LEADING THE EXPLOITATION ACTIVITY OF MINERAL AGGREGATES IN GRAVEL PITS DEPENDING ON THE TARGETED TYPE OF ECOLOGICAL RESTORATION. CASE STUDY

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Abstract: *This paper presents a case study aimed at a project for the exploitation of mineral aggregates in gravel pits slightly different from the usual ones, in the sense that it does not have as its sole purpose the exploitation of mineral aggregates, but has provided from the design phase a second purpose, namely to create fish ponds in the exploited areas. In other words, the activity of extracting mineral aggregates is directed in such a way as to ensure the physical conditions of ecological restoration of the area, and to reduce the impact generated on the environment.*
Key words: *mineral aggregates, gravel pit, fish pond, exploitation, ecological restoration*

1. Introduction

The activity of rocks and mineral aggregates exploitation for construction in gravel pits is widespread in our country, at present, there are several thousand of such exploitations.

Often, as a result of these exploitations, whether they take place in riverbeds or on their terraces, important land surfaces remain severely affected in terms of environmental conditions, and unfortunately no ecological restoration programs are implemented after the extractive activities are completed. Even if ecological restoration works are planned, they often require, in the first phase, extensive remodeling of the affected land areas (involving relatively long periods of time and substantial costs), so that they are suitable to take over a new function, usually established after the cessation of productive activities.

This type of planning and action is no longer acceptable in the 21st century, when mining is being put under increasing pressure from the authorities (through legislative requirements) but also by organizations working in the field of environmental protection. Or, in other words, mining, even in the case of relatively small projects, in order to continue to exist must incorporate the principles of sustainable development of the society [2].

The analyzed project, for the exploitation of mineral aggregates in gravel pits, is a different one at a conceptual level, in the sense that the works related to the ecological rehabilitation of the area (an obligation for the owner of the activity) are well established in the project, all activities on site being directed in order to ensure the conditions required by the targeted type of ecological restoration.

Practically, the exploitation activities are directed from the beginning to reach a final goal, other than the simple capitalization of the mineral aggregates, namely the creation in a period of 10 years of 10 pools to be used for fish farming and sport fishing.

Thus, in view of the final purpose, the mining activity is directed and staggered in such a way that the exploitation works overlap to a large extent with those of the arrangement of the fish ponds, aiming that the impact on the environment and the costs related to the ecological restoration be minimal, and to some extent the inherent negative impacts associated with the extraction of mineral aggregates should be offset by the positive ones given by the progressive ecological restoration and operation of the fish ponds.

2. Location of the project and description of the surroundings

The project is located in the northwest of Hunedoara county, on the border with Arad county, outside Zam commune (fig. 1).

Fig. 1. *Project location*

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The average altitude is of approx. 250 m. The relief is not very rugged.

Podzolic clay soils and brown podzolic clay soils predominate.

The climate is continental temperate with average annual temperatures of 11ºC and average multiannual rainfall of 750 mm.

The area is strongly furrowed by the tributaries of Mureş river, which in proportion of 80% have a permanent character, on a slightly rugged relief and with a maximum height of 400 m.

The problem of the project is that it is located in the vicinity of two Natura 2000 sites of community importance (ROSCI 0064 - Mureş Gorge and ROSPA 0029 - Lower Mureş Gorge - Lipovei Hills) [3, 5, 6], outside them, at distances between 1 and 3 km, being in question a possible influence on the flora and fauna of community interest (fig. 2).

Fig. 2. *Location in relation to Natura 2000 sites and the terrain [4]*

However, as can be seen from the image on the right (fig. 2), the location of the project is one that lacks arboreal vegetation, while grassy and shrubby vegetation does not completely cover the land [1]. Under these conditions, the fauna species of community interest identified in the two Natura 2000 sites can only reach the area of the project by accident.

3. Project description

We must specify from the beginning that the exploitation of mineral aggregates will be done in 10 different locations on the site, successively, for a period of 10 years. Thus, after the exploitation of one perimeter is completed, the next one is exploited, at the same time in the first perimeter being carried out the works of arranging the fish ponds (deposition of vegetal soil on slopes, vegetation of slopes, population with fish, etc.).

Next, in the paper, are presented the specific details for the creation of a single fish pond by the exploitation and capitalization of the mineral aggregates, activities carried out on the site during a calendar year.

The project will materialize on a land registered as agricultural, currently unused, with a total area of 79550.0 m^2, in each of the 10 years the activities being delimited in two stages:

Stage I with the sub-stage of excavation and capitalization of the ballast, respectively the sub-stage of redevelopment by transforming the remaining gap into a fish pond.

Within ***sub-stage 1***, the technological process will have the character of exploitation in the gravel pit of the mineral aggregates, comprising the following phases: stripping of the vegetal soil; extraction of mineral aggregates; sorting, loading and transport. The extraction of mineral aggregates is done by excavation below the level of the excavator. Two steps and a trapezoidal section of the excavation will be formed. The works are staggered so as to create one pool per year [4].

The excavation of a total volume of 45100 m^3/year/gravel pit is scheduled, of which 4300 m^3/year/gravel pit of soil and altered aggregates, respectively 40800 m^3/year/gravel pit of mineral aggregates usable in constructions (table 1).

Table 1. *Quarterly excavation schedule (for a gravel pit) [4]*

Excavated material	M.U.	Total / Year	quarter			
			I	II	III	IV
Soil	m^3	4300,0	1300,0	1000,0	1000,0	1000,0
Mineral aggregates	m^3	40800,0	10200,0	10200,0	10200,0	10200,0
Total	**m^3**	**45100,0**	**11500,0**	**11200,0**	**11200,0**	**11200,0**

The resulting excavations will have a trapezoidal section with a slope of 1: 1 and the following dimensional characteristics (fig. 3a) [1, 4]:
- length - 187.0 m;
- width - 32.0 m - 32.0 m;
- depth - 9.50 m, of which:

Average depth:
- above the hydrostatic level - max. 6.70 m;
- average depth below the hydrostatic level - 2.80 m.

Surface:
- at the top - 6143.0 m^2;
- surface area of water- 2400.0 m^2.

Water volume:
- 6160.0 m^3.

In ***sub-stage 2***, an earth perimeter protection dam will be arranged against the floods produced by the Mureş river. The dam will be arranged with a part of the vegetal soil and the altered aggregates coming from the opening works (fig. 3b).

The perimeter dam for flood protection will have a trapezoidal section, with a length of 445 m/pool, a height of 1.2 m and a crown elevation of +162.20 m.

The rest of the vegetal soil will be used for the arrangement of the area adjacent to the fish ponds and for the systematization of their slopes [4].

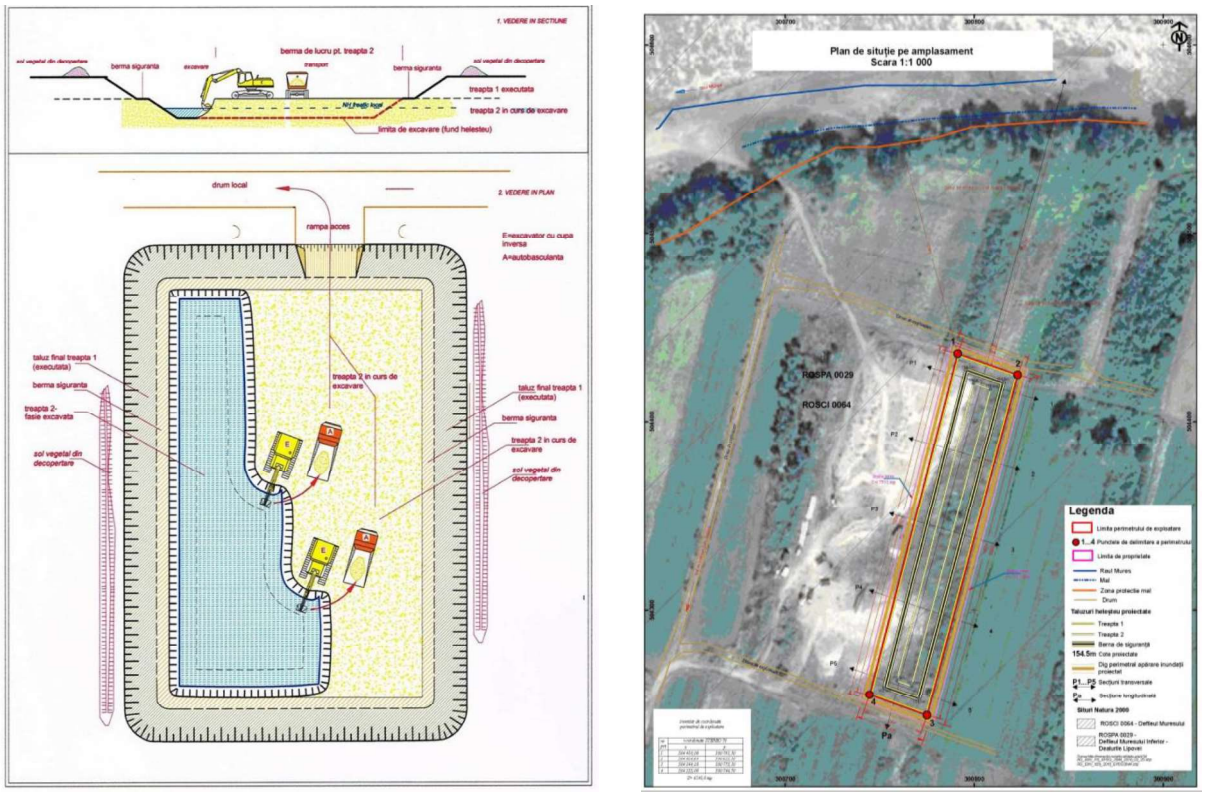
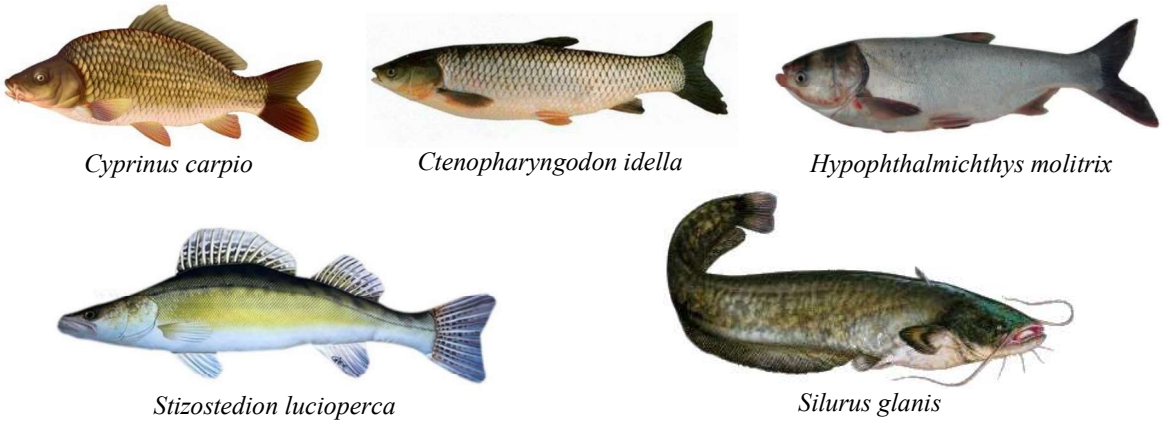


Fig. 3. *Stage I of the project, a - sub-stage 1 of mineral aggregates exploitation, b - sub-stage 2 of redevelopment [4]*

Stage II, post - redevelopment - fish farming - with a scheduled fish production of about 25 kg/100 m^2 water surface/year or about 600 kg / year / pond [1, 4].

The water supply for the fish ponds will be ensured from the local aquifer in natural regime and from rainwater, so that no special arrangements are needed.

Within Stage II - of fish ponds exploitation, the pools will be populated with carp species and in a smaller proportion (5 - 10%) predators (fig. 4).



Cyprinus carpio *Ctenopharyngodon idella* *Hypophthalmichthys molitrix*

Stizostedion lucioperca *Silurus glanis*

Fig. 4. *Recommended fish species for pond population [1]*

Feeding will be done naturally, only in exceptional cases, the fish will be fed with natural fodder of vegetable origin.

The fish will be harvested only through recreational fishing. In case of finding an overpopulation of the ponds, by natural reasons, or in order to perform the necessary general sanitation (at a period of 4 - 5 years), the fish will be harvested by the beneficiary with the net.

Other necessary arrangements: wooden pontoons for fishermen; perimeter forest curtain; site fencing; arrangement of the access road. The analyzed project does not require consumption of natural gas, electricity or thermal energy, the only resources consumed are fuels and lubricants used by the equipment.

4. Considerations regarding the environmental impact

As a tool to identify the impact of the project on the environment we used the method of simple checklists. For the analyzed project, the environmental components affected in the three sub-stages were identified, the results of this analysis being presented in table 2:

Table 2. *Simple checklist [1]*

Environmental component	Cause
0	**1**
Stage I - Sub-stage 1 - extraction of mineral aggregates	
Air	- operations of excavation, sorting, loading and transport equipments (noxious substances) - operations of excavation, sorting, loading and transport (suspended and sedimentable powders)
Soil and subsoil	- modification by excavation of the initial structure and relief
Vegetation	- removal of vegetation from the site (before stripping)
Fauna	- disorder of the natural habitats
Water	- the entrainment of fine particles by rainwater
Human settlements	- noise and vibrations from the activities of excavation, sorting, loading, transport and arrangement of access roads
Socio-economic environment	*- capitalization of mineral aggregates (stimulation of the local economy)*
Stage I - Sub-stage 2 - arrangement of fishing ponds	
Air	- operation of leveling, loading, transport, soil deposition, arrangement of access roads equipments (noxious substances) - operations of leveling, loading, transport, topsoil, access roads (suspended and sedimentable powders)
Vegetation	*- vegetation restoration (grassing the final slopes of the pools)*
Fauna	*- partial restoration of animal habitat in the area* *- emergence of new habitats (habitat diversification)*

0	1
Water	- the entrainment of fine particles by rainwater
Human settlements	- noise and vibrations from the activities of excavation, sorting, loading, transport and arrangement of access roads
Microclimate	- the appearance of water mirrors (increases the potential for evaporation locally)
Stage II - operation of fish ponds	
Fauna	*- food source for various species of mammals and birds*
Socio-economic environment	*- income from the sale of fish production (aquaculture)* *- income from fees and subscriptions collected for sport fishing* *- increasing the tourist potential of the area*

Aspects marked in italics represent positive impacts.

By analyzing the checklist, the following considerations can be made [1]:

- **in stage I, sub-stage 1** - extraction of mineral aggregates, the negative impacts predominate, these being exerted on all the environmental components. The exception is represented by the socio-economic environment, which is stimulated by capitalizing the mineral aggregates extracted on site;
- **in stage I, sub-stage 2** - arrangement of fish ponds, the negative impacts are exerted on air, water and human settlements for causes similar to those in sub-stage 1, to which is added the change in the local microclimate. In this sub-stage, the positive impacts are given by the revegetation works, through the partial restoration of the existing habitats and the appearance of new ones (ponds). In order for this impact not to turn into a negative one, a monitoring program is needed, so as to eliminate the possibility of the appearance of invasive species;
- **in stage II** - operation of fish farming and sport fishing ponds is expected to have a positive impact, especially due to the economic benefits, but also considering these ponds as food sources for different species of mammals and birds in the area.

5. Conclusions

Approaching in this way the exploitation of mineral aggregates in gravel pits, taking into account from the design phase the targeted type of ecological restoration, allows a progressive rehabilitation of the area, leading to a significant reduction and compensation of negative environmental impacts and to a reduction in operating costs.

Basically, after the exploitation of a perimeter, the physical conditions necessary for the ecological restoration are ensured and the next perimeter can be exploited, while in the first one the arrangement works of the fish ponds being performed (vegetal soil deposition on slopes, slope vegetation, fish population, etc.).

Executing the works in this way ensures an ecological rehabilitation of the area in a very short period of time, and, practically we cannot distinguish two completely differentiated stages: one of mineral aggregates extraction and one of ecological restoration of the area, the two being overlapped during the 10 years of operations.

Following the analysis of the results of this study, it can be stated that the considered project generates a low impact on the environment due to the way it was designed, respectively the overlapping of the exploitation stages with those of ecological restoration and fish production. Thus, it can be considered that the inevitable negative impacts of the exploitation are offset by the positive impacts, especially on the socio-economic environment and fauna, which partly derive from the ecological rehabilitation sub-stage and the fish production stage, thus being incorporated the principles of sustainable development in a small mining project.

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