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Experimental green roofs - a comparison of standard and green roof layers with a combination of biochar

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ABSTRACT:
The paper describes four experimental roofs located on the building of the library at the Technical University of Kosice and that represent two types of green roofs. The experimental roofs are designed based on research dealing with green roofs and their retention qualities, their impact on the microclimate and the possibility of using rain and gray water that could be filtrated through the media of these structures. The paper describes the world-wide conditions facing the issue of green roofs. The idea of this article is to use a new additive to standard green roof layers - biochar. The paper is intended to serve as a theoretical point of view, but it can also be beneficial in practice and the green roof industry.

KEYWORDS:
biochar; experimental structure; green roof; retention

1. Introduction

200 people responded to a 20-question online questionnaire [1-4] between April 1, 2016 and May 31, 2016. Respondents were from 6 different regions of the world, Central Europe (Slovakia, Czech Republic, Poland, Hungary, Austria, Germany, Slovenia), Western Europe (France, Great Britain, Belgium, Ireland), Southern Europe (Spain, Portugal, Croatia, Italy, Greece), Eastern Europe (Ukraine, Russia, Romania), Northern Europe (Latvia) and the rest of the World (Ecuador, Brazil, USA, Egypt, United Arab Emirates, Afghanistan, India, Taiwan, Australia).

Questions 15, 17, 18 and 20 were related to the topic of green roofs and their water retention qualities [5, 6]. The result of these questions forms the theory/hypothesis for the following research. The paper focuses on questionnaire evaluations and experimental green roof structures found at the Faculty of Civil Engineering, the Technical University of Kosice that have both standard green roof layers and standard green roof layers combined with a biochar layer.

2. Questions

15. What would be your reason to build a green roof?
   - ☐ saving money
   - ☐ technical specifications
   - ☐ ecology and sustainability

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☐ no reason
☐ something else (define) ...

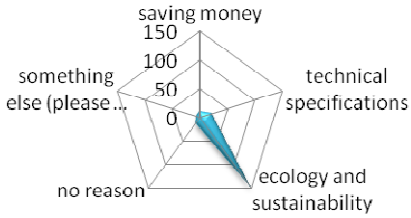

Fig. 1. Question 15 results

17. Do you know that a green roof has retention features (the ability to keep the water)?
☐ yes
☐ no

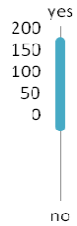

Fig. 2. Question 17 results

18. Can you imagine yourself using retained water, after filtration, for e.g. watering the garden, cleaning the car, washing clothes?
☐ yes
☐ no

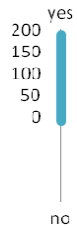

Fig. 3. Question 18 results

20. Should owners of green roofs have financial benefits for sewerage charge?
☐ yes
☐ don´t know
☐ no

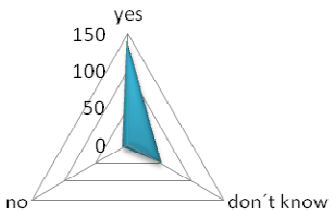

Fig. 4. Question 20 results

3. Interpretation

In question number 15, 150 people of 200 (75%) believe that ecology and sustainability is the most important reason to build a green roof.

In question 17, knowing the retention features of green roofs, 169 people (84.5%) say they know about it, 31 people (15.5%) say they did not know about it.

Evaluating question 20, 188 people (94%) can imagine themselves using retained water after filtration for watering the garden, cleaning the car, washing clothes etc.

If the owners of green roofs should have financial benefits for sewerage charge, 140 people (70%) say yes, 53 (26.5%) say they did not know and 7 (3.5%) say no.

4. Experiment

Following these results, four experimental structures (Fig. 9) representing green roofs were designed on the rooftop of the university library. The floor plan size of each structure was 1500x1500 mm. The slope of the construction varied between 0÷7° (the construction of the platform is adjustable). In total, there are 4 structures, 2 structures represent the first type of green roof construction - Green roof 01 (Fig. 5, Fig. 6, Tab. 1, Tab. 2), and 2 structures represent an alternative type of green roof construction - Green roof 02 (Fig. 7, Fig. 8, Tab. 3, Tab. 4).

Fig. 5. Green roof 01

Table 1
Green roof 01 layers

		Construction Height		Water Storage Capacity	
1	Vegetation	–	–	–	–
2	Substrate (+ BIOCHAR)	100 (?)	mm	24.6 (?)	l/m^2
3	Drainage and Water Retention Layer	20	mm	7.4	l/m^2

Table 2
Green roof 01 technical parameters

Weight * (+BIOCHAR)	111.20 kg/m^2 (?)	X X X X X
Layer Height (+BIOCHAR)	10 ≈ cm (?)	X X X X X
Roof Pitch	1÷5°	
Water Retention (+BIOCHAR)	continue research to verify % (?)	
Discharge Coefficient (+BIOCHAR)	continue research to verify (?)	
Vegetation/Aesthetical Value	herbs-grasses-perrenials	X X X X X
Water Storage/Eco Value (+BIOCHAR)	32.00 l/m^2 (?)	X X X X X
Maintenance		X X X X X
Cost Factor (+BIOCHAR)	75.13 €/m^2 (?)	X X X X X

Fig. 6. Green roof 01 - detail

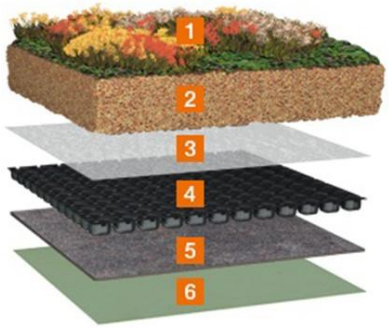

Fig. 7. Green roof 02

Table 3
Green roof 02 layers

		Construction Height		Water Storage Capacity	
1	Vegetation	–	–	–	–
2	Substrate (+ BIOCHAR)	80 (?)	mm	24.6 (?)	l/m²
3	Filter Fleece	125	g/m³	4.9	l/m²
4	Drainage and Water Retention Layer	20	mm	7.4	l/m²
5	Protection/Storage/Retention Fleece	600	g/m³	3.0	l/m²
6	PE Foil Separation and Glide Layer	0.2	mm	–	–

Table 4
Green roof 02 technical parameters

Weight * (+BIOCHAR)	121.10 kg/m² (?)	X X X X X
Layer Height (+BIOCHAR)	10 ≈ cm (?)	X X X X X
Roof Pitch	1-5 °	
Water Retention (+BIOCHAR)	continue research to verify % (?)	
Discharge Coefficient (+BIOCHAR)	continue research to verify (?)	
Vegetation/Aesthetical Value	herbs-grasses-perrenials	X X X X X
Water Storage/Eco Value (+BIOCHAR)	41.40 l/m² (?)	X X X X X
Maintenance		X X X X X
Cost Factor (+BIOCHAR)	80.53 €/m² (?)	X X X X X

Fig. 8. Green roof 02 - detail

Fig. 9. Green roof structures

5. Research

In Tables 1, 2, 3, 4 the technical parameters and green roof layers are described. Technical parameters are as follows: weight (*Weight specifications refer to saturated conditions; dry weight is approximately 60÷70% of the saturated weight), layer height, roof pitch, vegetation, water storage, maintenance and cost factor. Othe technical parameters: weight (+BIOCHAR), layer height (+BIOCHAR), water storage (+BIOCHAR) and cost factor (+BIOCHAR) will be defined after the research. Water retention, discharge coefficient, water retention (+BIOCHAR), discharge coefficient (+BIOCHAR) are two technical parameters that are not yet defined. The aim of this research using the 4 experimental structures is to specify these parameters. The second aim of the research is to focus and compare the quality of rainwater and the rainwater filtered through the green roof layers. Finally the third aim of the research is to focus and compare the quality of grey water and the grey water filtered through the green roof layers.

6. Biochar

Biochar is a solid material formed by the thermochemical conversion of biomass in an oxygen--restricted environment. The traditional biochar production process is similar to the production of charcoal, possibly one of the oldest industrial processes developed by mankind. Biochar can be considered a charcoal, a porous substance rich in carbon. In addition to the equipment itself, the greatest influence on the quality of the biochar is the temperature of the pyrolysis zone,

the heating rate of the input material, the residence time in the reaction core and the type of biomass used. The yield (production) decreases with the increase of the pyrolysis temperature. The ability to retain water and nutrients in the soil increases due to critical pyrolysis temperature and depending on the type of equipment [8].

7. Conclusions

Following the questionnaire results, interest in the problems of green roofs and their water retention qualities is essential. Two technical parameters of the selected green roof constructions are still missing. The experimental structures are designed and built and research will continue, both in the roofs with biochar and the roofs without. The other two aims of the paper, quality of rainwater and grey water, are defined.

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Eksperymentalne zielone dachy - porównanie standardowej i zielonej warstwy z kombinacją biowęgla

STRESZCZENIE:
W artykule przedstawiono cztery eksperymentalne modele, reprezentujące dwa rodzaje zielonych dachów, wykonanych na budynku biblioteki Politechniki Koszyckiej. Modele eksperymentalne zostały zaprojektowane na podstawie badań dotyczących dachów zielonych z uwzględnieniem: właściwości retencyjnych, wpływu na mikroklimat oraz możliwości wykorzystania deszczu i szarej wody, które mogłyby być filtrowane przez warstwy dachu. Opisano ogólnoświatowe podejścia do rozwiązania problemu. Ideą artykułu jest zastosowanie nowego dodatku, jakim jest biowęgiel, do standardowych warstw dachu zielonego. Artykuł omawia problem z teoretycznego punktu widzenia, ale może być również użyteczny dla zastosowań praktycznych i przemysłu dachów zielonych.

SŁOWA KLUCZOWE:
biowęgiel; struktura eksperymentalna; dach zielony; retencja