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The institutional capacity for a resource transition—A critical review of Swedish governmental commissions on landfill mining

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ABSTRACT

Recycling of minerals from waste deposits could potentially double the recycling flows while offering an opportunity to address the many problematic landfills. However, this type of activity, i.e., landfill mining, brings many advantages, risks and uncertainties and lacks economic feasibility. Therefore, we investigate the capacity of the Swedish authorities to navigate the environmental, resource, and economic conditions of landfill mining and their attitude to support such radical recycling alternatives towards a resource transition.

By analyzing three governmental commissions on landfill mining, we show how the authorities seem unable to embrace the complexity of the concept. When landfill mining is framed as a remediation activity the authorities are positive in support, but when it is framed as a mining activity the authorities are negative. Landfill mining is evaluated based on how conventional practices work, with one and only one purpose: to extract resources or remediation. That traditional mining was a starting point in the evaluation becomes particularly obvious when the resource potential shall be evaluated. The resource potential of landfills is assessed based on metals with a high occurrence in the bedrock. If the potential instead had been based on metals with low incidence in the Swedish bedrock, the potential would have been found in the human built environment.

Secondary resources in landfills seem to lack an institutional affiliation, since the institutional arrangements that are responsible for landfills primarily perceive them as pollution, while the institutions responsible for resources, on the other hand, assume them to be found in the bedrock. Finally, we suggest how the institutional capacity for a resource transition can increase by the introduction of a broader approach when evaluating emerging alternatives and a new institutional order.

1. Introduction

The minerals found in today's applications come mainly from the Earth's crust. The social and ecological consequences of extracting these minerals are severe (UNEP, 2013). Therefore, a transition of the resource sector towards a predominant use of waste as the main source of resources in the economy has been politically proposed (cf. European Commission, 2015). However, the waste streams are too small to cover a significant share of the increasing demand on resources. At the same time, the recycling rate of many base metals such as steel, copper, lead and aluminum is already high in countries with developed waste management systems and cannot increase significantly (UNEP, 2011).

One way to increase recycling would be to focus on a type of mineral stock that is often forgotten in discussions about resource availability (cf. European Commission, 2008; USGS, 2015), namely those excluded from the anthropogenic flows and over time accumulated in different waste deposits (Ayres, 1997). Some researchers claim that waste deposits are bursting with resources, i.e., globally the amount of copper is comparable to the current in-use stock (Kapur, 2006). At the same time, many landfills pose risks to the environment and health. The strategy of extracting disposed resources combined with remediation measures of landfills, i.e., landfill mining, could thus be a strategy to handle the many problematic landfills, while potentially avoiding primary production.

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Like other sustainability-driven transitions, a *resource transition*, i.e., the transition towards dominant use of secondary resources brings not only benefits but also numerous problems, uncertainties, and negative aspects. Recycling of disposed materials can partly substitute for primary production, thereby mitigating its consequences, but may at the same time cause other socio-ecological implications such as impacts and risks related to the landfill excavation. Furthermore, a major obstacle to recover minerals from unconventional stocks such as landfills is the lack of economic feasibility, as the costs typically exceed revenues (Van Passel et al., 2013; Frändegård et al., 2015). This environmental ambivalence and lack of economic turnover is common in most emerging environmentally driven niches such as wind turbines (e.g. Leung and Yang, 2012), organic food production (DeLonge et al., 2016) and biofuels (Tenenbaum, 2008; Levidow & Papaioannou, 2013).

However, the lack of profitability depends partly on a market situation where policies and economic frame conditions are adapted to conventional methods of agriculture, energy (IEA, 2016), and in this case, mineral production (Johansson et al., 2014). As environmentally driven transitions rarely bring an explicit market advantage, neither to the user in terms of lower price and higher performance nor for the company due to lack of profitability and lower returns, their success has typically depended on political intervention through, for example, various types of policy instruments. For example, the market share of biofuels has increased thanks to subsidies (cf. IEA, 2016), which have demonstrated an openness to different types of fuels: ethanol, biogas, hydrogen and electric vehicles.

The government support of the emerging alternatives, however, puts demands on capacity to navigate among the environmental benefits, risks, and uncertainties from such activities. To realize the potential of landfills and strive towards a resource transition, many researchers and industrial actors have proposed favorable policy changes to increase recycling (Van Passel et al., 2013; Johansson et al., 2014; Schelin, 2014). The governmental attitude towards innovative resource operations targeting novel mineral stocks such as landfills is, however, still unclear, as is how they navigate its pros and cons.

Sweden is one of the countries where landfill mining has received widespread attention and is mentioned for example in the national waste plan by the Swedish Environmental Protection Agency (SEPA, 2012). As a consequence, the Swedish government has formed commissions to investigate the potential and opportunities to support recycling of deposited waste (SEPA 2013, 2015; SGU, 2014). These reports open up opportunities to analyze how governmental agencies evaluate and make sense of landfill mining. This is in a country where the mineral policy has by tradition been adapted for minerals to be mined from the Earth's crust (Johansson et al., 2014).

The aim of this paper is to assess the governmental ability and capacity to evaluate landfill mining. With this background the following research questions can be formulated: how do Swedish governmental agencies navigate the advantages, disadvantages, and uncertainties of landfill mining? What is the institutional capacity of the Swedish government to evaluate emerging recycling alternatives? Institutional capacity should be understood as the ability of public institutions to manage, solve problems, and achieve goals in relation to increased secondary resource extraction.

2. Landfill mining: resource, environmental and economic aspects

The research on landfills as mines has so far been engineering-oriented with a focus on three main aspects: the resource potential, economic feasibility, and environmental impact of recovery operations as seen in Table 1. These aspects have been examined either by implementing small-scale pilot studies, material flow analyses or assessments of full-scale mining operations. Successful large-scale recycling projects are rare, but there are exceptions (e.g. Wagner and Raymond, 2015).

2.1. The resource potential

A review of the literature indicates that landfills hold great resource potential, but that it can be difficult to utilize. About half of the excavated base metals from the Earth's crust such as copper have accumulated in various types of waste deposits such as landfills, tailings, and slag heaps (Kapur, 2006). The advantage of extracting minerals from waste deposits is that they are gathered in a confined place and are immediately available. The concentration of minerals in some waste deposits, such as 2% copper in a shredder landfill in southern Sweden (Alm et al., 2006) are far higher than in active copper mines, which are on average 0.8% (Crawson, 2012), but lower than in a mobile phone.

Landfills are, however, just like mines finite stocks of minerals, and will deplete if landfilling of minerals stops. Some waste deposits and in particular municipal landfills have unfavorable conditions for resource extraction, such as a heterogeneous and humid content (Johansson et al., 2016). Furthermore, the quality of the material in landfills deteriorates over time due to oxidization and biodegradation (USEPA, 1997). There are also no reliable technologies for sorting disposed waste with high efficiency and

Table 1
Resource, environmental and economic aspects of landfill mining found in the scientific literature is presented according to advantages and disadvantages. Aspects marked with (*) are potential indirect consequences of landfill mining.

	Advantages	Disadvantages
Resource	+ In total, significant amounts of minerals + Directly available + High mineral concentration + Minerals confined in one place	– Lack of sufficient technologies – Heterogeneous material – A finite mineral stock – Declining quality over time – Some landfills are relatively small
Environment	+ Metal recycling avoids CO_2 emissions* + Avoids methane emissions* + Remediation and management of hazardous waste + Upgrade the landfill construction according to existing safety standards + After treatment and reduced leaching*	– Burning of plastic increases CO_2 emissions* – Increased noise, odor and transport – Risk of leakage, landslides and collapse – Health risks for workers – Local residents' concerns
Economy	+ Positive community effects, e.g., work opportunities + Increased self-sufficiency of minerals* + The cost of remediation can decrease + The land can be reclaimed into parks or housing + Additional landfill space could be created	– Costs higher than revenues – Metals are the only fraction that generates an income – Regulatory barriers such as landfill bans and taxes