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# ANALYSIS OF THE BEHAVIOR OF WORKS TO LIMIT WATER EROSION IN RIVER BASINS

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***Abstract***

*The erosion generated by water, called synthetically water erosion, especially caused by the stream of water induces, the continuous change of the watercourse with significant imbalances of form and path, but also if it is the aquatic ecosystem, or a series of many others negative changes in the riparian areas of the minor riverbed, with material damage and sometimes clear loss of human lives. In time, constructive measures have been developed and applied, located in the riverbeds, to manage and minimize the impact of this phenomenon. The monitoring of the behavior of these works shows the beneficial effect on the limitation of erosion, but it also reveals the negative effects of the hydrodynamic action of the water on their structure and stability, eventually on their durability. The present paper proposes a synthetic analysis of the causes and ways of degradation of the main types of works used in engineering practice to limit the erosion of the watercourses. The analysis is based on an extensive documentary and field study carried out on concrete cases, on a series of rivers in the river basins of Moldova. The causes that led to the observed degradation are highlighted, respectively the solutions by which these shortcomings could be avoided in the future. It highlights the increased efficiency and the longer life of the new types of works used for this purpose, respectively the works based on the use of geocontainers.*

***Key words****: degradation, erosion, gabions, geocontainers.*

## INTRODUCTION

The main objective of this work is to analyze the use of some hydrotechnical works that can be performed to ensure the protection of localities and social economic objectives, against the erosion process produced by the watercourse.
The erosion produced by the watercourse is the mechanical process exercised by the water of the river during floods on the bed of the riverbed and the banks where the particles of soil and rock are weakened, dislocated and entrained.
This process is accentuated during the floods in the areas where the river has additional energy and has high speed, being influenced by the transport of the alluvium from upstream to downstream, the nature of the soil crossed by the watercourse and the slope of the land.

The intensity of erosion can be normal being equal to the natural remaking of the soil and accelerated being faster than the natural remaking.

Depending on the area of action on the ground, there is surface erosion (it develops on relatively large surfaces) and depth erosion (is the advanced form of surface erosion that is pronounced after a certain concentration direction giving rise to permanent and action destructive formations. (Nicola O., 2013)
Types of erosion produced by the watercourse:
*Linear erosion* - occurs in the riverbed along the waterline, ie where the depth is high and the turbulence is active;
*Regressive erosion* - occurs on any leveling along the river bank, but the tendency is to reduce the slope, by withdrawing and ceasing it upstream;
*Lateral erosion* - is the mechanical process by which river water loaded with alluvium acts on the steep banks of the riverbed, frequently in the meandering concavities (Baloiu V., 1967);
*Torrential erosion* - it acts in the depths and in the area of the banks, it is formed during periods of heavy rainfall by concentrated water currents in the slope areas and at the edge of the terraces

where the soil is poorly cohesive (Radoane N., 2004).

## MATERIALS AND METHODS

This paper proposes an analysis the use of erosion control works, with classic gabions and geocontainers from an economic point of view, and their behavior in the areas located on the rivers of the Siret river basin.
The analysis of the works from an economic point of view was performed through the Windoc Deviz program, and the behavior of the works was performed through field verifications and periodic monitoring.

### Erosion control works, general aspects

Hydrotechnical schemes and works are important for our country due to the varied conditions of soil, climate, relief, and watercourses variation.
The erosion control hydrotechnical works contribute by their effect to the protection and improvement of the soil, the defense of agricultural lands and environmental factors. Also, through erosion control works i can be ensured localities and roads protection against erosion process or landslide.
Erosion control works used could be:
***- Cross works:***
- groyne;
- bottom sill;
- dams.

***- Longitudinal works:***
- gabion works;
- support walls;
- concrete and rock walls;
- prefabricated works.

***- Regularization works:***
- rock and gabion dams

(Oncia S., 2016).

### Gabion works

*Classic gabions* are construction elements consisting of parallelepiped or cylindrical boxes, and mattresses, made of metal frames and zinc-plated wire mesh, filled with river stone or broken stone.
Box type gabions are 1 m high, 1-1.5-2 m wide, and 2-6 m long.
The gabion frame gives resistance, therefore is made of steel having diameters of Ø 10-18 mm or of galvanized steel bars. The gabion sides are made of galvanized wire mesh Ø 2.8-5 mm, single or double twisted in square or hexagonal mesh of 4-8 cm. The mesh size and the diameter of the wire are chosen according to the filling stone size. (https://www.scrigroup.com/casa-masina/constructii/Modernizarea-tehnologiei-de-pr14156.php)
*Alternative gabions* are rectangular prismatic elements, constructed of a metal reinforcement and a metal mesh, with hexagonal, double twisted mesh.
The mesh can be hot galvanized, galvanized aluminum or PVC coated. All the gabions are constructed of core wire with a diameter of 2.7 mm and have an opening of 100 mm, the gabions are divided with internal diaphragms arranged at 1 m.
Gabions are available in the following standard sizes:
- 1 m x 1 m x 1 m;
- 2 m x 1.5m x 1 m;
- 2 m x 0.5 m x 0.5 m;
- 2 m x 1 m x 0.5 m;
- 2 m x 1m x 1 m;
- 4 m x 1m x 0.5m;
- 4 m x 1 m x 1 m;
- 6 m x 2 m x 0.5 m.

(https://www.maccaferri.com/ro/)
The gabions are used for the protection of the banks, local protection of the infrastructure of the bridges, buried bottom thresholds, support walls for the protection of the slopes, they can be used in the areas with lateral erosions encountered on the watercourses and torrential formations (Figures 1 and 2).
The gabions are usually placed over the gabion mattresses, it is recommended that these gabion mattresses be placed on a layer of rolls of twigs running in the direction of the water flow.
Gabion hydrotechnical structure are elastic and can be placed according to the configuration of the land and are resistant to degradation.
In the case of floods with coarse alluviums, the wire can be destroyed in time, for the protection in time of the wire used in the gabions they are protected with a concrete layer.
The execution of the gabions is complex and the costs are significant.

Figure 1. Classic gabion work, 200 m length, on Putna river in the village of Valea Sarii, Vrancea county (photo taken by the authors)

Figure 2. Alternative gabions work, 450 m with a length on Oreavu stream, Urechești locality, Vrancea county (photo taken by the authors)

**Geocontainer works**

Geocontainers are made of woven or non-woven geotextiles made of polypropylene or other polymers. These geocontainers can be made in standard dimensions but also for each work individually, with shapes and dimensions adapted to the needs of the applicattion.

Standard dimensions of geotextile weight is about 600 g/m$^2$.

a - 1.14 m x 2.28 m;

b - 1.45 m x 2.38 m;

c - 1.30 m x 2.65 m.

For high strength and safe handling, they can have reinforcement straps, hanging straps, as well as a lid with a filler to prevent sewing on the construction site. In this way, they become casket that, after landing on the site is filled with local materials - natural granular aggregates.

Geocontainers can be in the form of bags, parallelepiped, in the form of mattresses or tubes (Figures 3, 4, 5 and 6). The variety of shapes gives them the advantage of being used for different types of applications such as the hydrotechnical field, bringing significant advantages in the following directions:

- the replacement of the classic solutions of embankments or bottom thresholds, with the use of geocontainers, leads to significant reductions in the costs of implementation;
- the solutions using geocontainers have proved, in practice, to be ecological and environmentally friendly solutions;
- geocontainers made of non-woven geotextiles are well resistant to mechanical shocks, deforming and absorbing the impact force;

- can successfully replace any type of gabion having the advantage that they can be filled with any type of material;
- achievement of bottom sill or other hydrotechnical structures without the condition of working in dry environment;
- shows the advantage that they can be filled with any type of local material, with concrete or ballast stabilized with cement (http://roff.ro/index.php/catalog-produse/item/10-geocontainere-netesute).

Figure 3. Geocontainer appearance Avram Al. M., 2020)

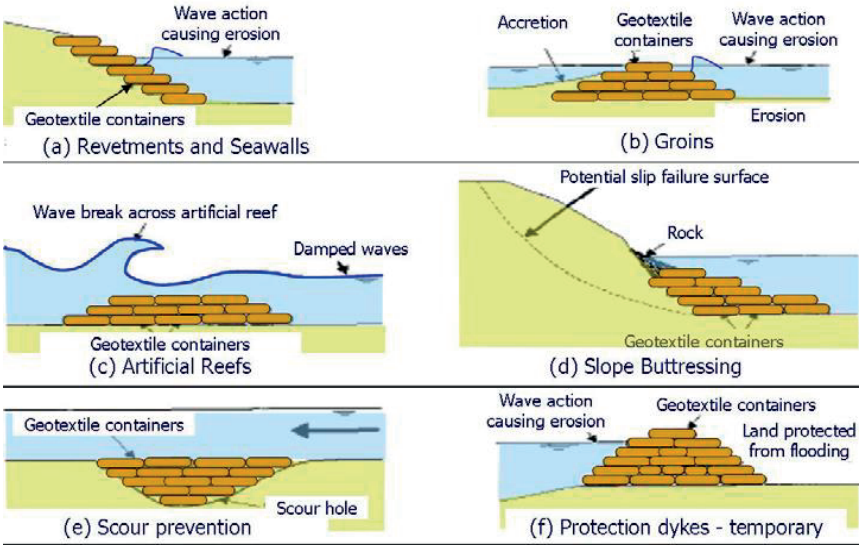


Figure 4. Models of geocontainers works (Young C. K., 2008)

Figure 5. Geocontainer work in the form of haulers, 500 m length on Siret river, Suraia locality, Vrancea county (photo taken by the authors)

Figure 6. Longitudinal geocontainer work, 240 m length, Ramnicu Sarat river, Ramnicu Sarat locality, Buzau county (photo taken by the authors)

**Economic evaluation of erosion control works**

For the economic evaluation of the erosion control works, two models of works were made in the Google Sketchup program that are used and applied on the rivers from the Siret river basin (Figures 7 and 8).

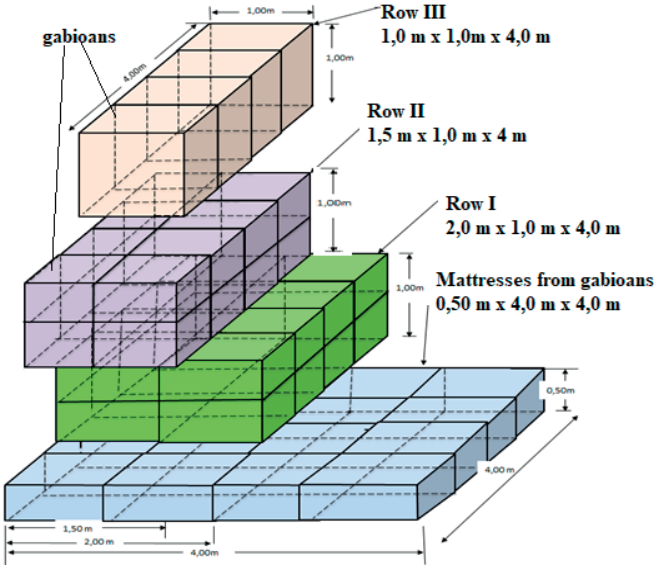


Figure 7. Gabion work scheme considered for calculation (modeled by Google Sketchup by the author)

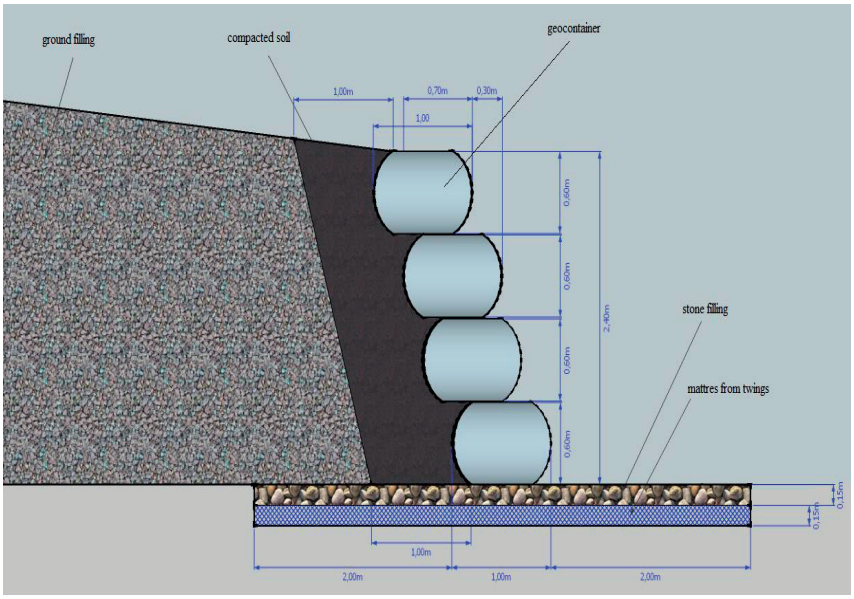


Figure 8. Geocontainer work scheme considered for calculation (modeled by Google Sketchup by the author)

**Economic evaluations**

The economic evaluation of the execution of the works from gabions and geocontainers was made from the point of view of the resources used, materials, equipment, transport and duration of execution, for works with a length of 100 m and 200 m (Figures 9, 10 and 11).

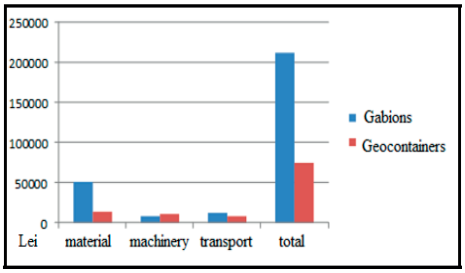


Figure 9. Economic calculation for gabion and geocontainer works of 100 m length execution (data processed and obtained from Windoc Deviz)

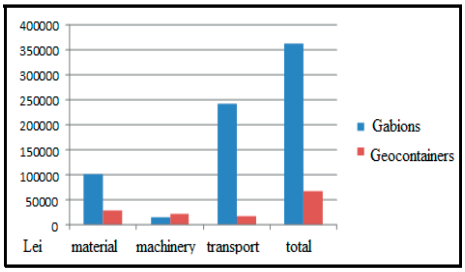


Figure 10. Economic calculation for gabion and geocontainer works of 200 m length execution (data processed and obtained from Windoc Deviz)

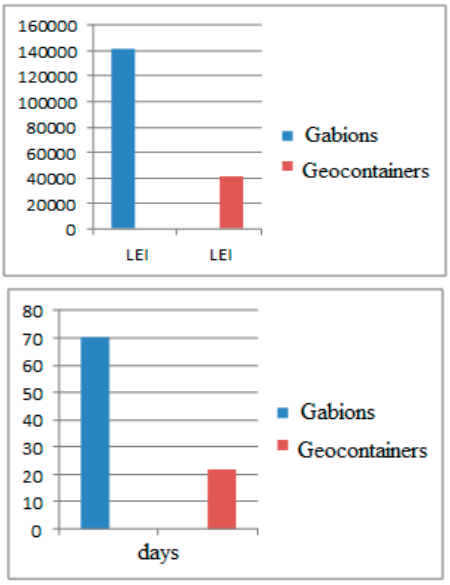


Figure 11. Economic calculation for labor cost and execution period for gabion and geocontainer works of 100 m length (data processed and obtained from Windoc Deviz)

**Degradation of erosion control works**

**Degradation of gabion works**

The degradation of the gabion works is a process as a result of the destructive action exercised by external geomorphological and chemical agents, by decreasing the thalweg quota, the displacement of the soil behind the work and the destructive action due to corrosion.

**The overturning of the gabion works**

Overturning is the phenomenon of moving a body from its normal position by rotation around a certain point/line leading to fall to one side or upwards (Figures 12).

*Causes:*

- High flows of the watercourse that exceeded the structure crest level;
- The transport of coarse river deposits during the floods that affected the mattress from the base of the work;
- Filling instability behind the work.

Figure 12. Gabion works of 300 m length, degraded by overturning, Putna river, Tulnici city, Vrancea county, Q=570 $m^3/s$ (photo taken by authors)

**Degradation through slip**

The slip represents the smooth movement, without encountering any resistance, when two bodies in contact move one against the other tangentially, without rolling (Figures 13).

*Causes:*

- High flows of the watercourse that exceeded the work crest level;
- Unstable foudation soil;
- Filling instability behind the work.

Figure 13. Gabion works of 2700 m length degraded by slip Putna river, Vidra locality, Vrancea county, Q = 670 $m^3/s$ (photo taken by the authors)

**Degradation by lowering the riverbed quota**

The deepest line along a river means the one that follows the lower part of the riverbed of a watercourse, varies according to the slope of the land, the nature of the rocks in the riverbed and influences the location and evolution of the hydrotechnical works (Figure 14).

*Causes:*

- High differences between the river source and the river discharge point;
- Exploaitation of mineral aggregates.

Figure 14. Gabion works of 200 m length degraded by the decrease of riverbed quota, Coza river, Tulnici, Vrancea county (photo taken by the authors)

**Degradation caused by the transport of river deposits and floats**

In areas with spontaneous forest vegetation in the minor riverbed or in the area of the banks, during the floods the banks are eroded and the trees are dislocated and then transported. Trees can narrow or even block water section and can destroy the wire mesh of gabion structures (Figure 15).

Figure 15. Gabion works of 300 mlength degraded by floats, Zabala river, Naruja locality, Vrancea county (photo taken by the authors)

**Degradation of geocontainer works**

**Degradation of geocontainer works by lowering the riverbed quota** (Figures 16, 17, 18).

*Causes:*

- Exploaitation of mineral aggregates;
- Variation of water flow rates.

Figure 16. Degradation of geocontainer works by reducing the riverbed quota, Siret river (photo taken by the authors)

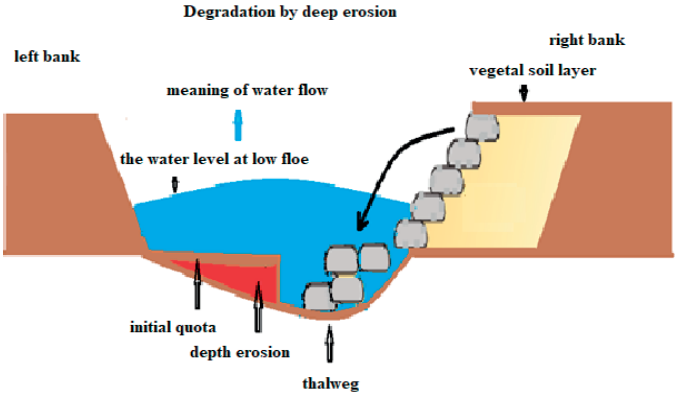


Figure 17. Degradation of geocontainer works by reducing the riverbed quota - scheme made by authors

Figure 18. Degradation of geocontainer works by lowering the elevation of the riverbed and relocating the geocontainer, Siret river, Suraia locality, Vrancea county (photo taken by the authors)

**Degradation by vandalism**

Vandalism is an action that involves intentional destruction or damage to an object. It can be made by cutting or firing the bags. If the work is set on fire, it will be completely destroyed. Vandalism is a great danger for geocontainer work (Figures 19).

Figure 19. Geocontainer works degraded by vandalism, Siret river, Vadu Rosca, Vrancea county (photo take by the authors)

## RESULTS AND DISCUSSIONS

Following the economic evaluation of the execution of gabion and geocontainer works, the obtained result shows that the geocontainer works are carried out with much lower costs than the works in gabions.
The execution period of geocontainer works is much shorter than the execution of works in gabions. Geocontainer works can be used to arrange an erosion area that needs to be resolved quickly.
From the point of view of degradation phenomena, geocontainer works are less affected than gabion works and, to the same extent, there are fewer losses from an economic point of view.

## CONCLUSIONS

Gabion hydrotechnical works are difficult to put into operation and require a specialized team for laying the stone and the costs for making the gabions are high.
There are many forms of degradation in gabions and they can be caused by several causes.
The wire used in the gabions can be destroyed by the transport of alluviums during the floods, the environmental factors favor their degradation.
Damaged gabions works can no longer be repaired or reused and do not allow the development of fauna and flora in the environment.
Geocontainer hydrotechnical works can be used in longitudinal works and are easy to put into operation.
The filling inside the works from the geocontainers is made with local material and does not require additional costs and can be used in saline areas and they are not vulnerable to the environment factors.
Geocontainers works are elastic due to the flexibility of the geotextile and the characteristics of filling materials, they could be degraded but the structures are not completely destroyed.
The total degradation of geocontainer structures can be caused by vandalism, by cutting or firing the bags.
The river deposits transport made up of gravel and boulders is easier to maintain in the case of longitudinal works, and in the area of rivers with medium flows.
Geocontainer hydrotechnical works are environmental friendly and allow the development of flora and fauna within the habitats.
The results presented in this paper come from filed measurements and economic values are made by computation. The behavior and the evolution of the gabion and geocontainer hydrotechnical works were tracked for their use in erosion preventing and control generated by watercourse.

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