STUDY REGARDING THE HUMIDITY AFFECTED BY GREEN AND TRADITIONAL ROOFS

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Abstract. The experimental protocol for determining the influences of roof type upon humidity was conducted at the University of Applied Sciences, Neubrandenburg, Germany, during 14 days. In order to emphasize the humidity differences between a traditional roof and a green roof have been establish three locations of humidity sensors. The mean humidity determined for traditional roof is 71.18%, which is lower with 12.2% then the humidity affected by green roof.

Keywords: humidity sensor, environmental conditions,

INTRODUCTION

In all over the world so many cities faces serious water and air-quality issues (Werthmann, 2007). It is showed that technology for present-day green roofs has some advantages, such as: stormwater management, air quality and thermal benefits. In the last 20 years, a very different approach has to come to prominence: an approach the attempts to restore the natural water cycle and celebrate the presence of water in the landscape, and that work with nature rater that against it (Dunnett and Clayden, 2007).

The capability of green roofs to store a certain amount of rain water and to delay the run off of severe storms is what makes them so valuable in urban agglomerations (Werthmann, 2007).

Effective drainage is the key to a success green roof (Dunnet and Kingsbury, 2004) and to store the rain water that gives us on long term humidity. Over a traditional roof, the green roof can keep buildings cooler and have positive effects for indoor climate (KÖHLER, 2001).

A study of Hopkins *et al*. in 2010 shows that the lowest relative humidity reading was only 4% on a particular day at 3 p.m. compare with the monthly mean of 23%, that demonstrates an extreme condition.

MATERIALS AND METHODS

The location where the experiments were conducted is the roof of University of Applied Sciences of Neubrandenburg, Germany. The experiments were performed on a single building of this university where roofs were built two types: one traditional and one green.

Traditional roof (Fig. 1) is composed of a concrete layer on which was placed a waterproofing membrane to a drainage layer and then 10 cm, made of gravel.

The green roof (Fig.2) on building of University of Applied Sciences of Neubrandenburg, Germany it was carried out for more than 10 years to the ZinCo Company and comprises all components of green roof membranes: root barrier, moisture retention, drainage layer and filter sheet. The growing layer it suits the needs of the green roof vegetation and provides for a stable growing environment and measures 10 cm depth (www.zinco-greenroof.com). Plant level was made with succulent plants, *Sedum sp.*, *Allium sp.*, grasses and other wild species.

Fig. 1. Traditional roof
Source: *original*

Fig. 2. Green roof
Source: *original*

In the observations and measurements made on the differences caused by the traditional vs. modern roof system for climate elements (temperature, humidity and dew point) were positioned six sensors Data Log 32 (Fig. 3), three for each type of roof.

Fig. 3. Data Logger LOG 32
Source: *original*

Moisture content was determined from 5 to 5 minutes, the data being applied as an average of 24 hours, resulting in a type of 2x3 bi-factorial statistical analyze (factor A- type roof with two graduations - a_1- traditional roofing and a_2 - green roof; Factor B - sensors location with three graduations: b_1 – 50.00 cm above the substrate (Fig.4.), b_2 – 00.00 cm above the substrate (Fig.5.), and b_3 - inside substrate) in 14 repetitions (from 14th June to – 27th June, 2014 year). The experimental protocol for determining the humidity is identical to that used to determine the influences of roof type upon temperature (VARVARA, 2015).

Fig.4. LOG 32 placed on 50 cm above the green roof
Source: *original*

Fig.5. Log 32 placed on the green roof
Source: *original*

RESULTS AND DISCUSSION

The analyses of variance (Table 1) shows that the values of computed F cutoff the theoretic F for 0.05 and 0.01 p-values. The effects upon humidity were computed using Duncan's Multiple Range Test (MRT) for each experimental factor (A – roof type and B – sensor location) and interaction between them (AxB).

Table 1

Analyses of variance regarding roof humidity (%) during 14 days, in the climatic conditions of 2014 year

Variability cause	Sum of squared (SS)	Degrees of freedom (DF)	Sample variance (s^2)	F -test
Total	13852.34	83	-	-
A factor – type of roof	3130.40	1	3130.40	66.482 > 4.67; 9.07
B factor – sensor location	3181.848	2	1590.924	46.452 > 3.19; 5.08
A*x*B interaction	1216.369	2	608.1847	17.758 > 3.19; 5.08
Error between treatments	612.1218	13	47.0863	
Error within treatments	1780.929	52	34.24863	

There were determined for MRT three values of mean errors ($s_{\bar{x}\,(A)}$, $s_{\bar{x}\,(B)}$ and $s_{\bar{x}\,(AxB)}$) , which were used to compute significant differences (SD) at the 5% probability level ($SD_{5\%}$) (Table 2 and Table 3).

Table 2

The computation of significant differences at the 5% probability level for factor A and factor B effects

	Factor A	Factor B	
Variant no. between compared limits	2	2	3
$q_{5\%}$ for DF_E=52	3.06	2.84	3.00
$s_{\bar{x}}$	1.06	1.11	
$SD_{5\%}$	3.24	3.14	3.32

Table 3

The computation of significant differences at the 5% probability level for interaction between factor A and factor B effects (AxB)

Variant no. between compared limits	2	3	4	5	6
$q_{5\%}$ for DF_E=52	2.84	3.00	3.08	3.15	3.21
$s_{\bar{x}}$	1.56				
$SD_{5\%}$	4.45	4.69	4.82	4.93	5.02

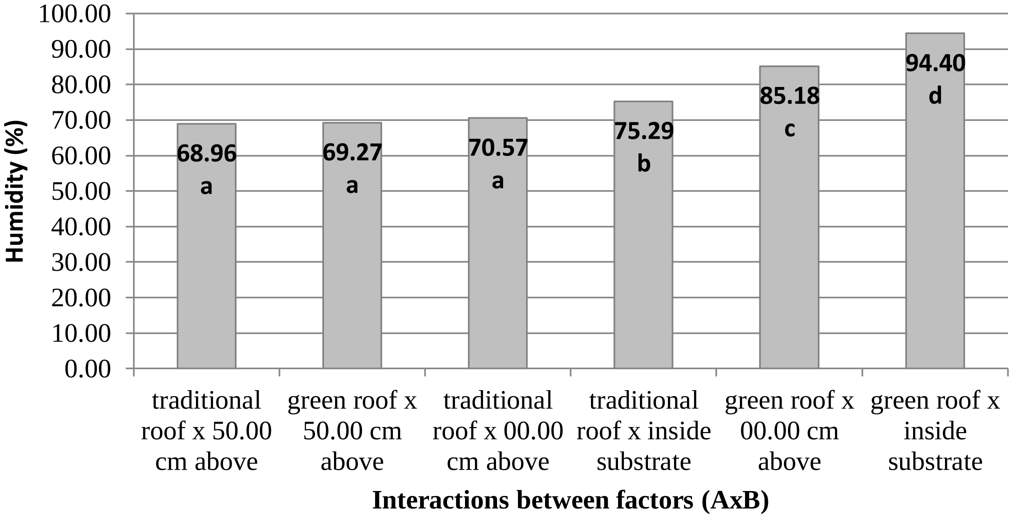
Table 3

Means of humidity affected by roof type (Factor A) and location of sensor (Factor B)

Treatment within Factor A		Treatment within Factor B	
Humidity (%)		Humidity (%)	
Traditional roof	71.18[a]	50.00 cm above the substrate	69.77[a]
Green roof	83.38[b]	00.00 cm above the substrate	77.23[b]
		inside substrate	84.84[c]

Note: a and b are signs for Duncan test

Different letters for each column indicates significant difference at p≤0.05



Note: a and b are signs for Duncan test
Different letters for each column indicates significant difference at $p \leq 0.05$

Fig. 6. Means of humidity affected by interactions between factors (AxB)

In table 3 are presented the mean humidity values registered for roof type affect and location of sensor affect, and in figure 6 are showed the values obtained as affect of interactions between the two factors.

CONCLUSIONS

The analysis of variance of data showed significant effects of humidity. The highest humidity was determined inside the substrate of green roof (94.40%) and the lowest humidity was registered for traditional roof at 50.00 cm above substrate (68.96%).

There were no significant differences at $p \leq 0.05$ for humidity affected by traditional roof or green roof at 50.00 cm above ground, but between the two types of roof at 0.00 cm above substrate were measured significant differences at $p \leq 0.05$.

Inside the traditional roof substrate was determined 75.29% humidity with a significant difference of 19.11% then the inside of green roof substrate.

Acknowledgements. This research work was carried out with the support of Daniel Kaiser and Christian Rares and also was financed by University of Applied Sciences from Neubrandenburg, Germany.

REFERENCES

1. Dunnett N., A. Clayden, 2007, Rain garden: sustainable rainwater management for the garden and designed landscape, Timber Press, Portland, Oregon, U.S.A.
2. Dunnett N., N. Kingsbury, 2004, Planting green roofs and living walls, Timber Press, Portland, Oregon, U.S.A.

3. Hopkins G., C. Goodwin, M. Milutinovic, M. Andrew, 2010, Feasibility Study: Living Wall System for Multi-Storey Buildings in the Adelaide Climate; The Government of South Australia and Aspen Developmens, Australia.

4. Köhler M., M. Schmidt, J. Sickermann, 2001b, Greened roofs and the technique of water harvesting; a synergistic combination!

5. Varvară Mihaela Simona, M. Köhler, M. Voevod, M. Dîrja, 2015, Study regarding temperature differences between a traditional roof and green roof, Buletin USAMV – Horticulture, ISSN 1843-5254.

6. Werthmann C., 2007, Green roof: a case study, Michael Van Valkenburgh associates` design for the Headquarters of the American society of landscape architects, Princeton Architectural Press, New York.

7. www.zinco-greenroof.com