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Researches on Permeability and Soil Structure for the Implementation of Sustainable Landscape Architecture Practice

KEYWORDS: Drilling, site, land use, permeability, bioretention

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ABSTRACT *Sustainable landscaping incorporates a variety of practices that have been developed as a response to environmental issues and are used in all phases of landscaping. Bioretention offers a combination of local storm water management, improving urban green aesthetic value and facilitating increased polluted water retention function. To establish an important implementation condition of the bioretention system was approached the issue of permeability and soil structure in four different sites in terms of land use, in Cluj-Napoca, Romania.*

The environment is severely affected duet to accelerated anthropization, requiring interventions that apply the principles of sustainable development and minimize the impact of urbanization (Barbosa *et al.*, 2012; Frondoni *et al.*, 2011). The bioretention is based on natural principles and on the quality of the soil, and use a given area, designed to capture and filter out the water surplus from precipitation, through a soil mixture that allows water absorption and at the same time its usage by the existing vegetation (Prince George's County, 2007; Atchison *et al.*, 2006). Knowing the conditions for implementation of bioretention cells is a sine qua non condition. Although apparently, at first definition is perceived simplicity in design, construction and operation, after a careful study of specialized information is clear and without equivocation that without knowledge in detail of their, bioretention cells implementation may suffer in terms of efficiency, and the basic functions will not be fulfilled (Emerson *et al.*, 2005; Gilroy and McCuen, 2009). One of the implementation conditions with significant influence on the constructive type of bioretention is the permeability and soil structure of the targeted site. Infiltration capacity of the most soils allows to precipitation with low intensity to infiltrate completely, except the case when the inferior layers are more compacted than the soil layer from the surface (Morel-Seytoux, 1978). A high intensity precipitation generates substantial runoff because the infiltration capacity of the surface soil is exceeded even if the underlying soil is still dry. There is a classical assumption, namely: the ability of infiltration of the soil is higher at the beginning of a precipitation event and decreases over time (Willeke, 1966). Natural infiltration is significantly reduced in urban areas due to several factors: decrease of the areas with exposed soil, removal of the surface soil and exposure of the inferior layers, soil compaction during construction activities (Characklis and Wiesner, 1997; Eriksson *et al.*, 2007; Lin Yu-Pin *et al.* 2007). Pitt et al. (2002) asserts that systems which rely mostly on vegetated infiltration surfaces gaining popularity and seem to be a more robust solution than conventional drainage and infiltration systems. In this paper, to establish an important implementation condition of the bioretention system was approached the issue of permeability and soil structure in four different sites in terms of land use, in Cluj-Napoca.

Materials and methods
For the research of the bioretention systems implementation conditions were selected four different sites in terms of land use located in the city of Cluj-Napoca, Romania: high density residential area, low density residential area, commercial area, and industrial area. For the determination of the permeability and soil structure, in the selected sites were performed four geotechnical drilling. Research from geotechnical point of view aimed to establish lithological succession, particle size distribution, and degree of nonuniformity, volumic weight, specific density and soil permeability in the studied areas, the classification of studied soils in the four hydrological groups. Water permeability was carried out in the laboratory using the method of permeameter with constant gradient. Figure 1 shows the location of geotechnical research work. The maps were drawn at different scales, depending on the surface area: 1:1000, 1:2000 and 1:5000 scales.

Results and discussion
After the analysis of texture on the soil profiles were found large oscillations under the aspect of the three categories of particles so that depending on their percentage, was determined the soil textural class from studied sites. Based on the results presented in Table 1 were determined the following soil types: silty clay in the high density residential area, loamy dust in the low-density residential area, dusty sand in the commercial area, clay in the industrial area. The site soils from studied sites were included in the six textural classes for soils in Romania established by Chiri' (1955) based on the percentage content of each granulometric fraction. We could enclose into these categories only the soil from the commercial site and from industrial site. The soil from the industrial site falls into the category of the soils with clay loam texture, while soil from the commercial site falls under the category with sandy loam soils.

With regard to these characteristics of the soil from studied urban areas and their influence on the implementation of bi-

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oretention cells, the results in terms of particle size distribution revealed that: the large amount of the dust of the soil from high-density residential area (52%) cause unfavourable properties regarding the soil compaction and contribute to a poor structuring of the aggregates, favouring formation of the crust on the soil surface, with negative repercussions on the growth of the plants. The high content of sand from the commercial area determines the following properties: high permeability, very low capacity for water and nutrients retaining, failure to satisfy the requirements of plant development and growth. The high content of clay of the soil from the industrial zone determines the following qualities: plasticity and high adhesion, high capacity to retain water and nutrients, very high specific surface area, favouring the deployment of physico-chemical and biological processes, good fertility.

Depending on the values of the nonuniformity coefficient of the soils from studied areas, all having the nonuniformity coefficient U_n>15, can be characterized as highly non-uniform soils (table 1). This characteristic of the soils from studied areas is favourable for sustainable drainage systems. Considering the fact that efficiency of traditional drainage systems may be destroyed by soil entering into the drains, this can have the same negative effect on sustainable drainage systems (in this case – the bioretention cells).

Uniform soils are not capable to form natural filters. These soils, those with high uniformity, are unstable when they are saturated finally blocking the drainage system. All soils with unstable structure are showing low permeability. In the table 2 are presented the results of the classification in the hydrological groups of the soil from the four sites in which have been made the drillings. The obtained data show that: soil from the commercial area shows moderate permeability; soil from low density residential area shows low permeability; soil from high density residential area shows moderate permeability, and soil from industrial area show moderate permeability.

Figure 1. Geotechnical drilling location in a low density residential area (a)

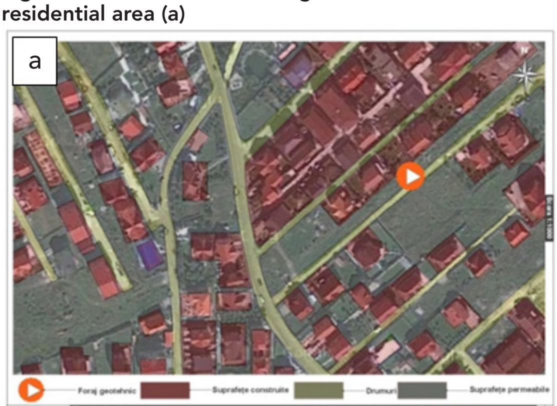

Figure 1. Geotechnical drilling location in a low density residential area (a)

Figure 1. Geotechnical drilling location in a commercial area (b)

Figure 1. Geotechnical drilling location in a high density residential area (c) and in the industrial area (d)

Table 1. Summary of analysis

Area	F/p Depth	Particle size distributio			Degree of Non-uniformity	Volumetric weight In the natural state	Specific density	Permeability
		Clay	Dust	Sand	U_n	Y	Ys	k
		%			%	KN/m³		cm/s
C	1,5	20	33	47	70	19,4	26,6	$2,6*10^{-4}$
R.D.R.	1,5	26	45	29	28	18,5	26,6	$6,2*10^{-7}$
R.D.M.	1,5	32	52	16	15	19,3	26,8	$2,5*10^{-7}$
I	1,5	40	37	23	20	19,4	26,9	$1,6*10^{-5}$

C - Commercial area; R.D.R.–Low density residential area; R.D.M.-High density residential area; I -Industrial area

Table 2. Classification in hydrological groups of soil from

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studied sites

Area name	Texture	Hydro-logical group	Description
Commer-cial area	Sandy loam	A	Has a low potential to drain and large infiltration rates when are completely wet; Formed on permeable rock, including light soils with coarse texture, profound soil, soil well and even excessively drained, sands or gravels that have a high rate of transmission of the water.
Industrial area	Clay	D	Have the greatest potential of drain and a very low infiltration rate when they are completely wet; are formed of clay soils with heavy texture with a high inflating potential; soils with permanently raised groundwater level; soils that have an illuvial more developed horizon (a compact layer with a much higher clay content than the upper horizons of the soil profile); or soils that present even a clay layer at or near the surface over nearly impervious material.
High density residential area	Dusty clay	D	-
Low density residential area	Loamy dust	C	They have above average drain potential; Have a small infiltration rate when they are completely wet; consisting of soils with a layer that prevents the downward movement of water on profile, and soils with moderately fine to fine structure.

Conclusion

We conclude that after classification of studied soils in the four hydrological groups, the soil from commercial area fulfils the recommendations regarding the implementation of bioretention cells, while the soils from high density residential area, low density residential area and the industrial area are part of groups C and D, groups with low infiltration rate. Nevertheless, the classification in groups C and D does not restrict totally the implementation of the bioretention cell, but should be considered constructive systems, sizing and mixtures of soil, planting and infiltration substrate that will improve the existing hydrological conditions. Soils with a high degree of nonuniformity (very nonuniform) are not subject to sedimentation. The nonuniformity coefficient, Un>15, of soils in studied urban areas in Cluj-Napoca represents a favourable condition for the implementation of the sustainable drainage systems (bioretention cells) especially if they must be provided with under drain.

Regarding the permeability coefficient it shows that prevail the soils with low permeability. This shows that urban soils in Cluj-Napoca, favours the rainwater runoff due to low permeability capacity. In addition to the degree coverage with impervious surface at the increase of the volume and pollutant loading contribute also the also the land area with permeable surface, due to the low-permeability capacity.

In conclusion, the implementation of the bioretention cells in Cluj-Napoca, Romania, is not only feasible but is also imperative to improve the soil quality and for an efficient management of surface pluvial runoff. It is recommended that for the construction of bioretention systems to assess carefully the soil structure from the implementation areas, given the fact that there is a variation in soil characteristics and that in some cases it is necessary to provide the bioretention system with underdrain to achieve the objectives of rainwater runoff management.

REFERENCE
1. Atchison, D., Potter, K. & Severson, L. (2006). Design guidelines for stormwater bioretention facilities. University of Wisconsin Water Resources Institute, Madison, WI, USA, 33 | 2. Barbosa, A.E., Fernandes, J.N. & David, L.M. (2012). Key issues for sustainable urban stormwater management. Water Research, 46 (20), 6787–6798 | 3. Emerson, C.H., Welty, C. & Traver, R.G. (2005). Watershed-scale evaluation of a system of stormwater detention basins, Journal of Hydrologic Engineering, ASCE, 10 (3), 237–242 | 4. Frondoni, R., Mollo, B. & Capotorti, G. (2011). A landscape analysis of land cover change in the Municipality of Rome (Italy): Spatio-temporal characteristics and ecological implications of land cover transitions from 1954 to 2001, Landscape and Urban Planning, 100, 117-128 | 5. Gilroy, K.L., Richard, H. & McCuen (2009). Spatio-temporal effects of low impact development practices, Journal of Hydrology, 367, 228–236 | 6. Morel-Seytoux, H.J. (1978). Derivation of Equations for Variable Rainfall Infiltration in the Water Resources Research, 1012-1020. | 7. Pitt R., Shen-En Chen, Clark S. (2002). Compacted Urban Soils Effects on Infiltration and Bioretention Stormwater Control Design. 9th International Conference on Urban Drainage, IAHR, IWA, EWRI, and ASCE | 8. Prince George's County (PGC) (2007). Bioretention Manual. Prince George's County, Maryland, Department of Environmental Resources, Environmental Services Division, Landover, MD | 9. Willeke, G.E. (1966). Time in Urban Hydrology, Journal of the Hydraulics Division Proceedings of the American Society of Civil Engineers, 13-29 | 10. Characklis, GW.,Wiesner, MR. (1997). Particles, metals, and water quality in runoff from large urban watershed, Journal of Environmental Engineering, 123(8), 753–75 | 11. Eriksson, E., Baun A., Scholes, L., Ahlman, S., Revitt, M., Noutsopoulous, C. & Mikkelsen, P.S. (2007). Selected stormwater priority pollutants – a European prospective, Sci. Total Environ. 383, 41–51 | 12. Lin, Yu-Pin, Hongb, N.M., Wu, P.J., Wu, C.F. & Peter, Verburg H. (2007). Impacts of land use change scenarios on hydrology and land use patterns in the Wu-Tu watershed in Northern Taiwan, Landscape and Urban Planning, 80, 111–126 |