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## Evaluation of vegetation diversity of the limestone quarry „Lafarge Ciment” (Moldova) S.A.

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**A**bstract: Actual floristic research is focused on the study of the flora biodiversity and elaboration of a management plan in order to recover the flora of the „Lafarge Cement” (Moldova) S.A. quarry ecosystem. The study refers to the taxonomic investigation of the floristic diversity on adjacent to the quarry and in the proper quarry. In the frame of the study 117 species of magnoliophyta from 43 families were identified in the study area. The quarry dendroflora is represented by 20 species of arbors and shrubs. The species of accompanying plants vegetate together with *Elaeagnus argentea* Pursh on the slopes of the dump storages are *Carpinus betulus*, *Robinia pseudoacacia*, *Acer negundo*. The most frequent shrubs are *Rosa canina* and *Crataegus monogyna*. At the same time, species of different age fruit trees were rarely found in sites within storages. Main species were: *Cerasus avium*, *Armeniaca vulgaris*, *Juglans regia*, which reached the quarry territory and probably were spread by birds. Those 117 species identified in the quarry represent around a quarter of the petrophyte ecosystem diversity which used to reach total 340 species which were represented by the spontan ones without including in this list ruderal and segetal species.

**Keywords:** biodiversity, ecosystem, dump storage, species, quarry, slope

### INTRODUCTION

The „Lafarge Cement” (Moldova) S.A. is situated in the northern part of the Republic of Moldova, in 100 km from Chisinau and in 7 km from Rezina town. The cement factory is an industrial platform located in the valley of the Ciorna river, at the altitude of 50 m, bounded from the northeast and southeast with hills of height 100-150 m and down-grades of 40 degrees. This factory is situated on the Dniester Uplands, which are a part of the geomorphological region Moldavian Plateau, characterized by the presence of high hills and mounds whose crests slowly come down to south, southeast according to water courses, which fragmentize them and separates in wide valleys, or, more rarely, in rushed slopes, on the parts of the same water courses and from the Dniester coasts.

Previously, a number of studies regarding the Politics of the „Lafarge Ciment” (Moldova) S.A. Corporation and research regarding the ecological state and biodiversity of the reference are of the limestone quarry were carried out in the area (Bulimaga, C., et al, 2015; Certan, C. et al, 2015).

Based on that, there was of a particular interest to perform studies regarding the biodiversity of the terrains located on the quarry’s territory with large amount of the uncovered mineral soil above the limestone, in order to create conditions needed to extract it to produce cement.

### MATERIALS AND METHODS

The object of the research was the flora from the „Lafarge Cement” (Moldova) S.A. stone quarry from Rezina. Analysis of floristic composition was taken into account to identify the number of component species, which give the information about the level of homeostasis of the system. The research was

carried out according to the linear transect method, which consist of noting the phyto individuals alongside a line or a band, whose length is established based on the investigated vegetation type (Cristea V., et al, 2004). Determining of the species of superior plants was also performed (Ciocîrlan V., 2000.; Negru A., 2007; Гейдеман Т., 1986).

## RESULTS AND DISCUSSIONS

Within the floristic research the study of the plant diversity and elaboration of a management plan in order to recover the flora of the „Lafarge Cement” (Moldova) S.A. quarry ecosystem was performed. Main focus was the taxonomic investigation of the floristic diversity in the neighboring regions of the quarry and in the proper quarry. There were identified 117 species of magnoliophyta from 43 families, the most diverse being Asteraceae family with 29 species and fam. Fabaceae - 7 species, fam. Lamiaceae - 7 species and fam. Poaceae with 6 species in the case-study area. According to the abundance of the species the first rank is given to Asteraceae, then the Poaceae, Fabaceae and Scrophulariaceae ones.



**Photo 1 *Elaeagnus argentea***

Predominate woody species is presented by *Elaeagnus argentea*. The quarry dendroflora is represented by 20 species of arbors and shrubs. The species of accompanying plants which vegetate together with *Elaeagnus argentea* on the slopes of the dump storages are presented by *Carpinus betulus*, *Robinia pseudoacacia*, *Acer negundo*, the more frequent shrubs are *Rosa canina* and *Crataegus monogyna*. At the same time, in places with storages of different ages rarely found species of fruit trees were found: *Cerasus avium*, *Armeniaca vulgaris*, *Juglans regia*, which reached the quarry territory and were spread by birds. As a whole, the ecosystem flora represents the state of ecosystem with high level of anthropological impact. Those 117 species identified in the quarry represent about a quarter of the petrophyte ecosystem diversity, which exceed the number of 340 species according to bibliographical data without the segetal and ruderal element which is spread pretty much within the quarry Гейдеман Т., 1980. The quarry vegetation is at the stage of establishing, because of the invasive species. The dominant species are - *Elaeagnus argentea*, which easily assimilated the quarry conditions due to the fact that it is a xerophyte one (resistant to the lack of humidity). Therefore, the limestone slopes in the ecosystem surroundings and also the dump storages are an ideal habitat for this species. In the depressions and more protected places on the quarry territory species like *Robinia pseudoacacia*, *Populus* sp., *Acer negundo*, *Carpinus betulus*, *Ulmus*, grow well and theirs' seeds were brought on the quarry territory by wind from the surrounding forest ecosystems. The herbaceous invasive species which assimilated to the growing conditions in the quarry are *Grindelia squarrosa*, *Erigeron annuus*, *Knautia arvensis*. These species came in the quarry territory by wind from the limitrophe agricultural areas or from the road sides where the *Grindelia squarrosa* species vegetate abundantly.

The most abundant herbaceous plants from the dump storages slopes are *Verbascum nigrum*, *Melilotus officinalis*, *Knautia arvensis*, *Festuca pratensis*, but the species *Grindelia squarrosa* and *Erigeron annuus* grow more abundant at the low part of the dump storages slopes and alongside the layouts that cross the quarry.



Photo 2 *Melilotus officinalis*

Photo 3 *Verbascum nigrum*

The floral diversity of the „Lafarge Ciment” limestone quarry and the adjacent quarry

No.	Family	No.	Species
1.	Ranunculaceae	1.	<i>Ficaria verna</i> Huds.
		2.	<i>Anemone ranunculoides</i> L.
2.	Fumariaceae	1.	<i>Corydalis marschalliana</i> Pers.
		2.	<i>Corydalis cava</i> (L.) Schweigg. et Korte .
3.	Urticaceae	1.	<i>Urtica dioica</i> L.
4.	Caryophyllaceae	1.	<i>Melandrium album</i> (Mill.) Garcke
		2.	<i>Spergula arvensis</i> L.
		3.	<i>Stellaria holostea</i> L.
5.	Chenopodiaceae	1.	<i>Chenopodium urbicum</i> L.
6.	Polygonaceae	1.	<i>Rumex conglomeratus</i> Murr.
		2.	<i>Polygonum aviculare</i> L.
7.	Rosaceae	1.	<i>Rubus caesius</i> L.
		2.	<i>Potentilla recta</i> L.
		3.	<i>Potentilla argentea</i> L.
		4.	<i>Agrimonia eupatoria</i> L.
		5.	<i>Crataegus monogyna</i> Jacq.
		6.	<i>Armeniaca vulgaris</i> Lam.
		7.	<i>Cerasus avium</i> (L.) Moench
		8.	<i>Rosa canina</i> L.
		9.	<i>Pyrus pyraister</i> Burgsd.
8.	Fabaceae	1.	<i>Coronilla varia</i> L.
		2.	<i>Melilotus officinalis</i> (L.) Pall.
		3.	<i>Melilotus albus</i> Medik
		4.	<i>Lathyrus tuberosus</i> L.
		5.	<i>Lotus corniculatus</i> L.
		6.	<i>Astragalus glycyphyllos</i> L.
		7.	<i>Lathyrus venetus</i> (Mill.) Wohlf. ( <i>Orobus</i> )
		8.	<i>Robinia pseudacacia</i> L.

9.	<b>Lythraceae</b>	1.	<i>Lythrum salicaria</i> L.
10.	<b>Euphorbiaceae</b>	1.	<i>Euphorbia</i> sp.
		2.	<i>Euphorbia amygdaloides</i> L.
		3.	<i>Mercurialis perennis</i> L.
11.	<b>Apiaceae</b>	1.	<i>Conium maculatum</i> L.
		2.	<i>Pimpinella major</i> (L.) Huds
		3.	<i>Daucus carota</i> L.
		4.	<i>Heracleum sibiricum</i> L.
12.	<b>Hypericaceae</b>	1.	<i>Hypericum perforatum</i> L.
13.	<b>Violaceae</b>	1.	<i>Viola mirabilis</i> L.
14.	<b>Resedaceae</b>	1.	<i>Reseda lutea</i> L.
15.	<b>Solanaceae</b>	1.	<i>Solanum dulcamara</i> L.
16.	<b>Convolvulaceae</b>	1.	<i>Convolvulus arvensis</i> L.
17.	<b>Boraginaceae</b>	1.	<i>Echium vulgare</i> L.
		2.	<i>Anchusa pseudochoroleuca</i> Schost.
		3.	<i>Pulmonaria officinalis</i> L.
18.	<b>Verbenaceae</b>	1.	<i>Verbena officinalis</i> L.
19.	<b>Lamiaceae</b>	1.	<i>Ballota nigra</i> L.
		2.	<i>Glechoma hirsuta</i> Waldst. et Kit.
		3.	<i>Teucrium chamaedrys</i> L.
		4.	<i>Salvia nemorosa</i> L.
		5.	<i>Salvia verticillata</i> L.
		6.	<i>Leonorus cardiaca</i> L.
		7.	<i>Lamium purpureum</i> L.
20.	<b>Plantaginaceae</b>	1.	<i>Plantago lanceolata</i> L.
21.	<b>Scrophulariaceae</b>	1.	<i>Linaria vulgaris</i> Mill.
		2.	<i>Linaria ruthenica</i> Bronski
		3.	<i>Verbascum nigrum</i> L.
22.	<b>Campanulaceae</b>	1.	<i>Campanula sibirica</i> L.
23.	<b>Rubiaceae</b>	1.	<i>Galium aparine</i> L.
24.	<b>Valerianaceae</b>	1.	<i>Valeriana officinalis</i> L.
25.	<b>Dipsacaceae</b>	1.	<i>Knautia arvensis</i> (L.) Coult.
26.	<b>Asteraceae</b>	1.	<i>Tragopogon major</i> Jacq.
		2.	<i>Sonchus arvensis</i> L.
		3.	<i>Sonchus</i> sp.
		4.	<i>Hieracium pilosella</i> L.
		5.	<i>Artemisia vulgaris</i> L.
		6.	<i>Artemisia absinthium</i> L.
		7.	<i>Grindelia squarrosa</i> (Pursh) Dun.
		8.	<i>Crepis rhoeadifolia</i> Bieb.
		9.	<i>Cirsium arvense</i> L. Scop
		10.	<i>Cirsium serrulatum</i> (Bieb.) Fisch.
		11.	<i>Cichorium intybus</i> L.
		12.	<i>Arctium lappa</i> L.
		13.	<i>Tripleurospermum inodorum</i> (L.) Sch. Bip.
		14.	<i>Taraxacum officinale</i> Wigg.
		15.	<i>Erigeron annuus</i> (L.) Pers.
		16.	<i>Erigeron canadensis</i> L.
		17.	<i>Onopordum acanthium</i> L.
		18.	<i>Eupatorium cannabinum</i> L.
		19.	<i>Carthamus lanatus</i> L.
		20.	<i>Senecio erucifolius</i> L.
		21.	<i>Xeranthemum annuum</i> L.

		22.	<i>Achillea millefolium</i> L.
		23.	<i>Inula helenium</i> L.
		24.	<i>Xanthium strumarium</i> L.
		25.	<i>Cyclachaena xanthiifolia</i> (Nutt.) Fresen.
		26.	<i>Carduus hamulosus</i> Ehrh.
		27.	<i>Lactuca tatarica</i> (L.) C. A. Mey.
		28.	<i>Tussilago farfara</i> L.
		29.	<i>Centaurea diffusa</i> Lam.
		30.	<i>Tanacetum vulgare</i> L.
27.	<b>Hyacinthaceae</b>	1.	<i>Scilla bifolia</i> L.
28.	<b>Convallariaceae</b>	1.	<i>Convallaria majalis</i> L.
		2.	<i>Polygonatum multiflorum</i> (L.) All.
29.	<b>Cyperaceae</b>	1.	<i>Carex brevicollis</i> DC.
30.	<b>Alismataceae</b>	1.	<i>Alisma plantago-aquatica</i> L.
31.	<b>Poaceae</b>	1.	<i>Elytrigia repens</i> (L.) Gould
		2.	<i>Festuca pratensis</i> Huds.
		3.	<i>Phragmites australis</i> (Cav.) Steudel
		4.	<i>Echinochloa crusgalli</i> L.
		5.	<i>Calamagrostis epigeios</i> (L.) Roth
		6.	<i>Bromus arvensis</i> L.
32.	<b>Typhaceae</b>	1.	<i>Typha angustifolia</i> L.
		2.	<i>Typha latifolia</i> L.
33.	<b>Corylaceae</b>	1.	<i>Carpinus betulus</i> L.
34.	<b>Salicaceae</b>	1.	<i>Salix caprea</i> L.
		2.	<i>Salix triandra</i> L.
		3.	<i>Populus</i> sp.
35.	<b>Juglandaceae</b>	1.	<i>Juglans regia</i> L.
36.	<b>Ulmaceae</b>	1.	<i>Ulmus</i> sp.
37.	<b>Aceraceae</b>	1.	<i>Acer negundo</i> L.
38.	<b>Simaroubaceae</b>	1.	<i>Ailanthus altissima</i> (Mill.) Swingle
39.	<b>Elaeagnaceae</b>	1.	<i>Elaeagnus argentea</i> Pursh
		2.	<i>Elaeagnus angustifolia</i> L.
40.	<b>Vitaceae</b>	1.	<i>Vitis vinifera</i> L.
41.	<b>Cornaceae</b>	1.	<i>Cornus sanguinea</i>
42.	<b>Viburnaceae</b>	1.	<i>Viburnum lantana</i> L.
43.	<b>Caprifoliaceae</b>	1.	<i>Sambucus ebulus</i> L.
<b>Total</b>	<b>43 families</b>	<b>Total</b>	<b>117 species</b>

The wet zone in the quarry, located in the depression around the groundwater reservoir is represented by species: *Eupatorium cannabinum*, *Lythrum salicaria*, *Phragmites australis*, and species of *Typha* and *Salix*. Other species which vegetate on that site are characterized by a low abundance. The majority of them are wild plants but sporadically there can be observed also segetal species, such as: *Echinochloa crus-galli*, *Convolvulus arvensis*, *Erigeron annuus*, etc. Medicinal plants like: *Melilotus officinalis*, *Melilotus albus*, *Daucus carota* were also identified in the site. The coverage level of the vegetal carpet is higher on the wetter places of that site, the other sectors have a lower level of the coverage - 50-60%.

According to the obtained results, in order to ameliorate the quarry vegetation from the recovered territory, supplementary investigations are needed for elaboration of the methods for fortifying of the slopes by planting certain arbor and shrub species which have resistance to impact conditions. Based on that research on the state of biodiversity is needed on the highlighted the zones where arbors and shrubs do not grow. A selection of the perspective species for the site has to be organized for this exhausted ecosystem. At the same time, the stocking of the rocks in the new storages must be coordinated together with ornithologists, which would suggest certain places in order to keep the ornithofauna which prefers unrecovered habitats. There is no doubt that the implication of some new species in the quarry ecosystem happens spontaneously and it is expected that the storages, in the next years, will be populated also by

some species of oak, maple and also by other forest species and this process happens without the human implication. The quarry ecosystem represents also a friendly environment for growing of the nut and berry plants. One of the species which could be planted and cultivated is *Hippophae rhamnoides*, which is an unpretentious one. It has a good capacity for fortifying the soil and its fruits have a valuable biochemical substance. The other berries - *Rosa canina* and *Crataegus monogyna* are presented in the quarry ecosystem, possess a good vitality, because they assimilated to the conditions of the quarry ecosystem and rarely they fructify quite abundantly.

In general, the state of the quarry ecosystem vegetation satisfies to the process of the recovery of vegetal communities and it is slow. The edifying species in the quarry (*Elaeagnus argentea* and *Elaeagnus angustifolia*) are not longevous species, so in the next 40-50 years they could be replaced with another species of woody plants which eventually come in the ecosystem by natural and anthropological factors.

## CONCLUSIONS

As the result of the investigation of the „Lafarge Cement” (Moldova) S.A. quarry flora and the adjacent territories 117 species from 43 families were identified. The investigated quarry flora is represented by 98 herbaceous shrubs and arbors plants, while the flora of the adjacent ecosystems is represented by 109 species.

In general, the floristic diversity in the quarry ecosystem is rather rich, but is much lower than natural limestone ecosystems in ratio of 1:3, this means that the number of the species registered in the quarry is three time lower than the number of species in the natural petrophyte ecosystems.

The quarry ecosystem is exhausted, because its flora is dominated by invasive species, the species from the natural ecosystems are represented here in reduced ratio and hardly withstand the conditions even in the recovered territory of the quarry.

The dominant species in the quarry ecosystem are: *Verbasum nigrum*, *Knautia arvensis*, *Grindelia squarrosa*, *Erigeron annuus*, *Melilotus officinalis*, which have adapted especially on the dumps aged of 20-25 years. These species vegetate abundantly and contribute to the ecosystem recovery.

In the conditions of the quarry ecosystem some species with economic importance occur: berries - *Rosa canina*, *Crataegus monogyna*, medicinal - *Hypericum perforatum*, *Polygonum aviculare*, *Valeriana officinalis*, *Tussilago farfara*, *Arctium lappa*, *Taraxacum officinale*, *Agrimonia eupatoria*, *Coronilla varia*, *Achillea millefolium* etc, melliferous - *Melilotus officinalis*, *Robinia pseudoacacia*, *Salvia verticillata* etc., aromatic oil - *Artemisia absinthium* and *Salvia verticillata*.

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