recycling rate of mixed building and deconstruction materials (Lichtensteiger, 2006), and making concrete granulate widely accessible for the building and construction industry. While for some materials the material flows and efficient processes for recovery are widely known (Hendriks et al., 2000; Obernosterer and Brunner, 2001; Brunner and Rechberger, 2004), this is not the case for, amongst others, rare earth elements (REE). To pool information about urban mining resource potentials from different sources, collaboration between authorities, research institutions and industry is imperative.

We aim to provide structured information and identify knowledge gaps regarding the evaluation of urban mining potentials in a broad sustainable development perspective. We demonstrate the feasibility of our *urban mining potential analysis* approach through its application to REE, and its relevance by submitting the results to a peer review process.

With regard to the monitoring of running projects, and also for the reappraisal of the cantonal engagement in running projects, a twofold approach was taken to assist the formulation of an urban mining resource strategy. First, expert opinions were collected and discussed during several workshops in order to define strategic principles for resource governance and waste management. Second, an analysis of the potential of urban mining was carried out by compiling and summarising existing knowledge, in order to establish the relevance of different aspects for the valuation of in-use and waste materials.

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### 1.1. Strategic principles

In the course of an international expert workshop held in September 2012, principles for a cantonal resource strategy that integrates the field of urban mining were discussed together with representatives from research, industry and the public authorities. The prerequisites for appropriate waste treatment were identified; important elements for a resource strategy of the public authorities, especially in the field of urban mining, were devised, and the responsibilities of the public authorities concerning the recovery of secondary raw materials were formulated. A lack of system understanding and a knowledge documentation and communication deficit were recognised to be a strategic problem and among the most pressing issues requiring attention.

During the workshop a need for action was identified for the five following areas of engagement:

(1) Determine fields of action by knowledge and competence development

A general understanding of the urban mining system has to be generated by compiling and expanding available data and information. This research is supposed to indicate existing data and model gaps and generate new knowledge. Primary and secondary raw materials have to be compared, as they usually have to compete with each other on the commodity trade market. Their reserves and reservoir quantities, concentrations, material flows as well as their environmental and economic costs are among the most important parameters.

(2) The waste management principles and the high significance of sinks have to be considered

Waste has to be prevented, minimised and recycled according to the Swiss waste management principles and the Swiss environmental legislation, foremost the Environmental Protection Act (Swiss Confederation, 1983) and the Technical Ordinance on Waste (Swiss Confederation, 1991). If the reuse and recycling of materials is not possible, waste shall be stripped from pollutants for a safe storage in landfills according to the current 'state of the art'. To allow for future recycling (landfill mining), waste preferably should be stored in mono-landfills (sinks), and, if possible, in a chemically inert state. The progressive improvement of recycling technologies has to be ensured, always taking into account the release of potentially harmful substances and pollutants.

(3) Success factors have to be implemented for individual substances and raw materials

Resource and system knowledge is to be made publically available and must be actively communicated. It is to be indicated where profound knowledge exists and where gaps remain to be filled, for instance by applied research. Communication is crucial and discussions are to be initiated with the relevant actors, and cooperation between public authorities and industry, like public–private partnerships (PPP), developed where required. Economic potentials are to be evaluated and supply risks are to be minimised by striving for self-sufficiency and paying attention to the quality and marketability of secondary raw materials. Furthermore the Canton of Zurich, as a public infrastructure owner, can influence the implementation authoritatively and directly.

(4) Measure progress towards sustainability by the use of indicators

For measuring and monitoring progress appropriate methodologies are to be critically evaluated (Thomas and Birat, 2013). The selected indicators should be relevant, accepted, credible, easy and robust according to the 'RACER' evaluation (European Commission, 2012) and ecological criteria such as the 'Swiss ecological scarcity method' (Frischknecht et al., 2009), 'resource efficiency' or a 'sink indicator' which discriminates acceptable from unacceptable flows to sinks (Kral et al., 2014) are to be used.

(5) Consider product design instruments to increase eco-efficiency of materials

This point goes beyond waste management and is only hinted at in this article. Relevant is not only the supply of secondary raw materials (waste management, recycling industry) but also the influence on the eco-design and even consumption patterns of the society. Pilot and flagship collaboration projects as well as national and international networking can leverage technological development. Gathering information on environmental profiles of products and services (integrated product policy) as well as voluntary agreements with the economy are of great importance.

### 1.2. Choice of instruments

According to Borrás and Edquist (2013) a strategic problem, for instance a deficit of technological innovation, exists when the objectives of private or public organisations are not met. When a problem, for instance a low recycling quota of a material (as is the case of REE), has been identified, a problem analysis is required in order to identify the causes and make a qualified selection of suitable instruments for an effective strategy mix as depicted in Fig. 1. For devising a resource strategy and analysing different problems (e.g. related to the urban mining potential of different materials) the process would be iterated until a useful strategy mix is defined and can be implemented.

The selection of instruments is already an expression of the strategy itself (Borrás and Edquist, 2013). Considering the knowledge deficit identified by the expert workshop, composing fact sheets can be understood as suitable instrument to aggregate and document available information, while incorporating expert knowledge. At the same time, fact sheets are already a part of the strategy mix to communicate remaining shortcomings and fields of action. In a second run, having the fact sheet knowledge at hand, the whole process would be repeated in order to select additional or other instruments to alleviate the most severe remaining deficits.

### 1.3. Urban mining potential analysis

The connotation of the expression '*urban mining potential analysis*' in this article describes an approach which seeks to systematically gather and present structured information according to the '*sustainable livelihoods (SL) framework*' and the associated '*five capitals model*' (DFID, 1999; Giurco and Cooper, 2012). The SL framework is widely used in the context of sustainable development. Its balanced consideration of different capital domains emphasises the relevance of non-economic aspects for public policy decision making, while its simplicity makes it suitable for communication of public strategies and supports dissemination. Horsley et al. (2015) argue that the "SL framework can be used not only to organise information, but also to help its users to restructure information and knowledge from multiple perspectives", which they consider to be another missing thread in resource literature. The five capitals model as proposed by Giurco and Cooper (2012) adapts the SL framework definition of sustainability to minerals

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