LIFE12 ENV/FI/000592

Impact Monitoring – Final Report

1.7.2013 – 31.8.2022

1. Baseline

a. Environmental situation

The mining boom, which resulted in opening plenty of new mines, has resulted into concerns of environmental impacts of the mining technologies. The extraction of ore was higher than ever before in Finland year 2013 (Geological Survey of Finland, 2022). In 2020 the global growing population, overall rising standard of living, urbanization and green energy transition has generated greater demand of metals and minerals. Amount of recycling metal materials doesn't suffice for long time period so there are also needed extractive materials in the future. Metallic minerals quarrying has growth and it's predicted that growing will continue in future, situation is visible in figure 1. (Ministry of employment and the economy of Finland, 2021.)

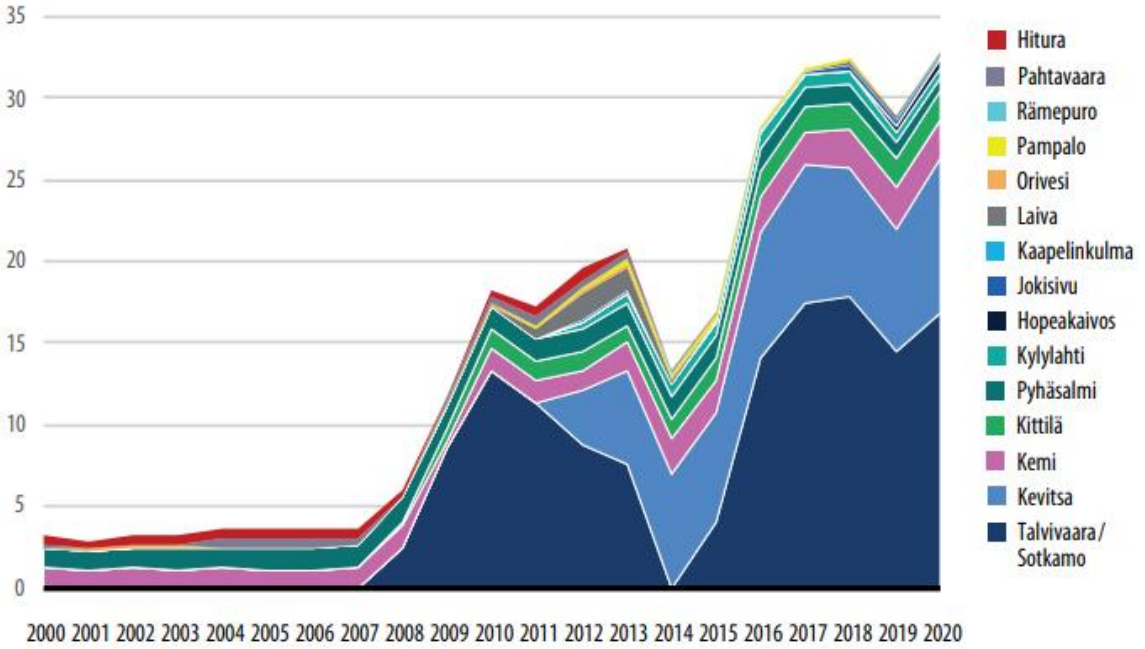

Figure 1. Metallic minerals quarrying (million tonnes) in Finland years 2000-2020 (Ministry of employment and the economy of Finland, 2021).

In the European context, mining and quarrying waste are a significant source of pollution and general environmental degradation, in particular of freshwater ecosystems (more on this in the next paragraph). Mining operations also produce variable amounts of waste rock and tailings material. Mining and quarrying waste was 26,6% of the total waste generation in EU in 2018. (Geological Survey of Finland, 2022) In Finland mining waste reached up to 75% of the total waste generation in a year (figure 2) (Statistics Finland, 2021).

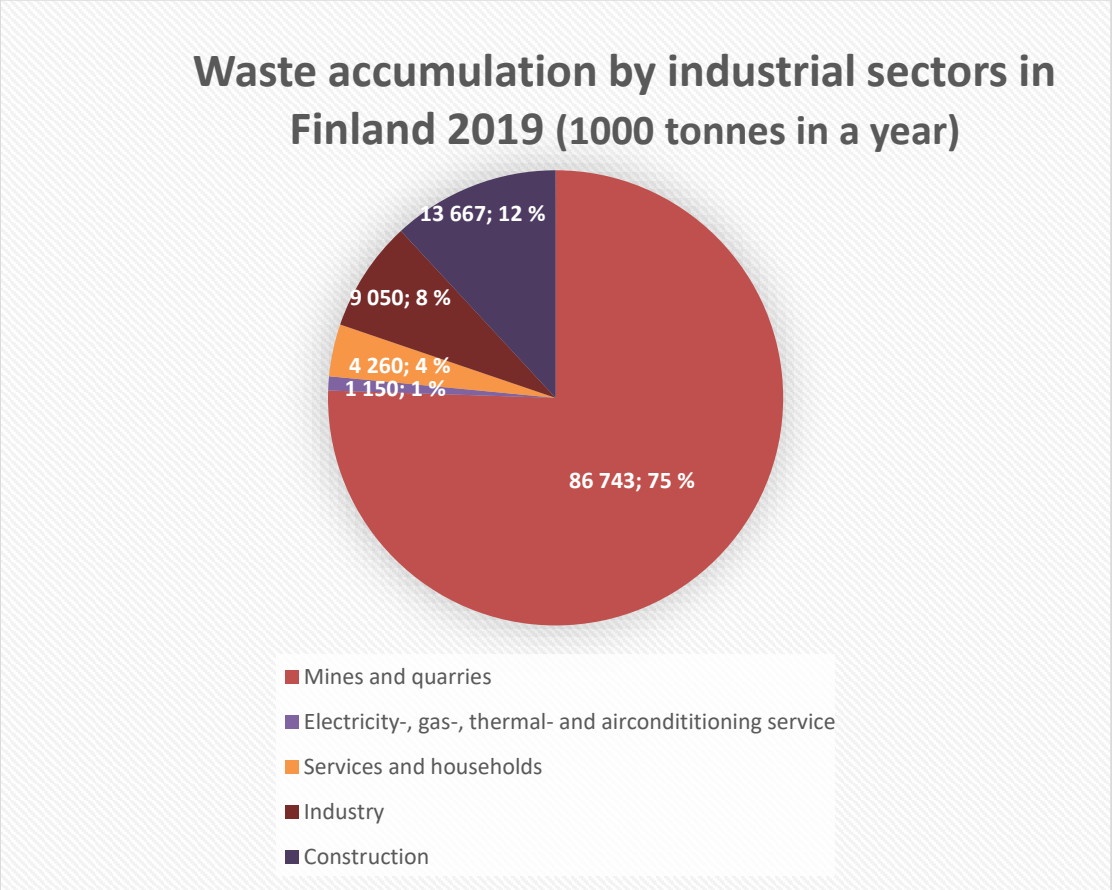

Figure 2. Waste accumulation by industrial sectors (Statistics Finland 2021).

Great bulk of mining waste end up to landfills (figure 3). Approximately 60-70 million tons eligible recycling materials for earth construction are produced annually in Finland, a significant part of this amount is from mining. Only approx. 10% of these recycled materials are currently utilized. Additional approximately 20-30 million tons of surplus soils accumulate annually, and in addition, large amounts of surplus soils have already accumulated in storage. The greatest parts of surplus soils, which are not utilized, are clay, silt and gyttja (Helsinki-Uusimaa Regional Council in Finland, 2018.).

Although some of the mining waste can be replaced as backfill during mining or utilized, still a large quantity of waste rock and tailings is stockpiled in proximity to the mine. Mining waste utilization is important part of climate change mitigation, which actors in mining fields wants to participate. In Finland alone there are about 45 mines and quarries, which means huge amount of earth construction materials in many locations. (Ministry of employment and the economy of Finland, 2021).

Figure 3. Destination of mining waste in Finland (Statistics Finland, 2017).

Tailings are waste from ore enrichment, in Finland number of tailings are about 15-21 million tons in a year. Mines offer a massive potential material for utilization, because they have million tons of different waste materials including tailings. Individual mines in numbers (Sustainable mining's network, 2016):

- Boliden Kevitsa mine amount of waste 38 million tons, 5 % of adjoining rock is utilized. (https://www.kaivosvastuu.fi/yrityskortti/fqm-kevitsa-mining-oy/2016)
- Sotkamo Silver Oy mine amount of waste: enrichment sand 524 000 tons, adjoining rock 128 000 tons and pyrite 6 820 tons. Adjoining rock is 100 % utilized, but enrichment sand and pyrite 0 % utilized.
- Terrafame mine amount of waste 19 million tons, which is mostly adjoining rock (18,4 million tons) and 0,6 million tons neutralizing sludge. 100 % of adjoining rock is utilized.

If waste materials weren't utilized, storing and disposal could require cover structures. Remediation of tailings heaps consumes hundreds of millions of tons natural aggregates, and enormous amounts of commercial sealing products, which together generate greenhouse gas emissions (presented in last paragraph). Due to large size of the mining waste storage facilities (can add up to hundreds ha of area in a single site), the construction of the bottom-, cover- and reactive dam structures for the tailings heap storage facilities requires a considerable number of materials. Most of those materials are originating from non-renewable and ultimately finite resources, such as gravel, rocks and topsoil. In addition to primary aggregates, imported commercial oil based geosynthetics and geomembranes, and bentonites are used.
The overall environmental performance of the contemporary sealing system could be drastically improved, if these materials could be substituted, with industrial by-products and waste material combinations, and new intelligent buffering systems developed. Naturally the substitution of primary aggregates and commercial products, means drastically less dependence on crude oil-based products.

If utilization of alternative construction materials such as fly ashes and calcium-rich industrial by products, can be demonstrated, a great deal of non-renewable (abiotic) materials can be saved. Alternative materials usage reduces virgin stone materials consumption and at the same time new type of structures could have positive impacts to the carbon footprint of the construction project.

b. Knowledge, awareness and legislative aspects

According to the feedback received form the stakeholders and actors in the relevant fields, currently there is moderately or a little knowledge and know-how on the utilization of alternative materials. The interest in finding more eco-efficient solutions has increased remarkably and the need for the projects results and information is needed. Mining sector's actors have also been interested in new kind of solutions constructed by waste materials.

The construction sector needs the verification of the feasibility of the materials and applications based on secondary materials in order to achieve an attitude shift. There is a need for a data how such materials fulfill the technical and environmental criteria set for intended applications. Also, the economic factor plays an important role – in order to ensure the use of the secondary materials, there is a need to prove their competitiveness with the engineering applications in the mining sector.

Mining sites always required permits, and mining law is controlling activities. Regulations were tight in beginning the project, but by policies like "end of waste" and the EU aims to be carbon-neutral by 2050, have amended legislation.

For introduction of solutions which are presented in the UPACMIC project, need to create an efficient and user-friendly system that will allow for monitoring the current and future sources of secondary materials, in order to plan their effective utilization.

2. The project impact:

a. On the environmental problems targeted

The approach proposed by the project derives from alternative materials utilizing solutions applied in various infrastructure development projects. Owing to the UPACMIC project new materials were implemented in the mining industry for the first time. Utilization of alternative materials has been piloted at Hitura mine, Pyhäsalmi mine and Fortum waste center Sorsasalo, Kuopio during the project.

Three producers' fiber clay were utilized in sealing layers for tailings basin in Hitura phase I. Conventional moraine structure was used as a reference. Another cover structure was piloted in second phase of Hitura. The pilot was implemented in the closure of the crushed rock pile. The construction utilized surplus clay from the mining area to replace the use of moraine.

Industrial by-product (fly ash) was utilized in Hitura mine water treatment sludge processing. Mixture could be used in sealing barrier's supporting layer after processing. Mixture and many other waste materials utilizing were piloted in the barrier structure at Sorsasalo landgfilling site in Kuopio. Three different reactive materials were piloted at Hitura: industrial by-product geopolymer, by-product lime and reactive matts. In the first structure was utilized by-product lime and geopolymer adsorbent, in the second structure was tested commercial actor's reactive matts. Structure's performance and working life has been evaluated by the pilot constructions. There was high concentrate of nickel and some other heavy metals in mine's seepage water, which were processed with water treatment constructions.

In all pilot structures virgin stone materials were replaced partial or total by waste, by-products or surplus materials. Pilots represent options for alternative material usage and verifies operability of materials based on the monitoring results. By this kind of structures could affect to natural resources consumption, because mine sites' cover structures need huge amount of material like moraine and geomembrane. Fiber clay cover layers were verified denser than traditional moraine, then water seepage trough to the covered tailings and its negative impacts were slight by new cover structures.

Gypsum and ash were tested in 10 pilot structures at Pyhäsalmi mine. Based on the water sampling's results, both materials could be useful in reactive cover layers. By the gypsum could replace even 70 % moraine but utilizing always requires research site-by-site. Quantity optimization and solubility tests are necessary before utilizing ash, because there are soluble detrimental elements concentration in ashes. Laboratory material testing results also verifies that ash could be useful to make moraine denser.

Materials, which are used in sealing structure at Kuopio, were waste or surplus materials. Materials production doesn't produce emissions or environmental impacts, and materials landfilling site would be Sorsasalo's waste centre even though those are not utilized in the site. Hitura's water treatment sediment was utilized in backing layers after processing by ash. Dense layer was made by surplus clay, and density targets achieved by compacting it to a mould. Barrier structure is used for landfill's seepage water negative environmental impacts management and to prevent negative environmental impacts.

The pilot applications in the UPACMIC project were allowed for considerable savings in the use of the non-renewable materials when virgin stone materials are replaced by alternative materials. During the project 71% of virgin materials were replaced and 176 500 tonnes of non-renewable natural materials were saved. Also, approximately 30 hectares of bentonite mats were saved. On the other hand, transportation costs and emissions multiplied, because alternative materials production factory distances were over than 100 km away the construction site. This was made by the suitable material was not available near to the piloting site.

The project advises to evaluate the distances between material producer and construction site and encourages to utilize local material when it's possible. When the availability of materials is close enough, can projects results replication and up-scaling prevent negative impacts of mine construction even more. Piloting implemented in the UPACMIC project gives positive experience and practical knowledge of alternative materials utilization which more likely inspire of using those methods and applications in the projects in the future. When distances have reviewed, can achieve environmental targets of the project (reduce carbon dioxide emissions and natural resources consumption).

At the beginning of the project there were tight legislation and regulations in Finland to the protection structures in mining sites. In UPACMIC project by means of test fields (technical compliance verification) and laboratory analytics (environmental compliance verification) new kind of materials were approved for utilized in barrier and cover layers.

UPACMIC project developed sustainability indicators for the future projects to use for evaluating the impact of the future projects or as a tool at the designing phase of the project.

b. On the awareness, knowledge and legislation

Through the Materials, Applications and the Piloting actions, the project provides valuable information on the use of secondary materials in the mining sector. This information is also a great value to the environmental permit authorities as a reference point for processing future cases of similar type. In the long run, this should make the environmental permit process easier.

Within the Management and Dissemination actions, the project team members have taken an active role in disseminating the information on the project and its objectives in discussions with various stakeholders both in Finland and internationally. The UPACMIC project has been presented for example in WASCON conferences in 2015 and 2018, Ash trade conference in 2017, Future Mine and minerals 2019, World Circular Economy Forum 2019, Sardinia Symposium 2019 and International Mining Congress and Exhibition in 2022. In addition, UPACMIC topics has been actively discussed in various workshops, events, seminars and meetings during the project. UPACMIC topics and information has also presented in many kinds of events and educations in Ramboll Finland.

UPACMIC-project has co-operated with other projects in disseminating solutions which are developed during the project. UUMA programme promotes the use of recovered materials in groundworks and thus decrease the use of untouched natural resources and the environmental effects of groundworks. UUMA has a wide network that has been used in projects dissemination. Co-operation and information exchange has also been done with two other projects that operated at Hitura mine area, KAIVASU and LeKaT. KAIVASU-project mapped the potential of closure facing mine sites in Northern Ostrobothnia to function as a platform for new possibilities will be assessed. KAIVASU arranged a public event at Hitura mine and mapped also general public's visions of the possibilities for the future use of the mining site. LeKaT "Lennokit kaivosvalvonnan tukena"-project (The Drones to Support Mining Control project) develops drone methods primarily to support mining surveillance.

The project has received very positive feedback from the Ministry of Environment and a representative of the ministry sits in the project Steering Group. Based on the discussions with the target audience and the KAP survey results, the interest in finding more ecological solutions has increased and need for information, which UPACMIC-project's researched, is needed. In KAP survey of 2022 it was stated that there is need for information about long-term performance of the structures as well as clear manuals for design and use. UPACMIC-project provides manuals, and the structures will be monitored after the project. Based on the KAP survey, the uncertainty of the acceptability of new materials was listed as one of the possible barriers for using alternative materials. However, the impact of cost uncertainty has not seen a barrier. The attitudes for using alternative materials have improved clearly and the answers compared to the 2014 questionnaire shows that the will towards this development has increased. Also, legislative situation has improved during this project which lowers the threshold significantly. Overall knowledge has also improved but it is clear, that even more practical piloting and reliable results are needed.

The project has indicated that alternative materials can be utilized by using standard equipment, with high quality technical methods and use the local materials effectively. Despite this positives results, attitude change needs a long-term work. The feedback from the field is that even more practical piloting is needed so that the practices introduced by the project can become widespread.

The UPACMIC project has created material matrix to serve the need for monitoring the current and future sources of secondary materials. The project also provides an easy-to-use guide for stakeholders to implement the project solutions in the future projects.

Lessons learned from UPACMIC project has been disseminated through projects website and all the materials are available for all audience. Plenty of material has been uploaded in the webpage, for. example:

- Technical reports
- Monitoring reports
- Carbon footprint reports
- LCC/LCA report
- Sustainability indicators

All these reports and materials will help the future mining construction projects to implement more environmentally friendly construction methods.

The use of industrial waste materials in environmental protection structures in mine closure has been noted in Finnish mining guideline "Kaivosten ympäristönsuojelurakenteiden suunnittelu- ja rakentamisopas". The purpose of the guideline is to put together Finnish guideline about BAT (best available technology) and BEP (best environmental practices) for environmental protection structures based on the existing knowledge. Best practices learned from UPACMIC project was proposed to include in the guideline as representatives of Ramboll Finland were part of the group preparing the guideline. The preparation of guideline is supervised by The Centre for Economic Development, Transport and the Environment in Kainuu.

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