Rožnovský, J., Litschmann, T., Vyskot, I. (ed): „Klima lesa", Křtiny 11. – 12.4.2007,
ISBN 978-80-86690-40-7

SOIL WATER DYNAMICS OF THE HILLSIDE

Elena LACZOVÁ, Vlasta ŠTEKAUEROVÁ

Institute of Hydrology, Slovak Academy of Sciences

1. Introduction

Knowledge of soil water dynamics on hillside is important for a landscape sustainable development guarantee. The mathematical modeling of the hillside soil water dynamics is a very effective and relatively accurate hydrological simulation method. This accuracy closely relates to the determination of a representative input data and characteristics in the mathematical model (Štekauerová, 2002; Mikulec, Štekauerová, 2003). Therefore, experimental hydrological research of hillside is very important.
The objective of this work was to observe a hillside soil hydrological response to the infiltration experiment. The infiltration method with one cylinder was used. Soil water content in two verticals was measured by TRIME method. Soil water content data were evaluated and graphs that represent soil water dynamics on hillside in time were constructed.

Keywords: soil water dynamics, hillside, TRIME-FM method, Malé Karpaty Mts.

2. Material and methods

2.1 Study area

Field experiment was realized on sloped soil surface in Malé Karpaty Mts. in the west of Slovakia, near Bratislava. The hillside is covered with the forest of oaks, hornbeams and beeches. The South oriented study hillside is about 30 m length and rises in height by about 5 m, general gradient is 9°. Vertical saturated hydraulic conductivity values of soil are in Table 1.

Table 1: Vertical saturated hydraulic conductivity values *(K)* of soil horizons ($cm.h^{-1}$)

Soil depth (cm)	0-5	6-10	11-15	16-20	30-35	36-40	41-45	46-50	51-55	56-60
K ($cm.h^{-1}$)	55,55	1,44	0,91	44,48	26,13	1,66	8,54	2,40	0,01	0,01

2.2 Infiltration test and soil water content measurement

The objective of this experiment was to monitor the soil water movement during and after simulated ponding infiltration on the hillside. The object of the interest was to know if and when infiltrated water would reach measuring points No. 1 and No. 2 (Fig. 1).
The infiltration method with 2042,82 cm^2 infiltration cylinder was realized in December 2006. Horizontal surface was created on the hillside and infiltration cylinder was installed into 10cm depth under soil surface. Two TECANAT tubes were inserted into soil, in distance 30 cm and 70 cm from infiltration cylinder (point No. 1 and No. 2 on Fig. 1). Before the test started, initial soil moisture was measured in both tubes by TRIME-T3 method.
Infiltration test began by pouring 5cm water column in the cylinder. When water level decreased 1cm, two litres of water were poured in the cylinder and time was recorded. This first decrease took 15 seconds. This action was repeated 32 times.
Soil water dynamics was monitored in 50cm soil profile (in interval from 15 to 65 cm from soil surface). Soil moisture was measured in 10cm steps and in 10minutes intervals by TRIME-T3 probe in both tubes. Thirteen series of soil moisture measurements there were realized.

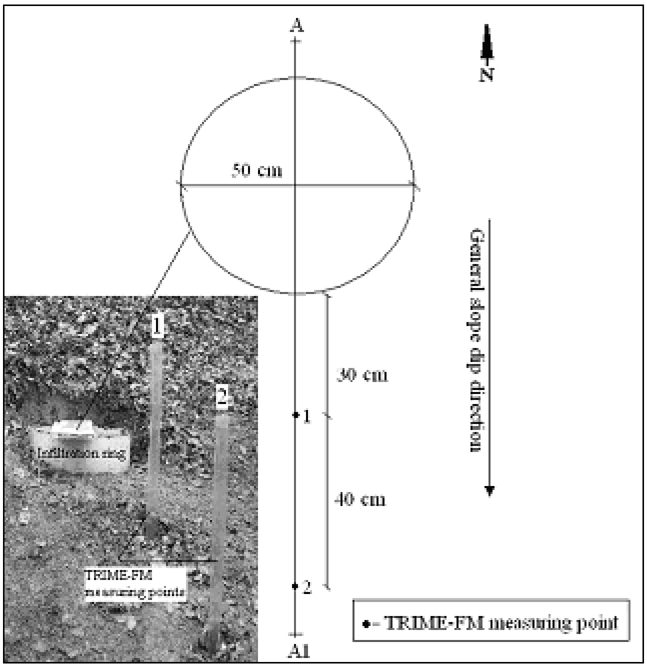

Figure 1. Schematic plan view of the test site and the terminology used herein

TRIME method

The TRIME-method (Time Domain Reflectometry with Intelligent Micromodule Elements) is a specially designed TDR-technique (Time Domain Reflectometry) to measure material moisture. The measuring of the TDR-pulse is carried out by electromagnetic waves transit time measurements in material. Soil moisture is calculated by using of calibration coefficients and empirically determinate coefficients. The effective penetration depth of the probe is about 15 cm with the highest sensitivity in the immediate vicinity of the access tube and decreases exponentially with distance. The method was calibrated and verified on the Institute of Hydrology, Slovak Academy of Sciences (Nagy et al., 2006, Nagy, Štekauerová, 2006).

3. Results and discussions

Infiltration rate at the experiment beginning was 39 $mm.min^{-1}$. At the end of the infiltration experiment (which ran 15 minutes), the infiltration intensity was not steady; infiltration rate was 2,2 $cm.min^{-1}$. 32cm water column was infiltrated on area of 2042,82 cm^2 during infiltration test (Fig. 2). Initial soil moisture value was measured in both points. Minimum initial soil moisture value was measured at the bottom of the both points. Maximum initial soil moisture value in both points was measured at the depth of 25 cm. Soil water dynamics in the 50cm soil profile was monitored during and after infiltration test; in duration 2 hours total time. Figs. 3a and 3b show the soil moisture trend in 30cm horizontal distance (point No. 1) and in 70cm horizontal distance (point No. 2) from infiltration cylinder edge.

The wetting front in the points No. 1 and 2 was not observed. Soil water content of all measured horizons in both points was constant during field experiment. This can be seen on Fig. 4, which shows water dynamics between points No. 1 and No. 2 in four depths under soil surface: 15 cm, 25 cm, 35 cm, 45 cm.

The mentioned facts might indicate the saturation state of all observed soil horizons. Alternatively, that the wetting front direction was oriented vertically downwards and did not reach the points.

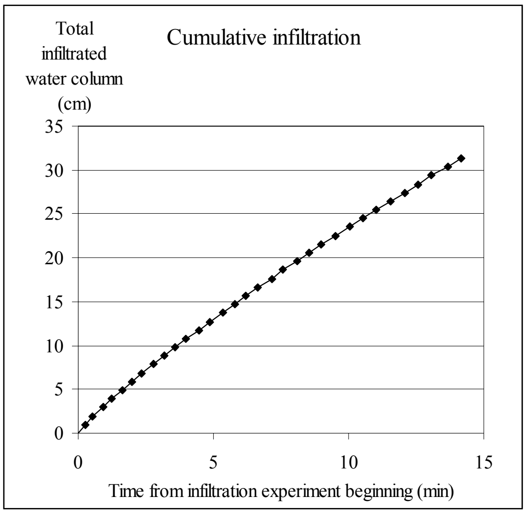

Figure 2. Observed cumulative water infiltration (cm) during infiltration experiment

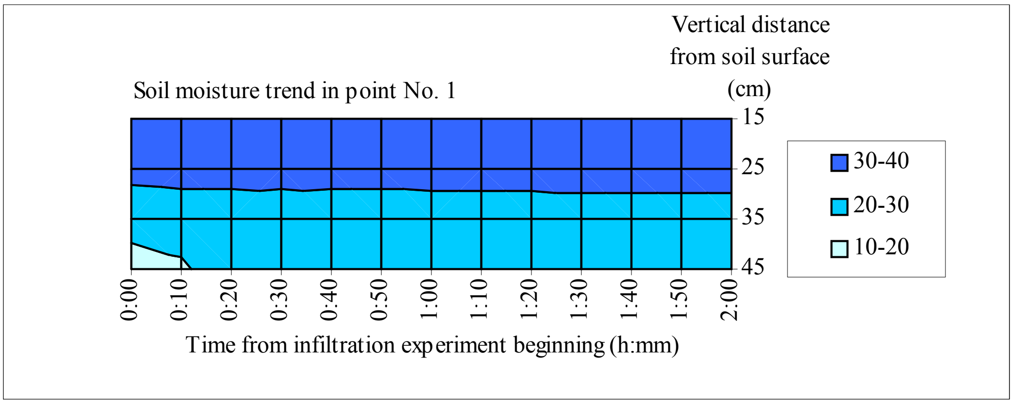

Figure 3a. Chronoisoplets of soil water content in soil profile in point No.1 (Vol. %)

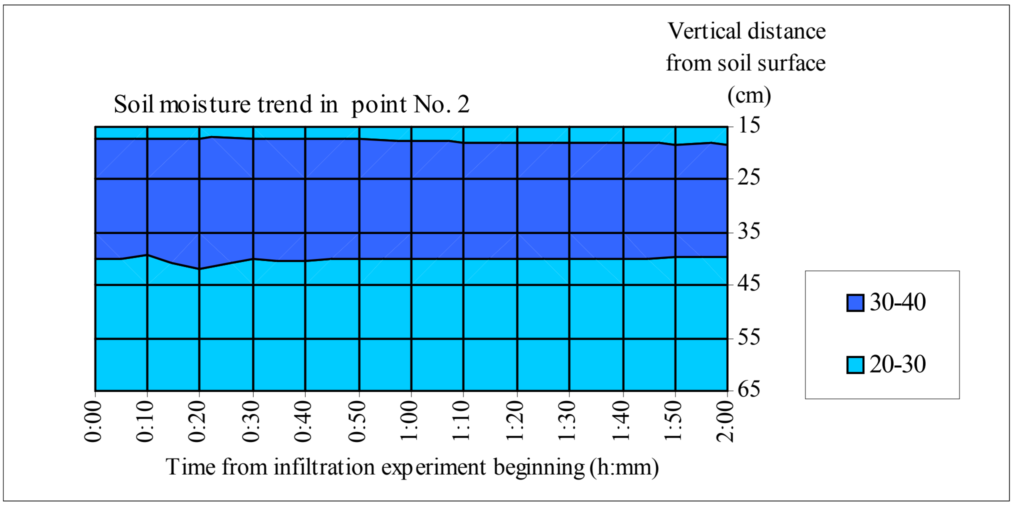

Figure 3b. Chronoisoplets of soil water content in soil profile in point No.2 (Vol. %)

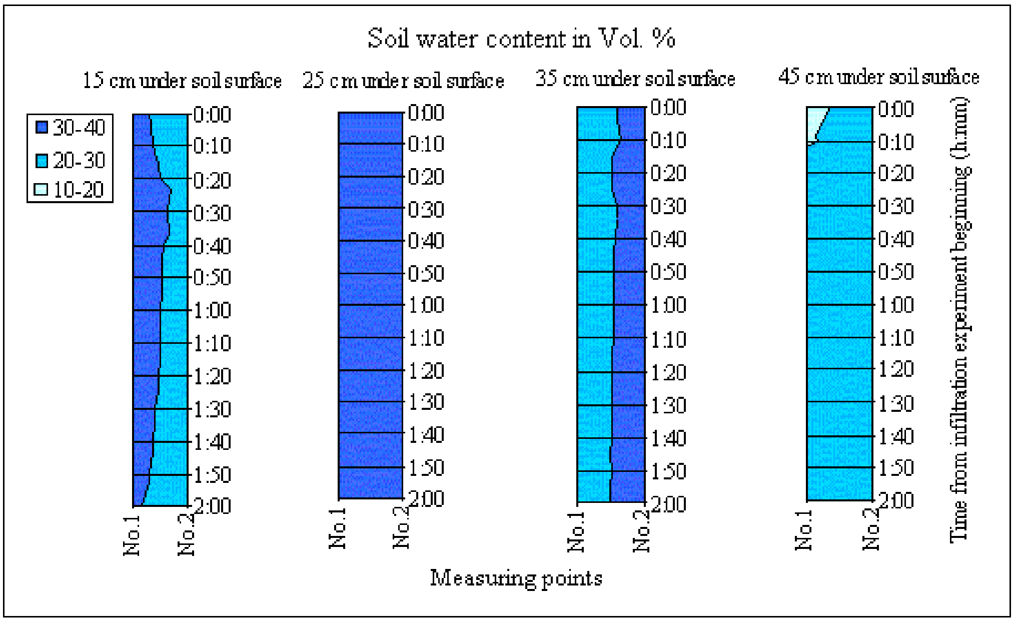

Figure 4. Soil water dynamics between points No.1 and No.2: in soil horizon 15 cm, 25 cm, 35 cm, 45 cm under surface (soil water content in Vol. %).

4. Conclusion

Knowledge and understanding how soil water varies over time and across hillside is fundamental importance to understanding many processes that influence mountain landscape. The objective of this work was to observe an infiltration experiment hydrological response in a soil of a forested hillside. Field experiment with one infiltration cylinder method was realized in Malé Karpaty Mts. in the west of Slovakia. The TRIME-FM method was used to fast and fine measurement of soil water content at the hillside.

At the end of the infiltration experiment, the infiltration intensity was not steady; infiltration rate was 2,2 $cm.min^{-1}$. During the test period, notable increase in moisture value in measuring points was not observed. Soil water content of all measured horizons in both points was constant during field experiment. The mentioned facts might indicate the saturation state of all observed soil horizons. Alternatively, that the wetting front direction was oriented vertically downwards and did not reach the points.

Acknowledgements

Projects VEGA No 2/5018/05 and APVT-51- 019804 funded this work.

References

Mikulec, V. - Štekauerová, V.: 2003. Vplyv použitých metód merania nasýtenej hydraulickej vodivosti na výsledky simulácie časového priebehu vlhkosti v lokalite Bodíky - Acta Hydrologica Slovaca, vol. 4, no. 1, 51-55 pp.

Nagy, V. - Štekauerová, V.: 2006. Using of new methods of soil water content measurement for intention of soil water regime optimalization – Bioclimatology and water in the land. International scientific conference, Strečno, Slovakia, ISBN 80-89186-12-2, 10 p.

Nagy, V. - Štekauerová, V. - Rajkai, K.: 2006. Použitie nových metód merania vlhkosti pôdy za účelom optimalizácie vodného režimu pôd - 16. slovensko-česko-poľský vedecký seminár „Fyzika vody v pôde“, Michalovce, Slovakia, ISBN 80-89139-09-4, 10 p.

Štekauerová, V.: 2002. Simulation of water movement in field soil - Polution and water resources Columbia University Seminar Proceedings, (Ed. G. J. Halasi - Kun), vol. 30, Budapest, Hungary, 141-151 pp.