MINING the EUROPEAN ANTHROPOSPHERE

BOOK of ABSTRACT
Poster session at Conference on Mining the European Anthroposphere

20-21 February 2020,
University of Bologna, Italy

Summary: The conference committee invited experts to give poster presentations about research project(s) in the field of COST Action MINEA. More than 50 poster abstracts have been submitted until end of Nov 2019. Finally, 43 abstracts have been selected and included in this book of abstract.

This book of abstract is organized according to the MINEA Working Groups, which address material recovery from four different sources, namely residues from extractive industries, landfills, construction and demolition waste, and residues from municipal solid waste incineration, as well as the classification of anthropogenic resources.

The poster presentation took place on 20 Feb 2020 at the Mineralogy Museum "Luigi Bombicci", 1 Piazza di Porta S. Donato, Bologna, Italy. The posters can be retrieved from the website http://conference.minea-network.eu/poster.

This book of abstracts can be retrieved from https://doi.org/10.34726/4nat-yb46.

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Content

1 Material recovery from construction and demolition waste

CEMENT MORTARS MANUFACTURED WITH INSULATING MATERIAL RESIDUES TO REDUCE THE USE OF SAND IN THE CONSTRUCTION INDUSTRY

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Currently the construction of buildings is one of the main pollution-generating activities in the European Union, so it is essential that the sector orients itself and evolves towards a circular economy model based on reuse, repair and recycling construction and demolition waste (CDW), and to use them as by-products, being able convert them in a highly viable option, as opposed to the current situation of landfilling. The use of insulating materials is currently booming due to the increase of thermal and acoustic requirements marked by regulations about the construction of homes, which seek to contribute to energy savings and improve thermal comfort. This has caused an alarming growth of mineral wool waste as is the most used insulation in the European Union, so it is essential to recycle or reuse it is nonexistent today.In addition, this waste will replace part of the aggregate of the mortar, a fundamental issue if we take into account that the extraction of sand worldwide has skyrocketed in the last 30 years, being the most demanded natural resource in the world after water, especially by the construction sector, that demands about 85% of sand This will also reduce the CWD generated by the construction industry.In addition, in Spain the consumption of aggregates for construction has grown by 10.5% in 2017, up to 12 million tons, likewise the aggregates quarries produced 40.8 million tons of industrial aggregates for, among other uses, the manufacture of binders.The results of the tests performed show that even though the mechanical resistance decreases there is a good connection between the cementitious matrix and the residues, while also maintaining optimal durability properties, making it a sustainable and innovative alternative to the commercial fibers currently used by the company reinforcement of mortars.

ADDRESSING BUILDING STOCK RENOVATION AND SELECTIVE DECONSTRUCTION WITH A LIFECYCLE PERSPECTIVE

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Several existing studies apply building stock energy models using a range of bottom-up approaches to estimate the energy demand of large building stocks and the consequent energy saving potential achievable by the implementation of retrofit measures. Despite the fact that the environmental impacts of buildings linked to their use phase are not negligible, nowadays the transition to low-ene rgy and nearly-zero-energy buildings determines an increased importance of the construction phase. Therefore, many authors have suggested a shift towards a life cycle approach for urban building stocks. We present a geospatial data model for the life cycle environmental impact assessment of building stocks at the urban scale, including a sensitivity analysis to identify the most significant input parameters explaining the variability of final energy use. Temporal aspects are considered both in the life cycle inventory and life impact assessment phases, by considering the evolution of the existing housing stock and applying time-adjusted carbon footprint calculation. However, when, for various reasons, building renovation is not a viable option and deconstruction is needed, selective deconstruction is an important action in order to foster materials circularity. In this respect, pre-dem olition audits play a very important role for resource management. In Luxembourg, an obligation to conduct pre-demolition audits was introduced as a legal requirement, transposing the European Waste Framework Directive (referred to as “material inventories”). We analysed the case of the Jean Monnet building, established in the 1970s, consisting of approximately 125,000 m^2 of office space and facilities for approximately 2000 staff and located in the city of Luxembourg. Both, the material inventory and the analysis of building contaminants during the early phase of the project allowed defining technical specifications and specific award criteria in the call for tenders to reinforce state of the art methods for deconstruction and to channel resource management.

GYPSUM PLASTERBOARD RECYCLING – A SUSTAINABLE APPROACH

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Gypsum (calcium sulfate dihydrate) has excellent building material properties and has been widely used in constructions in the last decades in many countries. Accordingly, an increase of waste gypsum in C&D waste is expected in the upcoming years. On one hand, sulfates are unwanted in other secondary building materials (particularly in recycled concrete aggregates) and should be minimized for quality reasons. On the other hand, used gypsum from CDW can also be used in gypsum production if the high quality requirements for the recycled gypsum – especially regarding the sorting accuracy - are met. A large percentage of the gypsum from buildings was installed as gypsum plasterboards in interior fittings so far. Gypsum plasterboards are comparatively simple to remove and to separate during selective dismantling. Therefore, a high sorting purity can be achieved. In addition, techniques for the recycling of gypsum plasterboards already exist and high quality standards can be achieved. Also, the reuse in gypsum production has been improved in the last decade. Furthermore, an environmental evaluation of the whole process of gypsum plasterboard recycling and reuse showed that this approach can be environmentally advantageous. Therefore, a closed-loop recycling of gypsum plasterboards is feasible. This poster will show the development of gypsum consumption in different countries as well as a prognosis for the upcoming of gypsum in CDW in the future decades in Germany. Furthermore, a simplified scheme of the recycling process and selected results from an environmental evaluation will be presented.

IMPROVEMENT OF CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT FROM THE PERSPECTIVE OF THE CIRCULAR ECONOMY

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According to recent studies, in Italy most of the mineral waste from construction and demolitio n (C&D) activities is already sent for recovery, but the closure of the circle, necessary for the realization of the circular economy, is not yet reached. Despite of the good performance in terms of recycling rate there are still obstacles that prevent the widespread use of the secondary resources produced in the recycling activities. A research project will be developed during 3 years of PhD. The first step will be a detailed analysis of all the different phases of the process, from the generation of inert waste in demolition yards to the use of the recycled aggregates produced. The environmental performance and costs of the entire management chain will be evaluated with the methodologies based on the life cycle concept. At the same time, a small pilot plant for the treatment of C&D waste will be built inside the ENEA laboratories with a “test field” through which the field performances of the recycled aggregates will be tested for the different uses identified. Through the development of these activities, attempts will be made to find possible correlations between the technical characteristics of the finished product, the recycled aggregate, the characteristics of the waste to be treated and the methods of carrying out the demolition. The final purpose of this project is to design a regional system for the building and construction sector aimed at maximizing its circularity and resource efficiency based on environmental and economic considerations. The ultimate goal is the preparation of guidelines for demolition and recycling plants so that from the demolition activity passing through the recycling plants we can arrive at the actual reintegration in the market of the resources used in the construction of the building then demolished, in a circular economy perspective.

STEELMAKING SLAG BASED ON FMP S.R.L. PATENT: POTENTIAL APPLICATION IN CONCRETE PRODUCTION

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Steel slag is an industrial by-product of steel manufacturing and can be categorized into BOF (basic oxygen furnace) slag, EAF (electric arc furnace) slag, and LF (ladle furnace) slag. Steel slag is useful in many fields such as agricultural fertilizer, soil improvement, road construction, and asphalt concrete. A massive utilization of the slag in concrete production is limited by its high porosity, water adsorption and possible phenomena of artefact expansion due to the presence of free lime (CaO) and periclase (MgO). In order to limit the risk of expansion, the steel slag is generally subjected to weathering in outdoor conditions during several months. These phenomena actually limit the use of slag in concrete at a maximum percentage of 25% w/w and this percentage requires a great increase of the chemical additives dosage (fluidifying agent).

This study focuses on the use of EAF slag for the production of concrete with a degree of substitution of natural inert up to 80% by weight without the use of chemical additives after treatment of inertization/stabilization of the slag according to a procedure patented by Fmp innovative start-up. After the chemical and mineralogical characterizations of the slag, the operating parameter for inertization/stabilization of the artificial aggregate were optimized. Comparison tests were carried to determine the physico-chemical properties differences between the slag submitted to the treatment process and the untreated one. A concrete with substitution of 50% and 70% w/w of natural aggregate were designed in order to highlight the influence of slag aggregate on the concrete behaviour.

Apparent density, porosity, permeability, compressive strength, tensile strength, and elasticity modulus were measured to assess the influence on concrete mechanical properties with different substitution of natural aggregate. Durability of the concrete samples was evaluated by accelerate aging tests.

CHALLENGES IN RECYCLING CONTAMINATED INDUSTRIAL RESIDUES FOR SUSTAINABLE CONSTRUCTION

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In various industries (mining, minerals processing, waste management) residues and contaminated effluents occur, which contain both toxic (due to chemical and/or radionuclide content) and valuable components. Due to developments in environmental regulation (lowering the thresholds of given components) and the raw materials policy on essential components, it is important to address this situation and try to clean the effluents as well as retrieving the valuable components at the same time.

The construction industry is the largest one, which can successfully handle, reuse and recycle the massive amounts of the industrial residues. However, this is possible under condition, that the contaminants they contain are addressed, while workers involved in all the stages of processing these residues (including their collection, transportation and handling in special installations), as well as building occupants and other end-users are prevented from being exposed to the harmful emissions. The finished construction products have also to meet successfully all the existing technical requirements guaranteeing the quality and designed service life of structures.

The aim of the further research activities is therefore to develop technologies by which the harmful and/or valuable components are separated from the fluid and solid residues regardless what the origin of the residue is.

The ultimate target of the future technologies to be studied and developed would be achieving a total solution, in which also the point of secondary wastes/by-products of the new processes must be addressed (what to do with the remainder), in terms of reuse or save landfill.

Examples of possible technological approaches aimed to achieve this target are given. They include production of new organic and organo-mineral admixtures for concrete, as well as the secondary raw materials to manufacture cement, which can replace a part of the traditional mineral raw materials, reduce carbon dioxide emissions and economy fuel and energy demands.

CONTRIBUTION OF SECONDARY RAW MATERIALS FROM C&D WASTE TO RESOURCE EFFICIENCY

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The building stock represents the largest "anthropogenic mine" of our society and at the same time accounts for a significant share of the demand for energy. Both aspects are important fields of action for increasing resource efficiency in the building sector. The research project *RessStadtQuartier* funded by the German Federal Ministry of Education and Research addresses this problem from the point of view of urban districts in conurbations: specific methods and instruments for municipal planning processes will provide suitable measures for increasing resource efficiency in all phases of district development: Planning, (Re-)use and demolition.

Concerning the End-of-Life (EoL) phase, recovery options for construction materials are identified and evaluated. In this poster, the methodological approach is presented. As the project is still ongoing, the current development status of the evaluation methodology as well as impacts of the expected results are shown. C&D waste flows are allocated to different recovery paths (recycling, remanufacturing and reuse) and linked to their resulting products. All options are systematically recorded in a material-process-matrix and evaluated due to their environmental impact using the Life Cycle Assessment (LCA) method. On this basis, substitution effects concerning the consumption of primary raw materials are identified. The development of a process-based evaluation methodology enables mapping of the two-stage procedure (demolition and recovery) for different material outputs and thus a targeted variation of EoL options. Thus, courses of action for municipalities can be derived enhancing the acceptance of secondary raw materials and closing material circles.

THE EFFECT OF GLASS ADDITION ON THE PROPERTIES OF CERAMICS TILES BASED ON CLAY AND C&DW

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The waste generated from construction, demolition and renovation of buildings as well as civil infrastructure projects poses a major environmental and economic problem. Currently in R of North Macedonia there is no formal collection system so all amount of construction and demoliti on waste (C&DW) are disposed of in the “wild dumps”.

The aim of this work is to investigate the possibility of improvement the physical properties of clay based tiles by adding the flask glass also considered as C&DW.

C&DW material were collected, separated, milled and characterized. In terms of oxides, WDB (waste demolition bricks) consist basically of SiO_2, Al_2O_3, Fe_2O_3 and CaO and minor contents of alkaline and earth alkaline oxides. SEM analysis was applied for investigation of the morphology of the particles. Productions of the ceramic tiles were conducted through consolidation of the clay, waste demolition bricks and waste glass. The samples containing clay, WDB and 5, 15 and 20 wt% WG were uniaxially pressed and sintered at the temperature range of 900-1050°C. Sintered tiles were characterized by physical and mechanical properties. Highest value for density as well as lowest values for porosity are evident at the tiles produced with 20wt.% WG on all investigated temperatures. The results show that glass addition increase mechanical properties of the tiles up to 23.5%. Microstructure of the ceramics determined by SEM shows that the WDB and WG are well incorporated in the clay matrix.

The use of glass and WDB for production of clay based tiles might be an innovative usage of this material contributing to the reduction of the volume of the C&DW, inadequate disposal and preservation of natural resources.

Keywords: construction and demolition waste, clay, glass, mechanical pr operties

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CIRCULAR ECONOMY IN BUILDING CONSTRUCTION IN TAMPERE, FINLAND

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This poster presents the advances achieved in the research project 'Future Circular Economy Hubs in Finland' (CircHubs) pertaining to the circularity of building construction in the City of Tampere. The research entails three separate entities: (1) a material flow analysis of built and demolished buildings in Tampere between 2000 and 2018, (2) a literature review of the current recycling possibilities, and (3) a review of possible future steering instruments and a proposal of criteria for selected instruments.

The poster presents the first and the third items in detail. The material flow analysis was conducted in GIS and it is based on the building and dwelling registers in Tampere. Among other things, it presents an overview of the volume and development of activities by building type, and zooms geographically into identified areas of building 'replacement', i.e. areas where both demolition and building construction to take place, to understand the drivers of demolition and the nature of the materials pertaining to both activities better.

The development of the future steering instruments is based on reviewing the current Finnish literature regarding steering instruments for circular economy and low carbon construction. In addition to identifying existing instruments, some new instruments are proposed, which have not been considered in this context yet. The work entails a steering theoretical discussion on the instruments' limits and possibilities. Tentative criteria are proposed for given instruments for future development.

The work was conducted in EcoFellows Ltd. The authors of the poster are Satu Huuhka and Mario Kolkwitz. Jussi Lahti also contributed to the work in the project. Most of the results have been published in Finnish only, so the authors would welcome the chance to disseminate in English via this poster.

A CIRCULAR CONSTRUCTION IN REGENERATIVE CITIES: A H2020 PROJECT

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The poster presents an overview of the H2020 project 'Circular Construction in Regenerative Cities' (CIRCuIT), started in June 2019, and Tampere University's (TAU's) planned activities. The project cities are Copenhagen (coordinator), London, Hamburg, and Vantaa, Finland.

The project has four areas of focus: (1) mapping the flows and stocks of materials in the built environment, (2) urban mining and recycling and reuse of building materials, (3) life cycle extension of buildings through their transformation, and (4) design for deconstruction (DfD) and adaptability.

In the first topic, i.e. flows and stocks of building materials, a material flow analysis is planned for parts of the building stock in Vantaa. The work is underlain by a previous project, where TAU reviewed the methods and materials available for built environment MFA in Finland.

In the second topic, i.e. urban mining, TAU focuses on the reuse of building components. Tests are planned for deconstructed components in TAU's construction laboratory to verify their properties and to compare them to those of virgin products. The work also contributes to standardized testing procedures for secondary components.

TAU is the WP leader for the third topic, i.e. life cycle extension of buildings. A GIS-based analysis on the demolition and renovation patterns is conducted in Vantaa to identify obsolete but transformable buildings types. Then, archetypes of these building types are formed and different development scenarios are designed. Lastly, the life cycle impacts of the scenarios are assessed.

In the fourth topic, i.e. DfD and adaptability, TAU has two distinct focuses. Firstly, the barriers to implementing more flexible housing is reviewed in an interview study of experts. Secondly, possibilities to design buildings for deconstruction is reviewed.

CATALOGUE OF CONSTRUCTION PRODUCTS WITH RECYCLED CONTENT FROM CONSTRUCTION AND DEMOLITION WASTE: EFFORTS TO THE CIRCULAR ECONOMY

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The construction industry is an important consumer of primary raw materials and generates almost 30% of all waste. The effort to reduce this gap between the amount of consumed primary raw materials and construction waste production leads to the creation of circular building industry. However, this effort faces various issues: distrust of products with recycled content, low awareness about resource consumption, and low understanding of standards. To tackle these and other similar barriers, we published the Catalogue of construction products and materials. This contribution described the findings in field of recycling of construction and demolition waste in the Czech Republic, which were summarized in our Catalogue. This Czech national handbook gives information about the utilization of secondary raw materials to contracting authorities, architects, civil engineers, and construction companies. The Catalogue contains a list of valid requirements on utilization of recycled materials, which are described in standards. Also, it is connected to the online database of products and examples of good practice. Furthermore, the future work is planned to extend the database with construction products containing secondary raw materials from other industries to support the circular building industry.

PREVENTION OF CONSTRUCTION AND DEMOLITION WASTE IN A BIM ENVIRONMENT

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The construction sector is responsible for about 60% of the lithosphere mining, of which about 40% refers only to buildings, that means 24% of the world's mining. ISPRA (Italian Institute for Environmental Protection and Research) in a yearly report about special waste, show how the largest flow of special waste comes from the construction and demolition of buildings, around 42.1%. By large and far, the quantity of inert construction and demolition waste (C&D) represents the most significant flow also in Europe, becoming about 500 kg per capita per year. A smart and efficient sorting and recycling can offer an important alternative to traditional landfill, becoming a mandatory choice for environmental, economic and social sustainability.

The aim of this research is to study and promote strategies for the prevention of C&D waste, considering the whole life cycle of a building (design, construction, management, maintenance, dismissing), in a circular economy perspective and fulfilling a natural resources optimization.

Furthermore, it is difficult to manage qualitative and quantitative data since the design stage in order to know what will happen at the end of life of building. For this reason, a digital model has been carried out in Building Information Modelling (BIM) environment that will consider several criteria related to Design for Deconstruction (D-f-D) and Design for Adaptability (D-f-A). This model could manage the waste flows properties (type of waste, criteria of adaptability, criteria of decommissioning and deconstruction, recycling) with all instructions already loaded since the project phase, and all information available by means of shared platform in a common data environment, with databases referring to different buildings. This might be a useful tool both for local planning and for management of urban built environment, boosting a digital market for secondary raw materials in the construction sector, in a circular economy perspective.

RECYCLED GLASS AS A CONCRETE AGGREGATE

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Concrete as a composite material, produced by mixing Portland cement along with the aggregate water and admixtures is the most widely used construction material. Using aggregate mostly of natural origin, the concrete industry causes high extraction of natural resources, especially rocks, sand and gravel. The continued exploitation of these natural, non-renewable resources, contributes to nature destruction. Due to that, current research activities are mainly focused on use of alternative materials, protecting the environment and promoting sustainable concrete industry. There is a growing interest in substituting natural aggregate materials with alternative materials such as blast furnace slag, granulated coal ash, as well as various solid wastes. One of the recycled solid wastes that are suitable to substitute aggregate of natural origin is glass.

The aim of this research is to analyze the applicability of recycled glass as a concrete aggregate. Laboratory experiments were performed to analyze the feasibility of utilizing recycled glass as a concrete aggregate in fine aggregates and fine glass powders. Four different mixtures have been made: the glass is used as partial (50%) or entire replacement (100%) of the fine aggregate (0-4mm) in concrete, with and without admixtures. Couples of samples were prepared for each recipe and properties of fresh concrete and hardened concrete were tested at 3, 7, and 28 days. The density, porosity, compressive strength and tensile strength, water absorption of the concrete with different percentage of glass aggregate have been tested.

Results from the laboratory experiments are indicating that the concrete containing waste glass has almost identical properties as the concrete produced with aggregate of natural origin. Concrete using waste glass can be commercially wide used for specific products such as paving stones, curbs, concrete masonry blocks, terrazzo tiles etc.

Using recycled glass as an aggregate contributes to great economical savings and huge ecological impact.

BUILDING STOCK CHARACTERIZATION: A PATHWAY TO INCREASE CIRCULARITY IN CONSTRUCTION SECTOR

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The built stock is the cornerstone of a city in several dimensions: economic, environmental, social. Nevertheless, it is one of the largest consumers of energy and natural resources, and one of the largest GHG emitters. For this reason, the built stock plays a crucial role in the fight against resource depletion and climate change because it is at the root of problems and solutions.

At the time of renovation or the end of the building's life, the outflows of secondary material stocks and waste of buildings explode. The problem is that most of these outflows are being landfilled and not included in a circularity process. One reason for this issue is the lack of knowledge in building stock constitutive materials and components characteristics. However, building stock represents a valuable mine of secondary raw materials.

For sustainability questions, it is essential to have a detailed knowledge of the quantity, quality, origin, and destination of the materials and components of the building stock to analyze territorial metabolisms better and anticipate the material flows.

This poster focuses on the importance of characterizing and estimating building stocks to help planners, stakeholders, and decision-makers develop pathways towards a circular economy in the construction sector. It could help to implement strategies for better managing recovery of secondary raw materials and their reintegration into the economic circuits while preserving a maximum of their added value.

MORTARS PREPARED WITH MECHANOCHEMICALLY TREATED ASBESTOS-CONTAINING WASTE

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The research is focused on the application of asbestos-containing waste (ACW). ACW was mechanochemically activated in a vibratory ball mill in presence of polynaphthalene sulfonate superplasticizers (PNS). Our results indicate that joint milling of ACW and PNS prevents agglomeration of the particles and favors the increment of the specific surface area. In addition, by means of X-ray diffraction is shown that the joint milling promotes amorphisation of chrysotile that can be observed by the reduction of its main peaks.

Mechanochemically activated ACW were used for the preparation of the mortars with different ACW to cement ratio. When substituted up to 20 wt.-% of cement to ACW the compressive strength is close to that of the reference, while the replacement of 10 wt.-% leads to an increment of the compressive strength to 20%.

CHARACTERIZATION OF CONSTRUCTION AND DEMOLITION WASTE IN MACEDONIA

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In Republic of Macedonia, the potential of recycling of Construction and Demolition (C&D) waste, i.e., the solid residues resulting from municipal activities, is underestimated and C&D waste are often dumped illegally in the environment. SAMCODE is a know-how exchange programme, the aim of which is a chemical characterisation in terms of major and trace elements, in order to evaluate the possible C&D waste recycling and re-using as raw materials for civil engineering works and/or in cement/ceramic industrial processes. Therefore, for this work 39 C&D waste samples were collected from different dump sites spread in Skopje city and its surroundings. After verifying the absence of radioactivity, major and trace elements analyses were carried out by XRF on C&D waste sample powders. Such analyses show i) highly variable major and trace element concentrations, indicative of the heterogenous nature of C&D waste and ii) high concentration in Cr, Ni, and Zn respect to Italian, Chinese, and Dutch tolerance limits, probably due to the presence of these elements in ophiolitic rocks and sulphide-bearing deposits used as raw material in the Macedonian building activity. ICP-MS analyses of leachates performed to assess the mobility of heavy metals, show significant concentrations of Cr, and to lesser extent Ni. Therefore, such results suggest that to foresee effective recycling, a preliminary screening of Macedonian C&D waste should be performed to eliminate heavy metals-bearing components, and then that sorting and grading processes are necessary for a better homogenization of the recycled materials.

2 Material recovery from extractive industry residues

APPLICATION OF GEOSTATISTICAL ANALYSIS INTERACTING WITH THE EARTH OBSERVATION DATA FOR RECOVERY OF RAW MATERIALS FROM MINING RESIDUALS (STOCKPILES AND TAILINGS): RESEARCH PROJECTS AT UNIVERSITY OF BOLOGNA

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The poster presents an overview of the ongoing research projects at University of Bologna – DICAM Department, applying geostatistical methods to mining stockpiles and tailings with the purpose of metal recovery. The educational program RawMatCop of EIT Raw Materials is the main supporter of the research.

The work takes advantage of the use of Earth Observation (EO) data for sampling optimization in mining residuals from abandoned and active mines. Purposes are both recovery of raw materials and environmental rehabilitation of tailing dams and landfills.

EO can play an important role in accounting the raw material resources of a territory, since current satellites, such as the Copernicus constellations (Sentinels), provide continuous spatial and temporal coverage of the global at no cost. Thanks to the spatial resolution, Copernicus data can improve the characterization (quantification and evaluation) of a resource, together with the assessment of the associated risks. Moreover, EO can be used for continuous monitoring of the target areas, conditioned by mining activites.

On the other hand, geostatistical analysis, using in situ sampling and EO images, exploit innovative methods to improve accuracy of grade and pollution maps, thus reducing the number of samples, with evident cost reduction.

Test sites are bauxite residuals, located in Mediterranean Region: Greece and Montenegro (under analysis, 2019), Sardinia and Apulia (programmed work, 2020). Finally, a new international Project, INCO-Piles, starting in early 2020 and led by the research group, has the scope to identify the most promising mining residuals of Southern Europe for recovery of critical raw materials.

SUSTAINABLE MANAGEMENT AND OPTIMIZATION OF MINING WASTES: AN INTEGRATED MULTIDISCIPLINARY APPROACH

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Our economy needs to collect raw materials (RMs) from mining activities and this produces an impressive amount of mining wastes and a number of environmental problems associated with the disposal of them. Nowadays, the advances of the innovative technologies and markets make mining waste sources of valuable minerals/elements, but, in order to exploit them, it is necessary to know accurate information and to develop smart strategies of management and planning. In this framework, we tested an integrated multidisciplinary approach for sustainable management and optimisation of mining wastes. We sampled iron (Fe) and manganese (Mn) wastes produced in Joda West Mine (State of Odisha-India). Afterward, X-Ray Powde r Diffraction, X-Ray Fluorescence and spectral signatures analysis were used in order to characterize the mining waste samples. Mineralogical, chemical and spectral data were used as input to classify Sentinel-2A image. The characterized mining waste map identified waste deposit areas with different percentage of Fe and Mn and represented a suitable tool for further optimizing strategies of mining waste management. In particular, the potentialities of phyto-mycoremediation of classified mining wastes for heavy metals up take and bioaccumulation were evaluated, in the perspective of their subsequent recovery from biomass through hydrometallurgical methods. The mycorrhized plant species tolerated the high concentrations of metals and were effective for the phytostabilization and phytoextraction of Cr, Cu, Ni, Sr, Zn, Mn, Fe, P, As, S, Sr, P and Rb although overall biomass growth was not suf ficient to sustain a significant recovery of heavy metals at this stage (i. e., process conditions should be optimized). Preliminary results showed that an approach based on both advanced techniques and low cost treatment methods successfully lead to significant waste reduction and materials recovery .

TOWARDS A DATABASE FOR THE VALORISATION OF TAILINGS IN MINING REGIONS

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For many years, coal has been the main economic engine of several European regions, including the province of León in the northwest of Spain. However, the ongoing energy transition has led to a massive closure of coal mines and high uncertainty within the mining industry. The current decline of the mining sector in these regions has triggered severe depopulation, jobs losses and a general industrial decay. Valorisation of tailings has proved effective as a way of revitalising these areas, but more knowledge is needed in order to fully exploit this potential. This study presents a method for the development of a new database with information on existing tailings in the province of León, based on scattered data extracted from public resources. The database includes a comprehensive set of data related to these tailings, including administrative, geographical and geological data. The pu rpose of this database is to constitute a valuable source of information of the existing mineral resources of the region, as well as to raise awareness on the great potential for technological valorisation of these raw and specific materials. Preliminary results and conclusions are reported. Further development of this work is expected to have positive effects regarding transfer and generation of knowledge, business opportunities and social recov ery of the region, all in line with the UN Sustainable Development Goals, the priorities of the European Commission on raw materials and the Circular Economy strategy.

THE RECOVERY OF METALS FROM MINING TAILINGS BY HYDROMETALLURGICAL PROCESSES

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The main objective of the present work is the recovery of metals from mining tailings, mainly post-flotation wastes, by eco-friendly hydrometallurgical methods. The presence of low-grade minerals hinders metal extraction by traditional pyrometallurgical processes. In addition, metals in the form of complex sulphide precludes chemical leaching. For this reason, some additives have been studied as efficient catalysts for the leaching of metals from complex sulphides. Mining taillings were selected from different mining areas of Spain. The results obtained in the project (Spanish Ministerio de Economía y Competitividad with reference RTI2018-096695-B-C31) will contribute to understand better the influence of catalysts in the leaching of metals from mineral sulphides.

HYDROMETALLURGICAL PROCESS FOR COPPER RECOVERY FROM FLOTATION TAILINGS

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Copper mining and ore processing is one of the most stable and profitable branch of the Polish economy and one of the fastest growing industry. There are two main methods employed in order to process copper ores for metal production. The most important one is the pyrometallurgical process widely applied for sulphide flotation concentrate s. It is economically reasonable for copper rich feed and for large scale o perations. On the other hand the process causes high losses of valuable metals into solid wastes streams. A second method called hydrometallurgy is a technique of extractive metallurgy involving of aqueous chemistry for the recovery of metals from the various raw materials such as low-grade ores, concentrates, post-pyrometallurgy process tailings, electronic waste and recycled or residual materials and others sources considered as a waste. The development and implementation of hydrometallurgical technologies can be a solution which is feasible for high elements recovery and decreasing hazardous impact of the wastes storage on the environment. The method for recovery valuable metals from copper production tailings has been elaborated. Various leaching media such as sulphuric acid, nitric acid, organic acids (citri c, acetic, ascorbic) were investigated. Moreover, a monitoring of radioactive tracer was applied for characterization of copper recovery in leaching p rocess of flotation waste. As a results about 55% of copper was recovered in 3-9 M nitric acid, 20-25% in 2-8 M sulphuric acid, and 20-25% in organic acids. ACORGA P50 is a good and selective extractant of copper. The most op timal parameters of extraction process were - pH of aqueous phase 1.2, amount of extractant 2.5 %vol. in kerosene, organic to aqueous phase ratio 1:1. Such conditions provide a very high iron rejection (at 98% level). Concerning to a Cu-64 isotope usage during leaching process a measurements by radioactive tracer and ICP-MS methods gave comparable outcome.

STOCKS AND FLOWS OF RAW MATERIALS

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Despite many efforts in EU projects like MICA, PROSUM, Minerals4EU, DESIRE and others, the EU lacks a comprehensive, consistent and balanced supply chain and stock-flow materials database for many materials, let alone one compatible with economic statistics like input-output tables. Such a data system is essential for the type of long term strategic materials management and industry investment decisions that the EU wants to support.

Current and future bottlenecks in the supply chain related to (critical) raw materials are currently not in the scope of existing tools and databases. For such activities the Raw Materials Information System (RMIS) of the EU's DG JRC and the EIT RM have been set up. The EIT RM is in an excellent position to support DG JRC in expanding the coverage of the RMIS, which in turn can help the EIT RM and the wider community to prioritize improvement options including new KIC projects for materials management. It is also essential for governments, industries, financiers and recyclers to understand the economic implications of materials supply and related risks.

Our project in progress combines the best data sources from different parts of the value chain collected in previous work, involves the most experienced players involved in such previous projects, and uses sophisticated gap filling and reconciliation approaches to build a comprehensive Supply Chain Database. It comprises extensive data on material flows and stocks and that will be the basis for a web-based information service system business model. The project aims to closely collaborate and contribute to the most important EU and international initiatives in the field including RMIS.

EXPLOITATION OPPORTUNITIES OF COPPER TAILINGS AND CRITICAL RAW MATERIALS IN THE ESEE REGION – RIS CURE AND RIS RECOVER PROJECTS

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Mining and processing tailings can present a substantial risk to the environment and represent valuable sources of secondary and in particular critical raw materials. Serbia and North Macedonia have an abundance of Cu mines which have been exploited since ancient times. These activities generated about 920 M tonnes of different types of mining, floatation and metallurgical tailings, containing approximately 1.3 M tonnes of Cu, 128 tonnes of Ag and 23 tonnes of Au, which could be a valuable resource for the European raw materials market sector. On the basis of aforementioned two projects were designed, RIS-CuRE and RIS-RECOVER.

The RIS-CuRE project aims at establishing a network of Cu value chain stakeholders in the ESEE region in order to promote an innovative service for the zero waste extraction of metals (Cu, Ag, As, Au, and REE) from Cu mining wastes, generated during past mining activities. The main objective of RIS-RECOVER is to build a roadmap for zero waste extraction of CRM and metals from mining tailings and metallurgical heaps in SEE and build capacity of T-shaped entrepreneurs and actors along the value chains.

The activities of the projects are based on an innovation model merging all relevant stakeholders within the knowledge triangle in the field of industry, research, and education in order to increase regional competitiveness based on a regional scale. This innovative approach is based on the zero waste paradigm, which means that, once valuable raw materials such as CRM and other metals are extracted, the residues can be recycled for the construction sector. Such a holistic eco-innovative approach to the extraction of valuable metals and the beneficial use of residues after the extraction of metals provides a guarantee for the successful development of a regional innovation scheme based on the exploitation of tailings, and is, from the economic, organizational, technological, environmental and social points of view, the most viable option. This will lead to the development of an encouraging environment for the boosting entrepreneurship and intrapreneurship in the region, based on the exploration of secondary deposits.

THE USE OF TAILINGS SAND AND MINE WASTE ROCK AGGREGATE FOR CONSTRUCTION PURPOSES

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Mining is the most important source of all the raw materials used to build and power up our modern societies, ranging from metals such as iron and aluminum used for the construction of automobiles and other machinery, steel used for heavy construction works, uranium used as fuel for power plants, and lithium and nickel used for making smartphone batteries. The pace at which the global population is growing, and technology is evolving, continuously calls for more and more extraction of these mineral resources in order to satisfy the ever-growing global needs. However, these resources are finite, and their extraction comes at a cost to the environment; so, scientists are obliged to look towards more sustainable and practical ways of supplying these resources without compromising the environment, or the future generations.

One of the ways forward is to use tailings sands and mine waste rock aggregates for construction works, thereby reducing the need to mine new resources. This poster is about the use of tailings sand and other aggregates for the construction of houses, embankments, pavements and other related infrastructure. It talks about how the crushed rocks and tailings sands can be recovered and used for their intended construction purposes, and the benefits of utilizing these secondary raw materials.

TRANSDISCIPLINARY APPROACH FOR DECISION SUPPORT OF WASTE VALORIZATION – NICKEL SLAG CASE STUDY

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With increasing social awareness, concerning impacts of climate change, waste valorization and carbon capture and utilization (CCU) a regaining traction on a world scale. It is being pushed forward by the European Union as one of the important levers to mitigate its environmental impacts. Life Cycle Assessment (LCA), is thus becoming a crucial point of support to provide a strategic political vision. However, these guidelines rely on current LCA standards and practices and are not adapted to provide a s trategic vision. System modelling of environmental impacts of valorization technologies with LCA use substitution scenarios and/or consequential LCA. Consequential LCA only considers unconstrained markets: every product issued from a valorization or CCU process is always considered as a substitute for a determining product. However, this is not always what is observed, especially in the construction and demolition sector. Valorization technologie s are always developed according to a given state of external constraints defined by waste composition and amounts as well as existing regulations and their amounts and nature is constantly changing. Thus, the first focus of waste treatment industries is thus to find possible technological means to “get rid of” undesirable amounts of waste or carbon dioxide , but the fact that it can replace existing and determining products is by and large ignored. To reflect actual situation, there is a need to introduce the possibility of constrained markets in the models. With constrained markets, price elasticity cannot be used as the basic relationship between price, demand and produced amounts. Thus, for constrained markets, the product scale is not adapted. To overcome the abovementioned obstacles, we propose a transdisciplinary approach described in this paper. This approach is currently being developed through its application to valorization of New Caledonia nickel slags by CCU, in the CARBOSCORIES 2 and CARBOVAL projects.

LIFE CYCLE ASSESSMENT OF AN INNOVATIVE FLOTATION TECHNOLOGY TO ENHANCE METAL FINE PARTICLE RECOVERY

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Froth flotation is an essential mineral separation technique. By making use of differences in surface properties between minerals, valuable particles are concentrated in large tanks by attaching to bubbles, which form a froth phase that overflows as a mineral-rich concentrate. However, current flotation technologies do not work adequately for fine particles, below 20 µm in size. This is a severe challenge at present, limiting the exploitation of deposits and proper recycling of end of life products containing Critical Raw Materials (CRMs). The FineFuture project, funded by the European Union Horizon 2020 research and innovation programme (grant agreement No 821265), will advance the fundamental understanding of fine particle flotation phenomena. It will lead to the development of ground-breaking technological solutions delivering on two strategic developments: 1. Help unlock new CRM deposits, contributing to boosting the resource and energy efficiency of current operations where the fi nes are lost to tailings. 2. Enable valorisation through reprocessing of old tailings deposits and be technology-transferred to other raw material par ticle-based processes within the circular economy, thus leading the way in the sustainable use of resources.

In this work, the challenge of assessing the environmental impacts of such a wide-application technology is tackled. After a literature review on current flotation Life Cycle Assessment (LCA) studies, the research faces the challenges of setting the system boundaries and the function of an innovative technology, addressing issues such as function inequalities of the systems under studies, data unbalance between well-established systems and innovative technologies, clustering with other projects that encountered the same challenges.

3 Material recovery from landfills

PROBABILISTIC JOINT INTERPRETATION OF MULTIPLE GEOPHYSICAL METHODS FOR LANDFILL CHARACTERIZATION

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The more than 500,000 landfills in Europe and their implications are leading to the development of a sustainable vision of present and long-term waste management within the concept of Dynamic Landfill Management (DLM). In addition to the environmental assessment, DLM enhances the recovery of materials and energy resources, for which, a proper characterization is required. In this context, geophysical methods have demonstrated to be useful for landfill exploration, characterization and monitoring. Still, due to the complexity of these sites and possible challenges in data acquisition and/or processing, the use of multiple methods is the best approach for landfill investigations. In this work we use a probabilistic methodology with co-located geoelectric data, passive source seismic data and ground truth data from trial pits along one profile, to estimate the structure of a municipal solid waste (MSW) landfill located in Meerhout, Belgium. We applied electrical resistivity tomography (ERT), time-domain induced polarization (IP) and H/V spectral ratio from microtremor records. The individually inverted models were jointly interpreted according to the layers observed in the trial pits, by means of the estimation of joint conditional probabilities. This was computed using the τ-model, based on the permanence of updating ratios principle. Overall, we derived probability maps corresponding to three layers distinguished in the landfill: two layers embedded in the covering stratum and the layer corresponding to the waste body. Finally, these results were used to infer the global structure of the site where no ground truth data is available.

EXPLORATION GEOPHYSICS FOR LANDFILL MINING: TWO EXAMPLES IN DENMARK

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Landfills represent both a potential environmental hazard and a resource potential that can be an important contribution to the circular economy. In this context, landfill mining provides a solution by combining remediation and metal extraction. However, a requisite and challenge for any landfill mining activity is good estimation of the extent, volume and nature of the buried waste.

Direct sampling of waste by digging or drilling can be very costly and can also constitute and environmental hazard. Geophysical surveys provide an attractive alternative as they can map the vertical and lateral extend of the landfill as well as variations of the fill material.

During 2019, integrated geophysical campaigns have been carried out at two sites in Denmark. First a ground magnetic survey was carried out to identify areas containing iron bearing materials. In the Hvalsø landfill, a local magnetic anomaly was identified and further investigated using seismic refraction and geoelectric methods. In correspondence to the magnetic anomaly, low resistivity and high seismic velocity were obtained, thus confirming the likely presence of iron bearing, high conductivity, high seismic velocity metals.

In the Avedøre landfill, which is still active at present, the waste is at the surface and thus has not suffered any compaction. The measured total magnetic field indicates that the waste is more magnetic than the surrounding soil, and this fact is confirmed by magnetic susceptibility measurements performed in situ. Seismic velocity of the waste is very low, even if compared to the underlying unconsolidated sediments of glacial origin.

The project is still ongoing and in the near future all the acquired data will be integrated to provide a geophysical characterisation of waste in the studied landfills.

GEOSTATISTICAL ELECTROMAGNETIC INVERSION FOR LANDFILL MODELLING AND CHARACTERIZATION

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In line with the increasing awareness about sustainable use of natural resources, scientific research is targeting the evaluation of (secondary) resource recovery from landfills. The characterization and modelling of landfills conventionally relies on a limited number of discrete observations from borehole drillings and excavations, which are often too spatially sparse to reliably capture the characteristic heterogeneity of these deposits. Among the geophysical exploration methods, electromagnetic induction (EMI) surveys have been successfully applied to the qualitative characterization of landfill deposits associated with mine tailings, and urban and industrial waste. These EMI methods are suitable to characterize landfill deposits due to the sensitivity of the measured subsurface properties to changes in waste composition and conditions (e.g. soil moisture content). However, the direct interpretation of geophysical measurements for the amounts and quality of waste fractions interesting for recovery remains challenging due to the large variety and heterogeneity of deposited wastes. Geostatistical inversion emerges as powerful tool to improve the landfill characterization from geophysical data, as it provides a framework to data integration and incorporation of a model for the spatial variability of the targeted subsurface properties, allowing to infer their spatial distribution and associated uncertainty in a more reliable way.

This work presents the first results of a new geostatistical EMI inversion applied to a synthetic landfill dataset created based on real data observations made at a mine tailing from the Panasqueira mine (Portugal), which the main production is copper and wolfram. This new methodology represents an advancement in quantitative landfill modelling using EMI survey data and can be universally applied to characterize waste deposits of different types and nature, which is not only relevant to assess the potential for landfill mining but also to evaluate associated environmental risks.

MUNICIPAL SOLID WASTE LANDFILLS - INTERMEDIATE OR FINAL "SINKS" FOR PHOSPHOROUS IN TRANSITION ECONOMIES?

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Serbia generates 2.5 million tons of municipal waste annually and this amount is increasing. Although the composition of the waste was changing during the years, the share of biodegradable waste represents the highest share of about 45% - 55%.

Landfilling of waste is still predominant solution and it is estimated that about 90% of it is disposed of without pre-treatment. There are only 10 sanitary landfills, on which about 30% of the total waste is landfilled, while other landfills are not constructed according to the EU regulations and cause emissions into the environment. 2170 such landfills were registered, where it is estimated that over 43 million m3 waste have been disposed.

Phosphorous is as non-renewable and essential resource with no substitute. Large the share of the biodegradable waste component which end up on landfills contained most of the nutrients and impact on loss in the phosphorus cycle. About 4000 tonnes of phosphorus originating from MSW are disposed on landfills each year. Phosphorus is hardly soluble his concentration in landfill leachates are very low, and main quantity will remain in waste.

The aim of research is to evaluate phosphorus quantity in landfills, analyze options for recovery and estimate the amount that can be extracted. One of option for phosphorus recovery from waste streams is through biological treatment of biowaste and reuse residue as fertilizer. In this way, only new separate collected biowaste is treated, and it is not solution for accumulated phosphorus in already disposed waste. Other solution is waste incineration and recovery phosphorus from ash. In this way it is possible to include old and new waste.

THE DYNAMIC LANDFILL MANAGEMENT WAREHOUSE

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Even though the landfilling percentage of waste is lower than 2%, Flanders faces the heritage of moreover 3.300 landfills. Recently OVAM introduced the concept of Dynamic Landfill Management (DLM). The objective of DLM is a cross-cutting approach to bring landfills in harmony with their environment by preventing or reducing negative effects as far as possible. This long-term management also aims at the valorisation of resources in terms of materials, energy, land and drinking water. In order to bring DLM into practice, OVAM focused on the interaction between 3 main system components, the DLM Warehouse: Software (concepts and methods), Hardware (technical means) and Orgware (inspiring and enabling policy).

A traditional Conceptual Site Model (CSM) gives a schematic overview of soil contamination and its impacted media in order to assess the risks and determine appropriate remediation measures. From this perspective, the model mostly simplifies landfills to hazardous particles, landfill gas and leachate. Seldom a detailed characterization of the landfilled waste is provided.

DLM broadens the scope of the content and the context of landfills to a complex adaptive system (CAS) taking into account several geometrical scales, timeframes, multiple systems and actions. The final goal is the optimal interaction of a landfill with its environment and multiple tools were developed in the past years, such as Flaminco (Flanders Landfill Mining, Challenges and Opportunities). This tool is further improved in the Interreg NWE RAWFILL project and a two-fold decision support tool (DST) called 'Cedalion' and 'Orion' was developed.

The 'Cedalion' application is an initial screening of the landfill site. A field application enables local employees to evaluate and promote DLM. Landfills that show potential in 'Cedalion' will be redirected to the Orion platform, where a dashboard and road map will guide users to various applications, each with its own specificity, strengths and weaknesses, but by using them in combination, the best decisions will be made. TU Wien, in cooperation with OVAM, has one more newly developed application: Ontol, Online Tool for the Evaluation of Landfill Mining Projects, and examines the economic and ecological added value of Landfill Mining projects.

A Landfill Miner Guide offers information on technical aspects of investigation, processing and redevelopment. Specific attention is paid to geophysical prospecting.

In order to facilitate / promote valorisation of (former) landfills, the following regulatory initiatives and changes were introduced:

- Soil Act: obligation to investigate all landfills before 2024; specific guidelines for investigation and rehabilitation of landfills;
- Sustainable Materials Act : zero taxation on residual waste generated from accredited ELFM-projects;
- Environmental Permitting Act: specific permit for ELFM-projects:
- Brownfieldcovenant Act : specific emphasis on landfill(site) project proposals.

More information: Decision Support Tools Cedalion & Orion, including link to ONTOL: https://www.ovam.be/landfill-mining

QUALITY OF RESOURCES IN LANDFILLS - WHAT CAN WE LEARN FROM MATERIAL FLOW ANALYSIS?

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In Serbia, 92% of generated waste is landfilled and a minor fraction of the recyclables are transported to a separation plant after which they are reused, recycled or recovered. There are more than 3,600 waste disposal sites (open dumping, controlled dumping, engineered landfills and sanitary landfills). The vast majority of disposal sites (up to 3300) are characterized by small volumes, where the total waste volume is less than 10,000 m3. Only about 50 disposal sites contain more than 100,000 m3 of waste. Currently, open dumping and landfilling have represented the main method of waste management in Serbia. As a European Union candidate country, Republic of Serbia is required to fulfill standards and goals defined in the EU waste management directives. Alternative scenario is developed for the year 2030, when the goals should be met and quantities are foreseen for that year. For the year 2030 it is estimated that 3.1 million metric tonnes of waste a year will be generated. Materials from the dry bin will be sent to a mechanical separation plant. Fulfilling the objectives of EU directives will result by diversion of materials from landfills and will result in use them for recycle and recovery. It will be able to separate 300,000 tonnes of paper and cardboard, 150,000 tonnes of glass, 60,000 tonnes of metal and 270,000 tonnes of plastic annually and use them either as for material recovery or as resource potential. The objective of this research is to (1) identify and evaluate the quantities of materials that can be diverted from landfills and reused for recycling or for material recovery and (2) to identify and evaluate quantity and quality of materials directed to landfills after fulfilling the EU directive requirements and (3) to assess long term landfill mining potential after fulfilling waste management quantitative goals.

MATERIALS RECOVERING FEASIBILITIES FROM C&D WASTE LANDFILL, JSC "BIONOVUS", VILNIUS, LITHUANIA

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Two investigations of JSC "Bionovus" C&D waste landfill were performed – before (in 2015) and after closing and re-cultivation (in 2018).

Firstly, the feasibilities for extraction of useful materials excavated at the construction waste site were determined in 2015.

The following building waste fractions were suitable for energy production: non-recyclable plastics, rubber, textiles, paper and cardboard, wood. A total of 26127t can be mined for this purpose. Before re-cultivation, recyclable plastics made up 8.78%, inert fraction – 18.89%, energy fractions (wood, textile, rubber, paper) – 32.59%, metals – 12.34%. Combustion of all combustible fractions would yield 402861 GJ of energy. 8306 tons of metals would be excavated, of which ferromagnetic metals would account for about 90% and aluminum for about 10%. Bionovus JSC construction and demolition waste landfill mining would bring economic benefits.

Secondly, the granulometric and morphological composition of already closed and re-cultivated same landfill of C&D waste in the upper layer up to 2 m deep was investigated in 2018.

The upper layer of the closed landfill now is dominated by a small fraction of soil and rocks (d <17mm) - 56.94%, which would be suitable for re-cultivation of the landfill after completion of landfill mining and resource recovery processes. Medium coarse stone fraction (17 mm <d <33 mm) is 8.09%, the remainder (34.97%) belongs to coarse (d> 33 mm) fraction consisting essentially of recyclable materials. The bulk fraction is dominated by the concrete-brick-stone fraction - 83.16%, the energy-efficient fractions (wood, textiles, rubber, paper) - 6.66%, the recyclable plastics (soft plastics, hard plastics, PS foam). - 6.30%, metals (mainly ferromagnetic) - 2.32%, non-recyclable inert fractions (glass, ceramic, stone wool) - 1.56%. On the basis of the economic analysis, it was concluded that there is a positive difference between revenue and expenditure.

4 Material recovery from municipal solid waste incineration residues

RECYCLING OF WASTE FLUIDIZED-BED BOILER ASH FOR ENVIRONMENT RESTORATION OF ABANDONED METAL MINE

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Fly ash is a by-product of coal combustion in a thermal power plant. Pulverized boiler fly ash is used as a cement substitute in concrete due to pozzolanic reaction. However, fluidized-bed boiler ash is inadequate to be used as a cement substitute in concrete, unlike pulverized boiler fly ash, due to a large amount of free-CaO and CaSO4 generated in desulfurization process, both of which result from differences in combustion method. And so, fluidized-bed boiler ash has limited recycling and most of tnem are simply landfilled.

On the other hand, abandoned metal mines are the source of environmental pollution due to residues after metal mining. Leached heavy metal ions and acid mine drainage from abandoned metal mines are the most cause of environmental pollution. In this study, we used the fluidized-bed boiler ash of power plant for environment restoration of abandoned metal mines by the immobilization of heavy metal ions and neutralization of acid mine drainage. In this study, We made CLSM (Controled Low Strength Materials, ACI 229R) by using fluidized-bed boiler ash from Samcheok power plant of Korea Southern Power Co., Ltd. and Blast furnace slag and others. And prepared CLSM as environment restoration materials was applied to tunnels of abandoned zinc mines in Samcheok-city. The heavy metal ions contained in the sludge inside the tunnel showed Pb 227.53 ppm, As 1,380.49 ppm, Cd 65.01 ppm, Cu 299.70 ppm, Zn 7,122.50 ppm, but after column test for heavy metal ions solidification by using CLSM showed Pb no-detact, As no-detect, Cd no-detact, Cu 0.041 ppm, Zn 0.453 ppm. And we filled CLSM by using fluidized-bed boiler ash in the tunnel of abandoned metal mines in Samcheok-city.

ECOTOXICITY ASSESSMENT OF BOTTOM ASH FROM MUNICIPAL SOLID WASTE INCINERATION

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Incineration bottom ash (IBA) from municipal solid waste is highly produced worldwide. IBA is an inorganic mixture composed of melt products, silicates, metallic compounds, ceramics, and glass, comprising a wide particle size distribution with different loads of potentially toxic elements. Although generally classified as non-hazardous, it is a mirror entry in the European List of Waste (codes 19 01 11* and 19 01 12) and the management practices differ significantly. Some EU countries reuse IBA but its classification as waste results in management constraints. The development of “end-of-waste” criteria (according to the Waste Framework Directive) could be relevant, possibly favoring reuse, and thus the circular economy. For this purpose, a proper HP14 (ecotoxicity) assessment related to potential environmental risks plays an important role. “Non-ecotoxic” classification through proper assessment should assist disqualification as waste, thus facilitating the material valorization. Regulation (EU)2017/997 claims that HP14 assessment can be aligned with Regulation (EC) No 1272/2008 (CLP - chemicals legislation), providing the calculation formulas and limits to estimate ecotoxicity based on w aste chemical composition. However, CLP concerns to pure chemicals and to mixtures of chemicals, while wastes are often variable complex blends of unknown composition. Furthermore, this approach considers total element concentration although not all content is bioavailable. In contrast, ecotoxicological tests reflect the effects of all substance interactions and bioavailability. According to Decision 2014/955/EU, the results of experimental tests should prevail over calculation formulas. However, official recommendation s for this approach at the EU level are still lacking (Commission notice 20 18/C124/01). Still, some proposals on the battery of biotests and on the thresholds have been made. Indeed, it is important to define the best methodology for HP14 assessment, which could contribute to the “end-of-waste” status of wastes such as IBA.

URBAN MINING FROM MUNICIPAL SOLID WASTE INCINERATION RESIDUES FOR ZERO-WASTE TO ENERGY PLANTS

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In this work a simple method to recover both municipal solid waste incineration (MSWI) fly ash (FA) and bottom ash (BA) is introduced. MSWI FA is treated by using MSWI BA, considered, for the first time, a new urban mining source due to its pozzolanic characteristics. The new method involves a mixing of these ashes, by also adding flue gas desulfurization residues and coal fly ash, that are by-products of coal combustion. The stabilization reaction occur at room temperature, but it can be also accelerated some reactions, with thermal annealing at 100-120 °C. The efficacy of the process is demonstrated by the results of leaching tests, made on starting ashes and on the obtained stabilized materials , that show the reduced solubility of leachable Zn and Pb (in respect to starting MSWI FA). The chemical, morphological, and structural characterization of the obtained materials allows to propose and discuss the stabilization mechanism, attributed to carbonation and to the formation of calcium silicate hydrate (C-H-S).

Because the proposed method involves the use of FA and BA generated in the same location, it is reasonable to conclude that it may be directly applied on incinerator plants, allowing to simplify the actual waste strategy management of MSWI FA, that generally involves its transport and stabilization treatment before its landfilling. Finally the saved carbon dioxide emissions and the economical benefits, due to the new urban mining proposed approach have been evaluated and presented.

HEAVY METALS STABILIZATION IN MSWI BOTTOM ASH DURING NATURAL WHEATERING

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Bottom ash (BA) is major residue of municipal solid waste incineration (MSWI). As the circular economy strengthens, the use of BA in civil engineering is also increasing, but successful use is hampered by heavy metal leaching. This research investigated the influence of natural weathering on heavy metals stabilization. Natural weathering is most popular and cost-effective treatment method of BA. During this process, calcium carbonate is produced, which causes a reduction of heavy metal leaching. The following methods were used in the analysis: fractionation of BA, XRF, XRD, extraction test and AAS. The research showed that all elements concentrations in BA decreases during natural weathering (laboratory aging). Analysis of mineralogical composition showed very high (>20%) content of calcium carbonate. Calcium carbonate content increased by 3.2 % during weathering, it was influenced that $Ca(OH)_2$ in the fractions < 5.6 mm and < 40.0 mm was hydrolyzed to $CaCO_3$. Analysis showed that metal concentrations (Cu, Pb) exceed limit values in untreated MSWI bottom ash eluate, therefore cannot be used in civil engineering. After three months stabilization (weathering or aging) heavy metals concentrations was smaller than limit values. The results of the research indicates the impact of natural weathering (aging) for municipal solid waste incineration bottom ash quality parameters which are important for the use of bottom ash in civil engineering.

INCINERATOR BOTTOM ASH (IBA) - CHARACTERISATION OF MATERIAL COMPONENTS, MINERALOGY AND ELEMENTAL COMPOSITION

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Disposal of municipal solid waste and other residual waste types has gradually changed from landfill to incineration within the EU. Waste-to-energy plants have two major by-products: incinerator bottom ash (IBA) and incinerator flyash (IFA). And for the EU-28 countries, these by-products amounts to 16,000,000 tpa IBA and 2,000,000 tpa IFA. The IBA composition varies, but is potentially a large multi-element resource. Recycling is, however, both technically, economically, and environmentally challenging due to the degradation and melting of IBA fragments. Consequently the majority of these resources are either down-cycled or landfilled, and this represents a substantial leakage in the circular economy (CE).

In order to assess the resource potential and to identify raw material streams that are not currently utilized or down-cycled, we have characterized the physical and chemical composition of IBA from the Amager Resource Center (ARC), Copenhagen which is a modern state-of-the-art waste-to-energy plant. The analysis was based on systematic sampling over a 30-day period. The material was hand-sorted into magnetic, non-magnetic, glass, building materials and 'other', and classified according to deformation. A large untapped resource of glass and building material was identified, constituting about 10% and 11%, respectively of the total amount of IBA, equivalent to about 9,000 tpa for each group. It is estimated that ARC produces 4,600 tpa non-magnetic metals and 18,000 tpa magnetic metals. Chemical assays indicated elevated values of Sb, Au, Sn, Ag, Zn, Cd and Pd in the IBA fines (grainsize <2mm). We conclude, that changes to the process routines could reduce the amount of environmentally harmful elements in the IBA before it is utilized, for example in construction projects. We also conclude, that a modification of the incineration process could optimize the separation of metal fractions and increase the potential for sorting the glass fraction.

LEACHING BEHAVIOR OF ANTIMONY IN MSWI BOTTOM ASH

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Bottom ash (BA) from municipal solid waste incineration (MSWI) contains harmful substances such as heavy metals, chloride and sulfate which are mobilized in contact with water. Standardized leaching tests are used to measure the extent of mobilization. It is known that fresh bottom ash displays elevated concentrations of various heavy metals such as lead or zinc due to the formation of hydroxo complexes as a result of high pH values of 12 and above. Storage of BA is accompanied by ageing processes, mainly the reaction of CaO and Ca(OH)2 with CO2 leading to lower pH values in contact with water around 11. Usually heavy metals concentrations are minimum at these conditions. Knowledge of the long-term leaching behavior of potentially harmful substances is crucial for the assessment of the environmental compatibility of reusing municipal solid-waste incineration bottom ash (MSWI BA) in construction, i.e., as a road base layer. BA fractions obtained from wet-processing aiming at the improvement of environmental quality were used to investigate the mobility of relevant substances. Eluates from laboratory-scaled leaching procedures (column percolation and lysimeters) were analyzed to learn about the long-term release of substances. Unsaturated conditions and artificial rainwater were used in the lysimeter tests to simulate field conditions. In addition, batch test eluates were generated at usual liquid-to-solid ratios (L/S) for compliance testing purposes. A variety of cations and anions was measured in the eluates. The wet treatment reduces the leaching of chloride and particularly sulfate by more than 60%. The release of typical contaminants for the treated MSWI BA such as the heavy metals Cu and Cr was well below 1% in the conducted leaching tests. An increase in the Sb concentration was observed in the lysimeter experiments starting at L/S 0.75 L/kg and in the column experiment at L/S 4 L/kg is assumed to be related to decreasing concentrations of Ca and thus to the dissolution of sparingly soluble calcium antimonate. The same leaching mechanism applies with V, but the concentration levels observed are less critical regarding relevant limit values. However, on the long term the behavior of Sb could be problematic for the application of MSWI BA as secondary building material.

ENHANCED ELECTRODIALYTIC BIOLEACHING OF MUNICIPAL INCINERATION FLY ASHES: RESULTS FROM A MINEA SHORT TERM SCIENTIFIC MISSION

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Metal recovery from wastes is essential for a circular economy and minimising present-day society environmental footprint. In this study, we combined electrodialysis with bioleaching of fly ashes for enhanced metal recovery from municipal solid waste incineration residues. Results showed that the use of low-level direct current with acidophilic bacteria enhanced metal recovery in the catholyte when compared to the abiotic experiment supplied with direct current and the bioleaching experiment without direct current (e.g., 91% vs 97% Cu, 51% vs 76% Pb, 22% vs 95% Cr). The use of electrodialysis with bioleaching showed increased performance on the removal and recovery of metals in the catholyte such as Al, Cd, Co, Li, Pb, and Zn. While Co and Ni were selectively mobilised by bioleaching, Cd and Li showed highly elevated concentrations by combining both techniques. These results are proof of concept of combined methods will allow optimising the process especially varying the liquid to solid ratio, mixing, duration of the experiments, and pH control in the anolyte.

5 Anthropogenic Resource Classification

HUNGARIAN CASE STUDIES FOR HARMONIZATION WITH UNFC BASED ON ANTHROPOGENIC RESOURCE CLASSIFICATION

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The need of the common language for secondary resources in order to facilitate the sustainable resource management system is obvious because the comparability and transparent procedure with appropriate data can support the resource efficiency for both the energy and non-energy fields with the mitigation of the raw material consumption. This poster represents three cases for the classification of the mining waste heaps according to Specifications for the application of the United Nations Framework Classification for Resources to Anthropogenic Resources.

DEVELOPING MATERIAL RECOVERY PROJECTS: LESSONS LEARNED FROM PROCESSING MUNICIPAL SOLID WASTE INCINERATION RESIDUES

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The production of secondary raw materials requires material recovery projects. The development of material recovery projects is a complex task. Researchers, industry stakeholders, legislators and policy makers join forces to identify recovery potential as well as implement recovery projects in reality. This poster shows the development of real recovery projects from the early stage of exploration to the final stage of production. The retrospective view from 2003 to 2017 identifies challenges and enablers to recover materials from municipal solid waste incineration (MSWI) bottom-ash in the Canton of Zürich. We focus on recovery of wet and dry bottom ash and use the United Nations Framework Classification for Resources (UNFC) to communicate the different phases of recovery project development including the phases exploration, non-commercial, potentially commercial and commercial. The findings of this research disclose the complex interactions during recovery project development. We conclude with lessons learned for the development of future recovery projects beyond the Canton of Zurich and provide suggestions for applying the UNFC in the future.

6 MINEA's scientific activities

STSM EXPERIENCES IN MINEA

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The Short-Term-Scientific-Missions (STSMs) are exchange visits of one researcher from a participating country in MINEA to other participating country in MINEA. STSMs are a key instrument in MINEA, aiming at fostering collaboration, sharing new techniques and infrastructure that may be unavailable in other participants' institutions or laboratories. The STSMs are intended especially for Early Career Investigators (ECIs), an individual who is within a time span of up to 8 years from the date they obtained their PhD/doctorate (full-time equivalent), but are also open to PhD students and senior researchers. There has been an intense exchange of researchers between instructions of 16 countries. A total of 19 Short-Term Scientific Missions (STSMs) have been funded in MINEA: 5 in WG1 (Resource potential of construction & demolition waste), 5 in WG2 (Resource potential in residues from extractive industries & Resource potential of waste in landfills and mining residues), 6 in WG3 (Resource potential of solid residues from waste incineration) and 3 in WG4 (Integration of WG 1-3 & Classification and reporting of material resources/reserves). The average duration was 20 days for WG1, 16 days for WG2, 20 days for WG3 and 40 days for WG4. The STSMs Grantees in MINEA have received financial support partially covering traveling, accommodation and living expenses.