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RECLAMATION OF STERILE WITHIN SETTLING PONDS UNDER CONSERVATION ON THE MURES RIVER VALLEY, ROMANIA

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ABSTRACT

This paper deals with the physical - chemical and mineralogical characterization of settling ponds under conservation situated on the Mures River Valley. The paper also presents proposals for stabilization and grass sowing as an ecological approach. The most important problems with environmental impact are: air pollution with carried away particles from ponds, water discharge from settling pond into natural emissaries and soil pollution with heavy metals. The research concerning reclamation of raw sterile for building materials industry has indicated the possibility of manufacturing the following prefabs: thick slabs, thin slabs, tiles and light cellular-expanded concrete. The ecological-economical study showed important savings obtained by reclaiming the raw sterile as building materials. According to this study, it has been possible to secure a production of 3.636 billion lei worth by processing 60,000 tones of washed raw sterile yearly.

KEYWORDS:

mining sterile, building materials, settling ponds, ecological approach

1. INTRODUCTION

Mining is an essential activity that provides raw materials for various purposes. However, if proper precautions are not taken, mining might have a major negative impact on environment and human health. The impact might consist of changes of the landscape, destruction of habitats, air and water pollution, changes in river flow pattern and ecology, continuous degradation and instability of soil, erosion of structures and dams [1].

In the building materials industry, which consumes huge amounts of raw materials, besides the efforts for the optimization of energy costs, there is a concern for the utilization of granulated industrial wastes, the so-called cheap raw materials. Reclamation is a beneficial activity [2] for:

- the surrounding environment, by abating pollution and gradual reclamation of lands affected by the disposed sterile;
- the building materials industry, which can process large amounts of granular material, can benefit of lower power consumption and products with useful characteristics;
- the producer of sterile, because it might lower the production costs required for the maintenance of areas needed for.

There are some settling ponds situated in the Hunedoara County, near the town of Deva, at about 2 km downstream of the preparation plant. They have been used as sterile disposal for the Deva mine.

2. EXPERIMENTAL

2.1. PHYSICAL - CHEMICAL AND MINERALOGICAL CHARACTERIZATION OF SETTLING PONDS UNDER CONSERVATION SITUATED ON THE MURES RIVER VALLEY

Table 1 shows the main technical characteristics of the Deva pond.

TABLE 1. TECHNICAL CHARACTERISTICS OF THE DEVA POND

Designed capacity, m^3	12,121,000
Actual capacity, m^3	9,685,000
Pond surface, ha	38.8
Date of commisioning	1972
Operating system	Closed, 70% recirculation
Technical state	Stabilised disposal

Sterile in wet state from the pond was dried and then it underwent three operations [3]:

- Determination of the granulometric composition;
- Characterization of the mineralogical composition by X-ray diffraction;
- Characterization of the chemical composition.

The granulometric composition was carried out with a Fritsch Analysette 22 device on a fine fraction of sterile (100 –500 μm). It was noticed that 99.42% of the sterile granules were less than 1 mm in size. Since compositions of small prefabs use sand fraction of 0-3 mm, it follows that the studied sterile can be taken into consideration especially in a mixture besides coarse sand and thus providing the fine fraction from the aggregate.

The granulometric composition of the sterile is presented in Figure 1.

The mineralogical composition of the sterile was determined by X-ray diffraction and is presented in Table 2. The chemical oxide analysis and the spectral analysis of the raw sterile are presented in Table 3.

TABLE 2. MINERALOGICAL COMPOSITION OF STERILE

Denomination of samples	Quartz (%)	Feldspars (%)	Muscovite (%)	Magnetite (%)	Calcite (%)	Oxyhydro oxides (%)	Amphi boles (%)
Sterile pool sample 1	47	32	13	6	-	2	-
Sterile pool sample 1 0.50-0.40 mm	40	33	11	4	6	2	4
Sterile pool sample 1 0.315-0.25 mm	39	33	22	5	-	spot	-
Sterile pool sample 1 d < 0.1 mm	38	34	17	5	2	spot	3

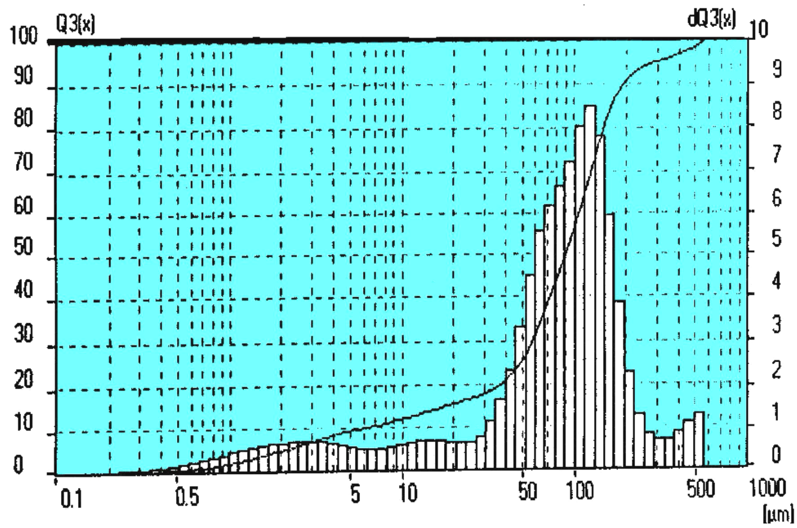


FIG.1. GRANULOMETRIC COMPOSITION OF STERILE

TABLE 3. SPECTRAL AND CHEMICAL OXIDE ANALYSES OF THE RAW STERILE

Chemical oxide analysis (%)			Spectral analysis (g/t)		
Oxide	Sample SVD1	Sample SVD2	Element	Sample SVD1	Sample SVD2
SiO_2	69.90	68.98	Ag	4.4	0.3
			Au	0.2	-
TiO_2	0.44	0.41	B	nd	30
			Ba	-	700
Al_2O_3	11.55	12.48	Co	nd	3
			Cr	nd	20
Fe_2O_3	4.95	5.34	Cu	1000	700
			Ga	5	-
FeO	1.29	1.39	In	165	0
			Mo	9	3
CaO	4.97	5.37	Mn	300	-
			Ni	nd	4
MgO	1.55	1.63	Pb	400	650
			S	0.34	-
Na_2O	2.82	3.04	Sn	nd	3
			V	140	80
K_2O	2.07	2.23	Zn	800	350

2.2. FLOW DIAGRAM OF WASHING RAW STERILE

The diagram of washing raw sterile is shown in the next figure.

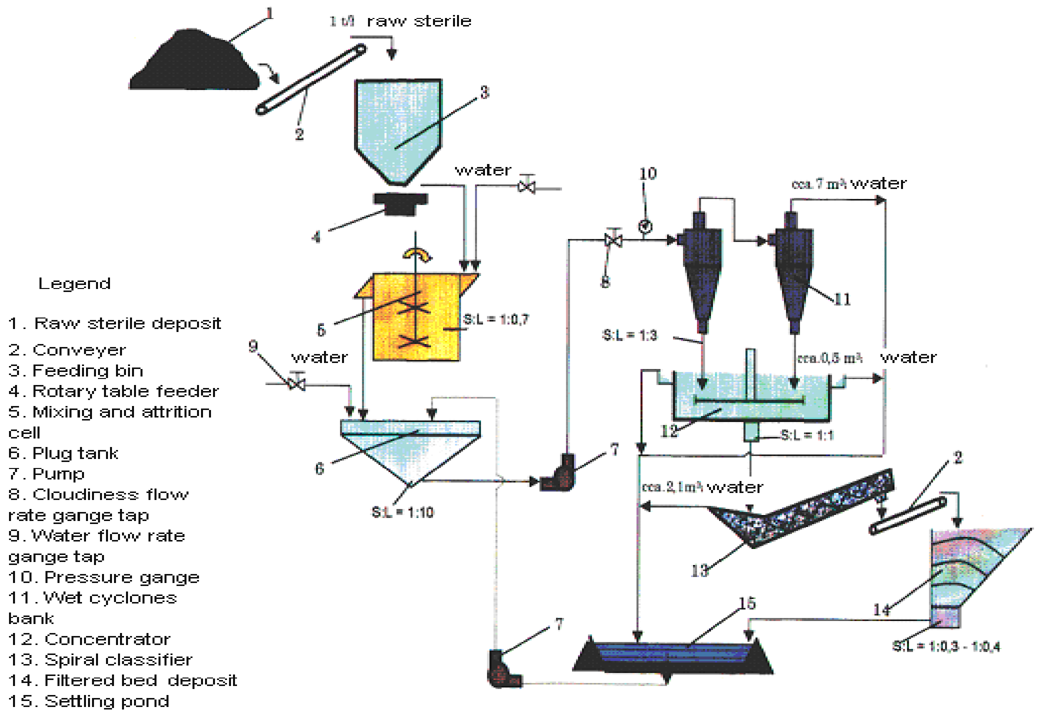


FIG.2. FLOW DIAGRAM OF WASHING RAW STERILE

2.3. WORKING OUT COMPOSITIONS TO SET UP MANUFACTURING TECHNOLOGY FOR PREFABS

Compositions of concrete for thick slabs (standard) and thin slabs (1/2 of standard thicknesses) either grey or coloured were worked out during experiments. In addition, compositions for light cellular-expanded concrete (in various dimensional variants) were determined. The experimental compositions for all prefabs are shown in the following figures. The mechanical and physical characteristics of processed lots of light cellular-expanded concrete, thick slabs and thin slabs are shown in Tables 4–6.

TABLE 4. MECHANICAL AND PHYSICAL CHARACTERISTICS OF THE PROCESSED LIGHT CELLULAR-EXPANDED CONCRETE LOT

Characteristics	M.U.	Experimental values
Porosity structure	-	Homogeneous porous structure with approximate spherical pits
Apparent density in dry state	kg/m^3	830
Water uptake at saturation	%	43.0
Compression resistance	N/mm^2	2.7
Resistance to bending, stretching	N/mm^2	0.9
Conductivity coefficient	W/mK	0.13
Response to freeze-thawing weather ▪ weight loss ▪ compression resistance	Cycles % N/mm^2	>15 3.3 2.55

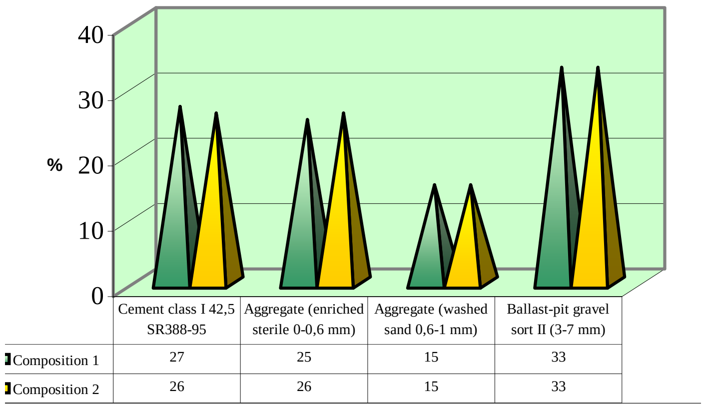


FIG.3. EXPERIMENTAL COMPOSITIONS FOR LIGHT CELLULAR-EXPANDED CONCRETE

TABLE 5. MECHANICAL AND PHYSICAL CHARACTERISTICS OF THE PROCESSED THICK SLABS LOT

Characteristic property M.U.	Experimental value	Reference characteristic according to the Romanian Standard
Depreciation with usual monograined sand [mm], max.:	0.6	1.3
Mean bending breaking strength for plates [N/mm^2]	4.4	4.0 STAS 1137-68
Freeze-thawing weather resistance	Without cracks and indentations	STAS 1139-87 Without cracks and indentations STAS 1137-68

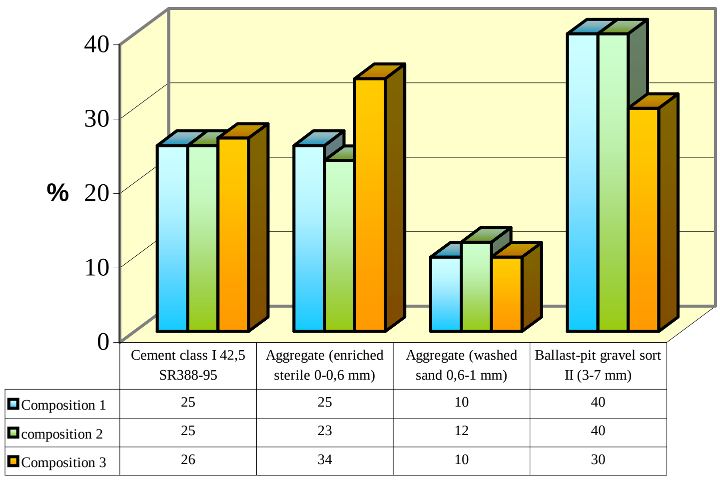
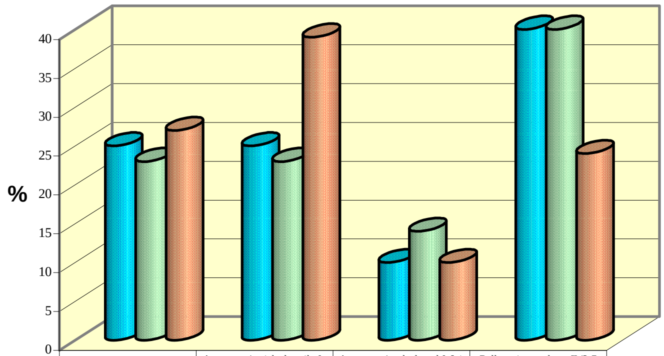


FIG.4. EXPERIMENTAL COMPOSITIONS FOR NATURAL AND/OR COLOURED THICK SLABS (STANDARD)

TABLE 6. MECHANICAL AND PHYSICAL CHARACTERISTICS OF PROCESSED THIN SLABS LOT

Characteristic property M.U.	Experimental value				Reference characteristic according to the Romanian Standard
Average bending breaking strength, [N/mm^2]	4.3	4.1	4.2	4.3	STAS 1137-68 4.0
Resistance to shock	Without cracks				Without cracks STAS 451-86
Depreciation of depreciation layer, [mm], max.:	0.8	1.0	1.1	0.9	1.3
Response to freeze-thawing weather	Without cracks No damages weren't produced for any samples tested				Without damages STAS 1137-68



	Cement class I 42,5 SR388-95	Aggregate (enriched sterile 0-0,6 mm)	Aggregate (washed sand 0,6-1 mm)	Ballast-pit gravel sort II (3-7 mm)
Compositions 1	25	25	10	40
Compositions 2	23	23	14	40
Compositions 3	27	39	10	24

FIG.5. EXPERIMENTAL FORMULATIONS FOR NATURAL AND/OR COLOURED THIN SLABS (1/2 OF STANDARD THICKNESS)

The prefabs were tested for the evaluation of lixiviation characteristics [4]. The laboratory experiments were carried out to establish whether heavy metals diffused from the hydraulic matrices. After 30 days under conditions of pH = 3-4, only iron had sufficient concentration to be detected in the lixiviated acid solution. The analytically measurements were made with a Varian SpectrAA 110 atomic absorption spectrometer.

2.4. THE IMPACT OF THE STERILE PONDS ON ENVIRONMENTAL FACTORS AND PROPOSAL FOR STABILISATION

The surface area of influencing for Deva – Mures Valley sterile pond was 21 ha. The main objectives within the influence area are: farms, highway Deva – Arad and non-productive lands.

Taking into account that over the last years the frequency of abundant rains (up to 200 l/m^2) increased, it is necessary to build additional facilities to ensure safe operation, as it was been pointed out by the expertise carried out with respect to stability of the pond.

Other influencing factors are: size of the Deva pond, its location, and particularly security of the surrounding area. A possible ecological accident might have a major impact on the environment in an area much higher than that of the immediate influence. One could speak even of a trans-border impact by affecting Deva – Arad highway and the Mures River .

The major impact of the settling ponds on soil is given by the pollution with heavy metals, including aquifers. The indicators evaluated were pH, humus and heavy metals (Cu, Pb, Zn, Fe, Mn, Cd, Cr, Co, Ni).

The results showed values higher than natural background of the area (reference sampled at 100 m and 500 m away from the influencing area) for Cu, Pb and Mn. For copper and lead, the alert levels were exceeded in certain points.

The water discharged into natural emissaries (e.g., the Mures River) from the area had no significant organic content and consequently did not affect surface water in spite of ore preparation process, which implied chemical reagents including organics. The pollutant concentrations were quite low and dilution high enough. Thus, no significant pollution occurred within the surface water.

One can notice important exceeding of the limits imposed by NTPA 001/2002 (Romanian norm) for “suspended solids” indicator. Taking also into account “fixed residue” indicator, one might consider that the water from pond did not have significant mineralization, but still contained suspended materials which were not efficiently separated in the settling ponds. The suspended solids content can seriously affect the natural biota (aquatic fauna and flora).

Also slight exceeding of the imposed limits for Cu, Pb and Zn contents were noticed.

As far as the impact on the Mures River is concerned, by comparing the values obtained up- and downstream the discharge point of the Deva pond, insignificant influence was found considering the very high dilution.

The most important problem with environmental impact was air pollution by particles carried away from ponds, especially in drought and windy seasons. Under these conditions, there were no pollution sources by NO_X, SO_2, CO, NH_3, etc. Therefore, the only compounds that were necessary to be analyzed were particulate and settled matter.

For these reasons, the stabilization proposal was grass sowing. Basically the new green technology consist in: applying aqueous suspension consisting mostly of grass seeds (2 types) and fertile support material for sowing by an atomizer. Due to the good genetic characteristics of the two types of grass, the area that was stabilized by grass sowing was very stable. Therefore, after minimum 30 days planting bushes and trees was allowed.

3. CONCLUSIONS

- After physical-chemical and mineralogical characterization of raw sterile samples taken from the pond Deva - Mures Valley and testing their behaviour as fine aggregates (0-0.8 mm) in the manufacturing formulation for small concrete prefabs, the necessity of enriching the raw sterile was demonstrated and scientifically argued. The compositions elaborated to establish the manufacturing technology for plates, pavement slabs produced positive results and demonstrated the possibility of using the enriched sterile as fine aggregate in proportion of 25-39%, together with sand sort (< 3 mm) and gravel sort II (3 - 7 mm).
- As far as the mechanic characteristics were concerned, the results of the tested samples after 28 days were:
  - average ultimate flexural strength within the 3.7...4.2 N/mm^2;
  - the impact strength for plates was fairly good (no cracks) and the wear for plates, slabs and light cellular-expanded concrete was within the limits 1.1-1.3 mm.

- The large scale facility for enriching the raw sterile will include a phase of attrition in specially designed cells without adding mixture of reagents. Thus, it is foreseen the removal of argillaceous minerals, micas and partially iron oxides and implicitly an increase of the silica content.
- Serious steps of continuous monitoring of the ponds from Deva – Mures Valley are required to prevent and avoid natural and anthropic events with negative impact on environmental factors.
- The ecological-economical study showed important savings obtained by reclaiming the raw sterile as building materials. According to this study, it was possible to secure a production of 3.636 billion lei worth by processing 60,000 tones of raw sterile yearly. From the point of view of stabilising and green approach of settling ponds against weather conditions, the estimations revealed the following costs:
  - stabilization and ecological approach by grass sowing: about €1.7/m^2;
  - stabilization by grass sowing applying the classical method costs about €2.6/m^2.

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