BIORETENTION - INTEGRATION OF RAINWATER MANAGEMENT IN LANDSCAPE DESIGN

BIORETENȚIA - INTEGRAREA GESTIONĂRII APELOR PLUVIALE ÎN DESIGN-UL PEISAJULUI

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Abstract. *This paper is a case study of an area with problems caused by stagnant rainwater; this study was completed by designing a bioretention cell. This type of planning is an approach with little impact on the environment. Bioretention cell is one of the techniques that can solve studied land problems; existing vacant land can be transformed into a green space with multiple uses. For designing an effective solution has made a thorough review of the site, the results of this analysis leading to the creation of a bioretention cell model correctly sized, the choice of appropriate plant material and ultimately to prepare a detailed plan of the proposed landscaped for the studied site.*

Key words: landscape, rain, bioretention, polluted water

Rezumat. *Această lucrarea reprezintă un studiu de caz, al unei zone cu probleme cauzate de stagnarea apei pluviale, studiu finalizat prin proiectarea unei celule de bioretenție. O astfel de amenajare reprezintă o abordare cu impact scăzut asupra mediului înconjurător. Celula de bioretenție este una din tehnicile care poate rezolva problemele terenului studiat, terenul viran existent putând fi transformat într-un spațiu verde cu întrebuințări multiple. În proiectarea unei soluții eficiente s-a făcut o analiză amănunțită a sitului, rezultatele acestei analize conducând realizarea unui model de celulă de bioretenție, corect dimensionat, la alegerea materialului vegetal adecvat şi în final la elaborarea unui plan detaliat al propunerii de amenajare peisagistică pentru amplasamentului studiat.*

Cuvinte cheie: peisaj, ploaie, bioretenție, apă poluată

INTRODUCTION

Along with rapid urbanization, the world's urban population has nearly quadrupled in the past 50 years, from 732 million in 1950 to more than 3.2 billion in 2006 (Worldwatch Institute, 2007). Cities are not able to accept these rising populations without increasing in size, typically leading to urban sprawl, land use changes, and environmental degradation. Increases in the density and size of urban areas have thus resulted in an increased amount of impervious surfaces and a corresponding decrease in forests, wetlands, prairies, and other areas that naturally infiltrate and purify water (Brabec et al., 2002).

Roads, buildings, driveways, and cultivated lawns change the partitioning of water between runoff and infiltration and increase high flows of storm water.

This imbalance can cause flooding of urban areas, as well as increase flows to streams and lakes. Further complicating the cycling of rain water is the installation of drainage networks in urban areas to contend with the water flowing off of impervious surfaces (Lerner 2002). Storm water, considered to be nonpoint source pollution, has been identified by the Environmental Protection Agency (EPA) as the leading cause of water quality problems, as it transports a variety of pollutants directly into waterways. Sewage control systems involve complicated and expensive systems that are designed to manage and purify water from rainfall before its discharge into the rivers. Have been developed alternative approaches with low impact on the environment (LID) to control the harmful effect of polluted water, one of the approaches being the bioretention cell (rain garden). The goal of systems with low environmental impact is to mimic natural techniques for capture, retention, infiltration and evaporation of storm water runoff (Prince George's County, 1999).

Purpose of this paper was to develop a complete draft for a bioretention cell based on a study of land with drainage problems.

MATERIAL AND METHOD

This paper is a case study of an area with problems caused by stagnant rainwater that will be completed by designing a bioretention cells.

In the area known as Bodon in the centre of Boteni, Cluj County there is a vacant land, representing plot no. 159, with area of 2173 m^2 (fig. 1).

Fig. 1. Studied area

„Bioretention cell" is one of the techniques that can solve the studied land problems, which could subsequently be turned from a vacant land into a green space with multiple uses: playground, sitting area, area aesthetics.

Bioretention is based on natural principles and soil qualities and uses a certain area designed to capture and filter out rainwater runoff, through a soil mixture and allowing water absorption while its use by existing vegetation (Prince George's County, 2002).

From an environmental perspective, a "Rain Garden" is a practical solution for storm water retention, while having an aesthetic appearance (fig. 2).

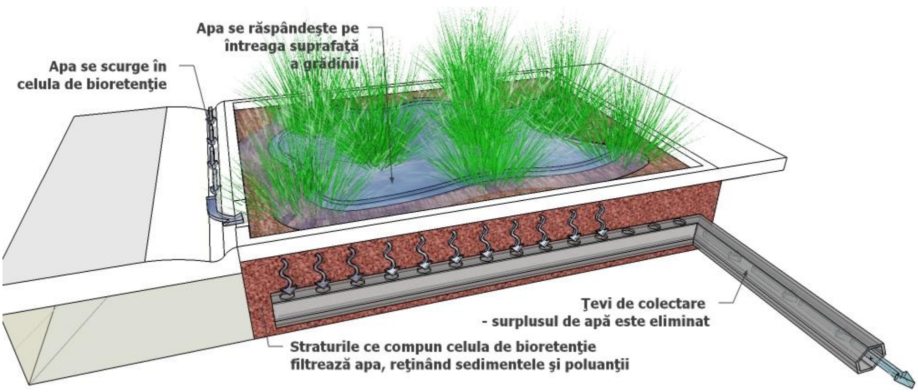

Fig. 2. „Rain garden" operation mode

To implement Bioretention cells in the landscape design to manage the pollution and negative effects of rain water, was analyzing the current situation of an area located in the Boteni centre, area during rainy periods is impractical hampering daily activities and negatively affecting locality aesthetics and environment. Installing a bioretention cells can be effective in reducing moisture in low areas where water temporarily stagnates.

There have been studies on climate, landscape, geological studies, photo analysis, and site behaviour in rainy periods; results were interpreted by the graphics.

From these studies it appears that drainage problems of this locations could be improved by installing several rain gardens. A preliminary design was carried out with proper sizing.

In sizing the rain garden was used a simplified version of Darcy law. Darcy's law was established experimentally in 1856 and applies to uni-dimensional flow of incompressible homogeneous fluids, both under saturated and unsaturated regime.. Darcy experimentally observed relationship between flow across a porous material (sand) and the corresponding load flow. Darcy's law expresses the fact that the specific flow q [L / T], is directly proportional to load hydraulic gradient: q = (-K) H / L = (-K) dh / dl (1) where: K [L / T] is hydraulic conductivity, dh / dl [L / L] the hydraulic gradient. Since rain gardens function is based on the flow of water leaking through the ground, a version of Darcy's law can be used in the calibration process. A simplified version of Darcy's law is:

$$SA = \frac{0{,}04 \cdot c \cdot DA \cdot depth}{(i) \cdot (depth + h\ \ edges)}$$

In this equation, the rain garden area (SA) is a function of flow coefficient (c) measuring the flow of rain on a surface, the total drainage area (DA), mixture planting depth (depth), the edge height planting area (edges), native soil infiltration rate (i).

Other additional data needed to build an effective model of bioretention cell are design parameters of the rain gardens, soil water retention capacity, infiltration rate, laboratory analysis, results in the field, the calculation of permeability coefficient, research on mixing plant use and implications for bioretention cells design, biological and social aspects of rain gardens, the main hydrological parameters for mixtures of soil

, typical values of permeability for unconsolidated sediments, typical values of porosity for unconsolidated sediments, laboratory measurements for permeability and determination of d10 values (defined as the inactivation dose) on samples from the field, suspended sediment, water quality, filtration efficiency.

RESULTS AND DISCUSSIONS

The site analysis has determined that the land is characterized by geomorphological, geological and hydrogeological conditions this: water poor drainage of surface leads to a very wet perimeter, moorland. In the south - west a well was dug for animals and water level in this well is at ground level.

Excessive moisture of this area due, also, to slope leakage witch form a small stream under the form of a gutter, which discharge into the creek that crosses the village. From the relief study result the Boteni area is located geographically in the north-west of the Transylvanian Plateau, the geographical unit is characterized by a succession of gentle ridges separated by wide valleys, the low plains, the average altitude hills being 400 m. Lithological columns for the site are as follows (table 1).

Table 1

Lithography Columns for the studied site, Boteni

Location	0,00– 0,20 m	0,20 – 0,5 m	0,50 – 1,40 m	1,40–3,00 m	Observations
Boteni	Very wet brown clay with soft texture	Very wet brown clay with soft texture	Very wet brown clay with soft texture	Brown sandy clay - yellow with viscous texture	Water infiltration were found in depth of 1.5 m

In designing an effective solution for problems of this area have been respected rules on bioretention cells dimensioning, installation, maintenance and type of plant material used, developing a complete landscape plan (fig. 3).

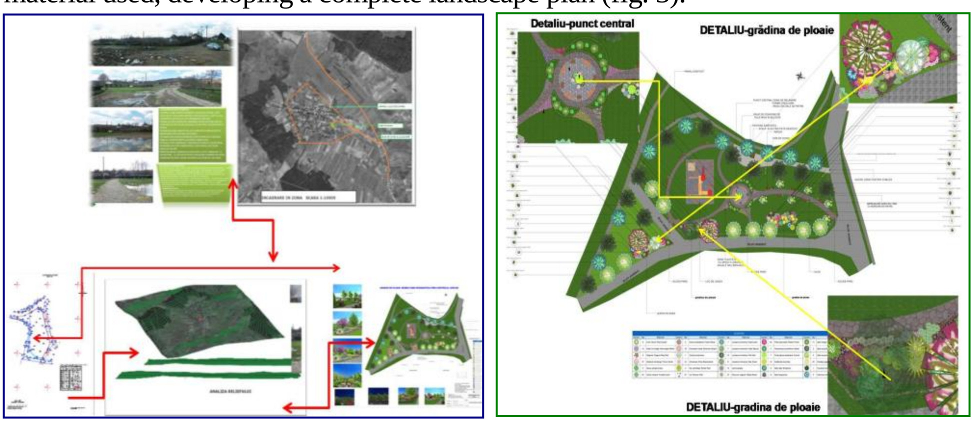

Fig. 3. Site analysis and development proposal

Given the structure of the soil in the area where is proposed the bioretention cell is recommended that the thickness of the stone to be between 12-15 cm. To install the plant layer is required additional excavation. Fertile layer can be mixed inside or outside the garden, before bedding and 50% of the content may be the first layer of soil obtained from the excavation and the remaining 50% will be added to compost, soil rich in organic matter.

The sizes of bioretention cell proposed for this site will be between 100-50 m^2, areas that will provide drainage for areas with stagnant water from rainfall and slopes runoff. They will be located at least 30.5 m of existing well and 15 m from the foundations of buildings.

Topography of the site poses no additional problems for installing bioretention cells, ground level showing insignificant differences. Proposed depth is 3000 mm edges slope 4:1, soil depth treatment 1200 mm, is indicated using a soil infiltration rate of 13 mm / hr.

Plant selection. There are a variety of species suitable for planting in a bioretention system. They will be chosen from a list that includes large trees, small trees, perennial flower species, shrubs, ornamental grasses (table 2, table 3).

The plant material chosen has the following qualities: it is able to tolerate excessive moisture conditions during rainy periods and, various pollutants resulting from the surrounding roads and slopes pastures washing. The prolonged drought periods is recommended supplementary irrigation

Table 2

Trees and shrubs

Large trees	Small trees	Shrubs
Acer rubrum	*Aesculus pavia*	*Aronia arbutifolia*
Betula nigra	*Carpinus caroliniana*	*Callicarpa americana*
Fraxinus pennsylvanica	*Cercis canadensis*	*Calycanthus floridus*
Nyssa sylvatica	*Chionanthus virginicus*	*Cephalanthus occidentalis*
Quercus phellos	*Crataegus phaenopyrum*	*Clethra alnifolia*
Quercus nuttalii	*Magnolia tripetala*	*Euonymous americanus*
Magnolia grandiflora	*Asimina triloba*	*Lindera benzion,*
Quercus laurifolia	*Alnus serrulata*	*Viburnum nudum*
Betula lenta	*Amelanchier arborea*	*Corylus americana*
Salix species	*Cornus alternifolia*	*Physocarpus opulifolius*
Taxodium distichum	*Hamamelis virginiana*	*Sambucus canadensis*
Platanus occidentalis	*Cornus sp.*	*Spiraea latifolia*
Aesculus octandra		*Spiraea tomentosa*
Nyssa sylvatica		*Spiraea alba*
Prunus serotina		*Rhododendron viscosum*
Tilia heterophylla		*Rosa palustris*
Acer negundo		*Vaccinium ashei*

Table 3

Ornamental grasses and flower species recommended for bioretention cell planning

Ornamental grasses	Perennial flower species	
Carex sp.	*Aster caroliniana*	*Pontederia cordata*
Rhynchospora latifolia	*Coreopsis auriculata*	*Rudbeckia sp.*
Scirpus cyperinus	*Coreopsis lanceolata*	*Solidago rugosa*
Juncus effusus	*Coreopsis rosea*	*Liatris spicata*
Chasmanthium latifolium	*Helianthus angustifolius*	*Lobelia cardinalis*
Muhlenbergia capillaris	*Iris versicolor*	*Phlox paniculata*
Panicum virgatum	*Iris virginica*	*Phlox subulata*

CONCLUSIONS

In the process of analysis and design were obtained data and detailed plans that allow installation of a system composed of three bioretention cells in Boteni, Cluj county, landscaped method that will provide a way to use and optimize every drop of rainfall, and will improve drainage conditions of this site.

Benefits of the bioretention cells placed in this area are varied: increasing the amount of water that infiltrates in soil, solving the problems caused by poor drainage, reduce pollution caused by rainwater, improved aesthetic appearance of the locality without interfere with the natural ecosystem, will provide a favourable habitat for fauna and biodiversity, contributing to the promotion and implementation of a type of landscape architecture which respects the principles of sustainable development.

In Romania we are not aware of such bioretention systems, although their presence is needed and would represent a step forward for greening several areas, noting that this design would be implemented on a large scale to be effective.

REFERENCES

1. **Atchison D., Potter K., Severson L., 2006 -** *Design guidelines for stormwater bioretention facilities. University of Wisconsin Water Resources Institute,* Madison, WI, USA, 33 pp.
2. **Brabec E., Schulte S., Richards P.L., 2002 -** *Impervious surfaces and water quality: A review of current literature and its implications for watershed planning.* Journal of Planning Literature 16, 499-514.
3. **Lerner D.N., 2002 -** *Identifying and quantifying urban recharge: A review.* Hydrogeology Journal 10, 143-152.
4. **Prince George's County, 2002 -** *Bioretention manual*. Prince George's County Government, Department of Environmental Protection, Landover, MD, USA, 202 pp.
5. **Worldwatch Institute, 2007 -** *State of the World 2007: Our Urban Future.*
6. *****, http://www.goprincegeorgescounty.com/Government/Agency**