

Stage. 4. Remedying technology of soils polluted by activities specific to metallurgical industry

In this stage, the final stage, nine complex activities were carried out. The activity of representative **soil sampling from highly polluted areas by activities specific to the metallurgic industry** consisted of choosing the sampling point from two mining areas in Romania: Baia Mare area and the Călimani Mountains, representative soil sampling, followed by sample preparation for biological treatment.

A second activity carried out in this stage consisted of **qualitative and quantitative characterization of soils polluted with heavy metals**. Soil samples taken from Baia Mare area were characterized in physical and chemical terms in the ICIA laboratories from Cluj-Napoca and ICPA Bucharest, by applying the following types of analysis: structural and textural analysis; soil respiration determination; determination of soil hygroscopicity; humidity determination; pH determination; determination of cationic exchange; determination of total content of alkaline-earth carbonates; determination of organic carbon; humus determination; determination of nutritive microelements; determination of heavy metal concentration. Soil samples taken from the Călimani Mountains mining area were analyzed for determining of heavy metals, FTIR analysis of different soil profiles, and quantitative determination of rhizosphere soil microbiota.

Research activity devoted to **developing innovative experimental model of biological treatment of soils contaminated with heavy metals**, is structured in two big parts: A. **Development of the innovative model of biological treatment of soils polluted with heavy metals, “ex-site” variant** and B. **Development of the innovative model of biological treatment of soils polluted with heavy metals, “in-site” variant**.

A. **Development of the innovative model of biological treatment of soils polluted with heavy metals, “ex-site” variant**. The paper presents the preliminary tests conducted in order to develop the innovative model of biological treatment of soils polluted with heavy metals, the “ex-site” variant. Seven preliminary laboratory tests were conducted, in which were tested various experimental conditions of contaminated soil treatment. Various washing solutions were tested (water washing, acid washing with 96% H₂SO₄, bacterial leaching using bio-lixiviation solution in 9K environment). The experimental parameters were varied, on: soil – extraction solution mix ratio; extraction time, etc., and for each testing variant chosen the efficiency of the applied solution was evaluated, by determining the concentrations of metals extracted from the soil. Based on the results obtained upon the preliminary experiments conducted, it was proposed that the best way to elaborate the innovative experimental model of biological treatment is **aerobe bio-lixiviation by stirring**, using the bio-lixiviation solution in 9K environment and a consortium of microorganisms characteristic to the *acidithiobacillus* genus.

B. **Development of the innovative model of biological treatment of soils polluted with heavy metals, “in-site” variant**. In this case, preliminary experiments were conducted in order to elaborate the innovative model of biological treatment for “in-site” variant, and the optimum treatment method was identified to be based on aerobe bio-lixiviation, using the bio-lixiviation solution in 9K environment and a consortium of microorganisms characteristic to the *Thiobacillul ferrooxidans* genus.

A very important activity from this stage is represented by **Designing and implementing the experimental model of biological treatment of contaminated soils and Test operation of experimental model**. The experimental model of biological treatment of soils contaminated with heavy metals – “ex-site” variant was designed and implemented. A block diagram of the RESOLMET facility was developed for bioremediation of soils polluted with metals, “ex-site” variant. The flow sheet of RESOLMET model is based on the following technological stages: feeding the bioreactor with the material subjected to treatment; dosage of treatment agents, aeration and homogenization; heating and maintaining a constant temperature during the treatment process; control of the technological parameters during the treatment process; extraction of the treated product. RESOLMET ex-site experimental model consists of: bioreactor, stirring system – mechanism for ensuring movement of stirring (agitation by rocking), heating system for the aqueous solution from inside the cylinder, temperature control system. The functioning of the experimental model was tested. Also, the experimental model of biological treatment of contaminated soils with heavy metals – “in-site” variant was designed and implemented. For *in-site* treatment of soils polluted with metals, the proposed RESOLMET model is by aerobe bio-lixiviation technique. After delimitation and mapping of the area of interest, the bio-lixiviant solution is being injected (9K environment) and the consortium of microorganisms selected according to the type and concentration of the present pollutants.

The **experimental study of soil decontamination using the biological treatment procedure by quantitative characterization of contaminated soils after the biological treatment on the experimental model** was conducted. The two variants of decontamination – *in-site* and *ex-site* – were tested; yields of the extraction processes of heavy metals were calculated for each experimental model.

The **remediation technology of soils contaminated by activities specific to the metallurgic industry** was made, based on the innovative solution of biological treatment – on site and off site – of contaminated soils and the **technical documentation** was elaborated. The main stages of the RESOLMET “ex-site” technology are: ► site investigation in order to develop the biological treatment plan; ► risk evaluation; ► excavation and soil forwarding to the storage from where it will be treated; ► restoration of the area. The stages of RESOLMET “in-site” technology are the following: ► site investigation in order to develop the biological treatment plan; ► risk evaluation; ► in-site treatment of the soil; ► restoration of the area. A detailed description of the RESOLMET bio-lixiviation “in-site” technology was made, presenting each process from the flow sheet. The technical project for equipment was also elaborated, the technical memo for technological installations, the data sheet for the experimental model was elaborated and the drawings were also presented.

In the stage there was also realized the **risk evaluation and impact of activities specific to the metallurgic industry on soils**. The impact of the mining activities on the environmental factors was assessed; factors which influence the biodiversity and health of the population and the technological and ecotoxicological risks generated by the Romplumb Baia Mare factory were identified. There were identified and assigned the **rights of intellectual property on the innovative solution** of biological treatment of soils contaminated with heavy metals and the **patent request was made**. The results were widely disseminated through scientific communications and articles published in professional journals.