18/2017

Lederer, J.; Syc, M.; Bogush, A.; Fellner, J. (2017) „A network approach towards a secondary raw material inventory for Europe applied to waste incineration residues" In: CD-Proceedings Sardinia 2017, 16th International Waste Management and Landfill Symposium "Sardinia Symposium 30th Anniversary Book", 2-6 Oct. 2017, S. Margherita di Pula (Cagliari), Sardinia, Ed.: Cossu, R.; Stegmann, R., CISA Publisher, Sardina, paper 170, p 1-6, ISSN 2282-0027, ISBN 978-88-6265-010-6

A NETWORK APPROACH TOWARDS A SECONDARY RAW MATERIAL INVENTORY FOR EUROPE APPLIED TO WASTE INCINERATION RESIDUES

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SUMMARY: European governments as well as multilateral bodies (EU) in Europe are increasingly interested in the strategic utilization of secondary raw materials, i.e. from wastes. This should be achieved by developing a secondary raw materials inventory for both, states as well as the EU. What we have learned from past and present ambitions towards producing secondary raw materials is i) that there are many more or less isolated activities going on by different research groups all over Europe, and ii) when it comes to secondary raw materials inventories, there is a trend that selected institutions are doing research or consulting projects where the result are reports or databases with selected features. However, these databases/reports do often neither have a clear structure, nor they are frequently updated. In order to structure and group these activities, we suggest to: i) design a framework for the reporting of secondary raw materials and adjacent data, and 2) to built-up a network of competent institutions (rather than just a database) that can provide and update the information required within a secondary raw materials inventory. To do so, we use the case study of residues from municipal solid waste incineration (MSWI), mainly bottom and fly ashes. The framework for reporting of secondary raw material inventories of countries suggested is generally derived from two major sources, i) the procedure of compiling the Mineral Yearbook by the US Geological Survey (USGS, 2016), and ii) the procedure of mining development as illustrated by Harman and Mutmansky (2002). The first means that a network of competent institutions in analogy to the competent persons as defined in mining codes, is built up. These institutions are located in every country in the EU. The second means that for the reporting, each competent institution follows a stepwise approach (shown in Lederer et al. 2016) that consists of retrieving data on waste incineration technologies and mass flows of its residues, and their composition with respect to the extraction of secondary raw materials. In the first step, easy accessible data from public available information is retrieved.

1. INTRODUCTION

European governments as well as multilateral bodies (EU) in Europe are increasingly

interested in the strategic utilization of secondary raw materials, i.e. from wastes. One ambition in this direction is a secondary raw materials inventory for both, states as well as the EU.

Two things that we have learned from past and present ambitions towards establishing secondary raw materials inventories in Europe are:

1) Selected institutions are doing research or consulting projects where the results are reports or databases with selected features, e.g. quantity of secondary raw materials. However, these results do often neither have a clear structure, nor are they frequently updated.

2) There are many more or less isolated activities going on by different research groups all over Europe on investigating anthropogenic resources (i.e. wastes) and the production of secondary raw materials (i.e. recycling materials).

In order to structure and group these activities, we have to 1) design a framework where the activities on producing secondary raw materials from wastes can be integrated in, and 2) to built-up a network of competent institutions (rather than just a database) that can provide and update the information required within a secondary raw materials inventory. To do so, we would like to carry out a first case study within the Working Group (WG) 3 of the COST Action “Mining the European Anthroposphere” (MINEA) on a particular waste stream, namely solid residues from municipal solid waste incineration (MSWI), mainly bottom ashes and APC residues (fly ashes from boilers, filter ashes from electrostatic precipitators and fabric filters).

The general objective of the WG3 in MINEA is to built-up a network of competent institutions from different European countries which can provide the information required for a secondary raw material inventory. The specific objective is to use the case study of solid waste incineration residues as a role model for such a network.

2. MATERIALS AND METHODS

2.1 General

The framework for reporting of secondary raw material inventories of countries suggested is generally derived from two major sources, i) the procedure of compiling the Mineral Yearbook by the US Geological Survey (USGS, 2016), and ii) the procedure of mining development as illustrated by Harman and Mutmansky (2002). The first means that a network of competent institutions in analogy to the competent persons as defined in mining codes, is built up. These institutions are located in every country in the EU.

Evaluation step	Method	Result
1. Prospection	Identification of relevant and potential secondary raw materials (e.g. metals, minerals) in MSWI residues (data on from literature)	Relevant potential secondary raw materials are identified for different MSWI residues (considering different MSWI technologies and input materials)
2. Exploration	Detailed material characterization using different methods of sampling and laboratory analysis	Size, grade (concentration), material compound incl. uncertainties
3. Evaluation	Economic, ecological/environmental, societal, etc. evaluation of different secondary raw materials processing technologies	Costs/revenues ratio EIA/LCIA enpoints Multi criteria analysis (MCA) results
4. Classification	Economic: McKelvey cross classification (USGS) Ecological/Environmental: comparative assessment MCA: socio-economic, feasibility, knowledge	USGS: 2-axes reserves, resources, other occurences UNFC-2009: 3-axes resource diagram

Figure 1. Evaluation and classification procedure for anthropogenic resources - example MSWI residues (after Harman and Mutmansky 2002, Lederer et al. 2014, Fellner et al. 2015)

The second means that for the reporting, each competent institution follows a stepwise approach (shown in Lederer et al. 2016) that consists of retrieving data on waste incineration technologies and mass flows of its residues, and their composition with respect to the extraction of secondary raw materials. In the first step, easy accessible data from public available information is retrieved. In the second step, data established but not publicly available is retrieved.

2.2 Evaluation steps

2.2.1 Prospection

Prospection in natural resource evaluation can be seen as the search for an ore for future mining activities. This search can be either commodity or site-specific. Commodity specific search would mean that the target commodity (e.g. fossil fuels, metals, minerals) is given, but the sites for potential mining activities are not. Site-specific means that the sites for potential mining activities are given, but the final decision on which commodities should be mined from these sites is not. In analogy to our case study of MSWI residues, we would talk about a site-specific search, as the sites, namely the MSWI plants, are known. Consequential, the decision on the commodity to look at is not yet done, as more than one commodity can potentially be produced from MSWI residues (metals, cement additives, salts, fertilizers). In the mining industry, prospection is often done based on geological maps, review of drilling and sampling reports etc. For MSWI residues, the prospection would contain in analogy a literature review.

2.2.2 Exploration

Based on the result of the prospection, the decision is carried out which deposits should undergo an Exploration (Lederer et al., 2016). In natural resource evaluation, the exploration is more detailed and thus also more expensive to be carried out. Thus, a pre-selection of potential sites has to be done, based on the prospection – otherwise it is getting way too expensive. The same counts for anthropogenic resources, thus MSWI residues. Furthermore, based on the prospection, a decision should be made on which secondary raw materials one should focus on (metals, cement additives, salts, fertilizers). If the prospection phase result do not allow to make this decision, additional information based on sampling, analysis, tests must be obtained, but only if there is evidence that the production of a secondary raw material that meets the requirements (e.g. requirements of metal smelters or the building industry), of which some are market-based, and some are legal (e.g. European or National Norms), is possible.

2.2.3 Evaluation

However, this would also be a part of the evaluation phase, which shows that the allover evaluation process is an iterative one. The evaluation of natural resource deposits is determined by the classification system used, and can consider purely economic and geological (as in the McKelvey Box of the USGS) attributes (e.g. cost/revenues ratio), but also in addition socio-economic, environmental, and legal aspects (as in the UNFC 2009 code – a description of this code is shown in Winterstetter et al. 2015). For real mining projects, an environmental impact assessment (EIA) has to be carried out, but for mining companies, this is more of a legal question with economic consequences. As anthropogenic resource evaluation usually deals with wastes, a wider range of evaluation methods can and has to be considered. Beside economic and socio-economic considerations, EIAs, Life Cycle Impact Assessments (LCIAs), or Multi Criteria Assessments (MCA) are possible to help in deciding for “mining” an anthropogenic resource like MSWI residues or not.

2.2.4 Classification

No matter which evaluation methods and aspects are considered, in the end, a classification is performed in natural resource evaluation. These are either done by mining companies themselves (in order to decide between different deposits for mining), but also by National Authorities and International Organizations like the USGS, the UN ECE, etc. (in order to make strategic use of a countries' or the worlds mineral resources). One of the most renowned natural resource classification schemes is the so-called McKelvey Box of the USGS. It classifies natural resource deposits according to economic (cost/revenue ratio) and geological (knowledge on size of a deposits) features. Such a classification would also be possible for anthropogenic resources like MSWI residues. It can help to illustrate the evaluation results for the utilization of different MSWI residues to produce various secondary raw materials from MSWI plants.

2.3 Structure for a secondary raw material inventory

Contrary to data-base approaches, the suggested structure constitutes of a network of institutions. The role model for this structure is the Mineral Yearbook of the US Geological Survey (USGS). For this year book, country experts all over the world report some key information (e.g. size, grade, mining stage of deposit) on natural mineral, metal, and fossil fuel deposits to the USGS. In analogy to this reporting system, the present Cost Action MINEA aims to built-up such a network of country expert institutions for the case study of MSWI residues in Europe. Figure 5 shows a possible structure of such a network for the MINEA project.

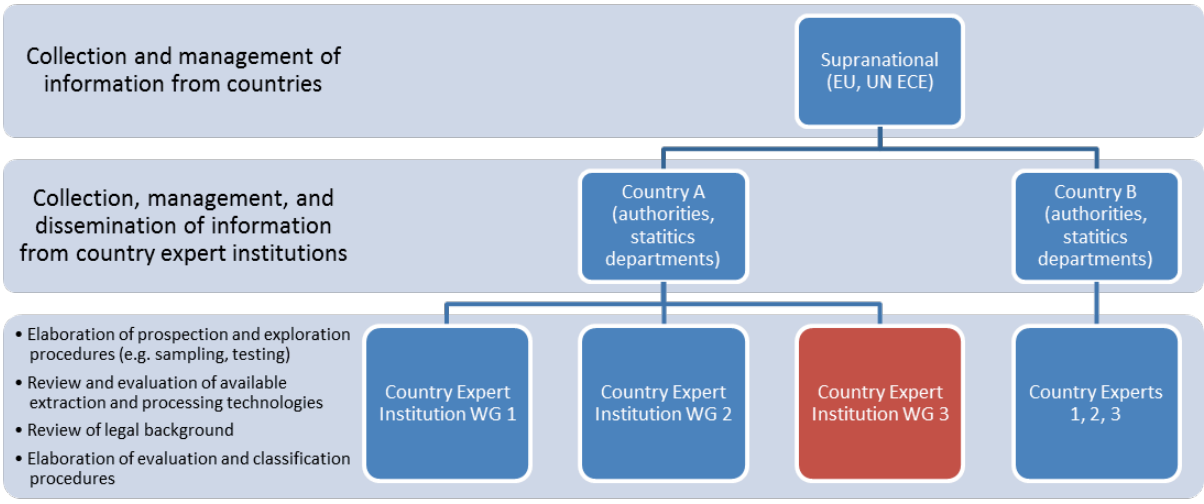

Figure 2 Structure for a Secondary Raw Material Inventory for MSWI residues in Europe based on a network of expert institutions

The expert institutions participating in the network should have major experiences in secondary raw materials that can be produced from MSWI residues. In analogy to the USGS country experts, some of the possible reporting task of a country expert institution are presented in Table 1 in the Results and Discussion section. As a first reporting task, quantities and handling practices of MSWI residues in Europe where determined based on a questionnaire survey with expert institutions from different European countries. The reference year for the survey was the last year where data was available, in the most cases 2015. Only data from publicly available documents were used by the survey participants. For the results section, however, only a sample of three countries, namely Austria, Czech Republic, and the United Kingdom will be presented. These are then compared to official data, for instance by EUROSTAT.

3. RESULTS AND DISCUSSION

3.1 Reporting tasks

Table 1 shows some possible reporting tasks for country expert institutions in the MINEA approach.

Table 1. Possible reporting tasks for country expert institutions

	Natural resource deposits	Anthropogenic resource MSWI residues	Comments and examples on some major differences between natural and anthropogenic resources
Location	Location of deposits	Location of MSWI plants	Contrary to the resources considered by USGS (deposits, non-renewable or stock resources), the resource under investigation in MINEA WG3 is a flow resource, as it continuously appears at different time intervals.
Size	Size of each deposit	Amount of MSWI residues generated	Natural resource deposits are there, they don't change in quantity. Only the knowledge on their quantity can change. For MSWI residues, the quantity can change, depending on various factors (e.g. different APC system, higher amount of MSW incinerated,...).
Grade	Grade of targeted commodities	Grade of targeted commodities	The plural is not a mistake. From natural resource deposits, as well as from MSWI residues, different primary or secondary raw materials can be produced. For instance, in natural Zn deposits Cd is present too and only produced as a byproduct. In this case, the extraction of both raw materials is in contradiction with each other. In MSWI residues, however, the extraction of different secondary raw materials is often contradictory. This is the case, for instance, for the utilization of CaO, SiO_2, etc. in MSWI ashes either as binder, or the extraction of metals like Zn or Cu from MSWI ashes. However, this again depends on the technology utilized. What is also important here is the sampling procedure and type of lab analysis used to determine the grade.
Impurities	Impurities in deposits	Impurities in MSWI residues	Impurities impair the quality of the raw material produced from the resource, and they usually require higher processing costs. An example from natural resource deposits would be Cd sedimentary phosphate deposits. For MSWI residues, an impurity constitutes by the type of secondary raw material produced. Thus, an impurity for one utilization can be the targeted commodity of another utilization. An example would be P in sewage sludge incineration ashes, which can be the target commodity for producing P fertilizer from the ash, but an impurity if this ash should be used as cement substitute. The sampling procedure and type of lab analysis used also matters in this point.
Stage of mining	Stage of mining the deposits	Stage of "mining" the MSWI residues	In natural resources, deposits are classified also due to their mining stage. There is a wide range – from just having some idea on the size and existence of a deposit based on geological maps to an already almost exploited deposit. For MSWI residues, the analogy would be the technology already installed for extracting secondary raw materials. An example would be a bottom ash from MSWI without any metal recovery (pre-mining stage) compared to a beyond state-of-the-art ferrous and non-ferrous metal recovery.
Legal background	In the country where the deposits are located	In the country where the MSWI plants are located	For extracting raw materials from natural resources, different legal issues must be considered. These may differ from country to country. Examples would be rules on reporting of deposit sizes, tax systems, but also environmental protection. For MSWI residues, typically environmental protection laws such as waste management and technology acts, waste disposal acts, end-of-waste-criteria, but also waste testing guidelines can be of relevance. An important point would be here also the national legal reporting system, as this is also a source of information for miners (and researchers). In Austria, for example, MSWI plants must by law report their air emissions. However, they don't have to frequently report the composition of their MSWI residues.

3.2 Quantities of MSWI residues generated in Europe

Expert institutions of nine countries in Europe participated in the survey. The result showed some major differences to other statistics available, which was not only based on the reporting year, but also due to different interpretation of data. For instance, Austrian official reports distinguish between MSW, residues from MBT, and source-segrated MSW incinerated, while EUROSTAT does not have such a distinction. This explains the difference in the quantities of wastes incinerated. Furthermore, it was not possible from simply reading Austrian Statistics to trace out the origin of MSWI residues like fly ashes based on the incineration technology. For this differentiation, a deeper understanding of the MSWI plants in Austria is required. Higher data availability was found for Czech Republic, as MSWI plant operators have to publish the regarding data on an annual basis. Together with the fact that the Czech Republic only has three MSWI plants in operation, this means a better overview on the amounts of wastes incinerated and MSWI residues produced. However, a centralized data base as in Austria is not present in the Czech Republic. For the UK, most data is published by Department for Environment, Food & Rural Affairs (DEFRA). What makes the management of data in the UK challenging is the rapid growth of MSWI capacity in the country. Between 2013 and 2016, the number of installed plants increased from slightly over 30 to 45. As the target is over 80 MSWI plants for the UK in the coming years, this challenge might continue to exist.

For all three countries, the major information of national statistics is provided in the National

language. While this is of course no problems in terms of international readability for the UK, it is for Austria and the Czech Republic.

4. CONCLUSIONS

The first steps of building up a network of experts for the evaluation and classification of secondary raw materials from MSWI residues have been undertaken. Future activities will focus on recovery technologies for the production of different secondary raw materials and products from MSWI residues.

AKNOWLEDGEMENTS

This work was carried out in the COST Action “Mining the European Anthroposphere” CA15115, supported by COST (European Cooperation in Science and Technology).

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