UTILISATION OF BY-PRODUCTS AND ALTERNATIVE CONSTRUCTION MATERIALS IN NEW MINE CONSTRUCTION

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ABSTRACT

UPACMIC LIFE12 ENV/FI/000592 (Utilisation of by-products and alternative construction materials in new mine construction) is an EU LIFE funded project studying the utilization of alternative construction materials in the mining facilities. The project tests different waste and by-product materials in pilot construction as such and as refining components together with local moraines and mine enrichment sands. The project started in 2013 and will be continued until the year 2020. The coordinator of the project is Ramboll Finland and the associated beneficiaries are Suomen Maastorakentajat Oy and Fortum Environmental Construction Oy. The project is supported by the Ministry of the Environment and Yara Finland.

1. PROJECT ACTIVITIES

1.1. Objectives

The UPACMIC project demonstrates through pilot applications the utilisation potential of waste materials and industrial by-products that these alternative materials are a true option for construction tailings ponds' bottom and cover layers and reactive barrier layer, when used together with locally available materials. The piloting action tests all the details of the process including material storage, treatment and transports until the construction of the application has been finished. This demands a well-designed synchronisation of the materials flow to achieve financial benefits in logistic and material costs.

All the obtained information and experience will serve the future needs of the stakeholders and the target audience. The UPACMIC project will supply the environmental authorities with valuable background data needed for the development of the legislative and decision-making tools. The project is a practical implementation of the EU waste hierarchy and a step towards building a more circular economy society.

1.2. Alternative materials

Materials to be used in the UPACMIC applications are waste materials and industrial by-products, such as fly ashes, fibre clay and foundry sands. These materials will be used together with local moraines and mine enrichment sands. Refining local materials together with alternative materials, it is possible to impact significantly on the properties of different structure solutions, such as compactibility and water permeability.

The objective of the material studies is to find a right solution to a right purpose by utilizing alternative materials together with local materials. This will allow financial savings in the use of non-renewable natural aggregates like moraines and commercial insulating materials. When the local materials are utilized, it is important to consider the availability of the materials, cost-effective distance of the material transportations and forming waste material amounts as the mining areas are large and the needed material amounts are very voluminous.

1.3. Material tests for Hitura Mine materials

Material studies of the UPACMIC project show that by mixing ash with moraine, the water permeability value can be decreased. This allows in many cases the use of such local moraines that otherwise would not fill the requirements set for the protective structures.

The material studies made in the project has included extensive laboratory tests:
1. to find out the solubilities of the nickel and gold enrichment sand,
2. to explain the differences and joint effects when materials are together in the cover structure,
3. to find out the functional differences of the materials and
4. to preliminary study if the recovered materials can be used in the cover structures of the enrichment sand basins.

The material studies included column tests (Figure 1), modified according to the standard CEN/TS 14405 (Characterization of waste - Leaching behaviour tests - Up-flow percolation test (under specified conditions)). The diameter of the columns were 50 or 100 mm and height 280 mm. When compared to the field situation, the materials in the column were packed downwards to have the same water flow direction as in the real situation. The total amount of different material compositions was 10 (total of 10 columns).

Figure 1. The sample packed in the column before starting the test. The materials starting from the below are moraine, gold enrichment sand and nickel enrichment sand. In both ends of the column is placed 1 cm layer of inert glass pearls.

The tested materials are presented in the Table 1 and the column test results (solubilities) are shown in the Figure 2.

Table 1. Column ID's and materials used in column tests.

Column ID	**Materials**
HK1	Gold enrichment sand
HK2	Nickel enrichment sand
HK3	Gold enrichment sand, nickel enrichment sand
HK4	Moraine, gold enrichment sand, nickel enrichment sand
HK5	Gold enrichment sand + 15 % biotite, nickel enrichment sand
HK6	Stabilised gold enrichment sand + piled fly ash, nickel enrichment sand
HK7	Stabilised gold enrichment sand + fly ash, nickel enrichment sand
HK8	Stabilised nickel enrichment sand + fly ash, nickel enrichment sand
HK9	Lime stabilised gold enrichment sand
HK10	Stabilised gold enrichment sand + lime, gold enrichment sand, nickel enrichment sand

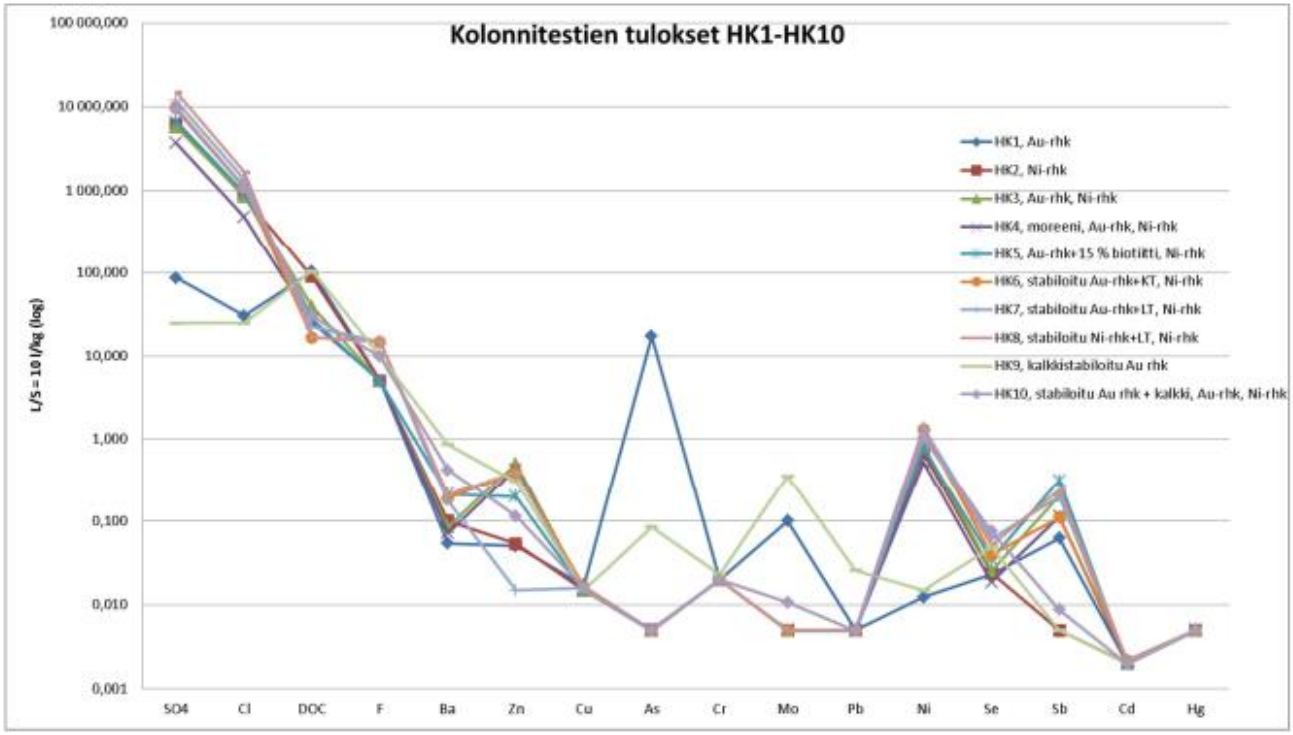

Figure 2. Column test results, solubilities of metals in different material mixtures. Axel Y is on a logarithmic scale.

In addition to the column tests, also filtration tests were made. These tests included the filtration of actual water from the Hitura mine ditches through varied materials. At the first test the ditch water was filtrated through crushed ash. This water was separated into two partial water samples and the other part was pumped through peat and the other part was pumped through fibre clay. The intention of these studies was to precipitate metals from the water by adjusting the water pH more alcaline.

The results from these laboratory tests has been utilized when the preliminary field tests have been designed in Pyhäsalmi Mine.

1.4. Field tests in Pyhäsalmi Mine

In Pyhäsalmi, preliminary field tests were done in spring 2016 (Figure 3). The intention of these field tests was to study the previously tested material compositions performance in actual field conditions. The main emphasis of the tests was to complement the laboratory results, especially for water permeability and solubility characteristics. These field tests also tested the actual manageability of the materials and construction works together with the material logistics.
The most interesting solutions according to the customer and the materials that need more material studies, were chosen for these field tests to have complementary information for the future pilot structures.

The materials used in the field tests were:

- coarse and fine enrichment sand
- moraine
- ash
- gypsum
- soil
- inert material to be used as water permeable 0,2 m layer at the bottom of the lysimeter vessels

Figure 3. Field tests in Pyhäsalmi Mine. 10 lysimeters were built in 2016.

The water quality and amount filtrated through the lysimeters were followed in order to have information of the cumulative water amount as function of time. In addition, the precipitation and evaporation of each lysimeter was studied. The results showed definite differences between the structures. Discharging the sample wells and weather information registration has taken place by Pyhäsalmi Mine and the testing is still going on (not included in the UPACMIC project).

1.5. Piloting activities

Piloting activities has started in Hitura Mine, where cover structure is constructed by utilising fibre clay. Water treatment possibilities and applications are studied now, how these reactive structures could be used for ao. jarosite water treatment in order to ease the incoming water to the water treatment station. Jarosite water contains a lot of metals, e.g. the incoming water contains approximately 30-40 mg/l nickel and it should be treated to level 3 mg/l according to the environmental permit requirements. Water contains also cobalt and iron. The amount of waters to be treated is 1 000 000 m^3. Piloting site possibilities and the content of piloting applications and follow-up studies are further discussed.

2. CONCLUSIONS

By this far the studied have showed that the structures made of alternative materials can impact on the quality and amount of the seeping water, which further impacts the water amount and quality seeping from the enrichment sand basin. For example, pH of fly ash is very alkaline which can impact on the seeping water pH level.

By adjusting the pH level, the solubility of certain metallic detrimental elements to the seeping water can be decreased. The amount of water seeping through enrichment sand basin (cover structures) and the amount

of uncontrolled waters to the environment (bottom structures) can be impacted by material's water permeability. For example, bentonite rich foundry sand and fibre clay can have a significant impact on the water permeability.

The achieved water permeability level varies significantly depending on the initial materials and refining method, but according to the studies there are functional solutions to many mining sites that need protective structures.

According to the preliminary results there are evidences that by suitable (reactive) layer it is possible to impact on the amount and quality of the seepage water insomuch that it influences on the solubility behavior of the masses deposited in the enrichment sand. In this respect the studies are yet unfinished and will further continue. The project will continue until August 2020. The project website is http://projektit.ramboll.fi/life/upacmic/index.htm

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