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Hydrus's-1D capability for assessment of soils water regime

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ABSTRACT

Many areas of the world already have water shortages, and climate change could make this problem worse. Water regime is one of the components of soil system and it is very important for agriculture during nowadays climate change. Due to soil moisture nutrients become available for plants, chemical elements can migrate as radial, as lateral directions. Different soils have immanent features in the movement of water, so and movement of all dissolved in water elements. The aim of this research is comparative assessment of water dynamic between different two soils types located in similar climate conditions. These soils are characterized own texture because of features their genesis, first parent materials. For the simulation of water regime, we used well-known program Hydrus-1D. For it, we were compared next parameters: pressure head, water content, hydraulic conductivity and hydraulic capacity between Haplic Luvisol and Luvic Chernozem. On base of soil texture, we calculated some parameters becoming from modelling. These soil parameters assessed in fifth times: 0th, 15th, 30th, 45th, and 60th days. Thus, during of observation time these parameters were showing significant differences between Haplic Luvisol and Luvic Chernozem, despite the similar soil forming factors. The main difference is, first, their profile distribution, and then their quantitative values of parameters. Considering the location of the studied soils on Agroecosystems, the obtained data are important for the practical use of agro-technologies. Using of Hydrus-1D, we can also predict the soils contamination. Soil leaching processes is significantly relationship with vertical transport of water. This poses a risk both the loss of the nutrients from the soil and the contamination of the groundwater [1]. Therefore, the quality of the last is closely linked to the ability of soils to infiltrate water. Significant results of our researching indicate achieved in the simulation during the first 30 days. Therefore, for modelling it is advisable to choose periods of control over parameters of the Water regime in 5-10-20-30 days. Compared to Haplic Luvisol Luvic Chernozem have optimal indices of its texture, that provide better parameters of water regime, which is due to the higher content of fine particles. Illuvial clay of Haplic Luvisol, because of elluvial-illuvial processes, has an indicated effect on the vertical distribution such a parameter of the water regime as water content and less influence on the hydraulic capacity. When included in the simulation the real amount of precipitation during the observation, data on the corresponding changes for hydraulic conductivity and less for water pressure were obtained. It is likely that the more displayed effect of rain on day 45th than in other periods maybe explained by the nature of the precipitation (downpour rather than prolonged rain).

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1. Introduction

The effects of climate change are becoming more evident. Many areas of the world already have water shortages, and climate change could make this problem worse. Extreme precipitation and drought events occurred across the world [2]. Soil as a multifunctional resource plays a significant role in ecosystem services, which affects human well-being both directly or indirectly, including surface and groundwater supplies in water cycling. Soil parameters have a strong influence on drain water quality, while climate change does not have a sizeable impact on soil water distribution. However, plants must have water supply that is the main condition for solving food supply. As we have known [3] the climate is becoming warmer and warmer during last decades. Climate change dominated the global agenda in 2019. Several major reports in this year showed why this would be a disaster. As the latest reports show, climate changes already having profound consequences. Therefore, the assessment of water dynamic is the essential problem, but we have many ways and programs for modelling to solve it. Prediction modelling is an indispensable for monitoring nutrition elements. Water prediction is a difficult and complex, as we need to consider a high number of parameters, which are connected or independent. According to the problems the program Hydrus is one of the most popular program in the world because it is easy to use in water flow assessment, which requires information about soil texture, but also can include other parameters such as plant transpiration, weather conditions, solutions etc.

The basic information about modelling has been taken from the Hydrus-1D manual [4]. This book has a description of all methods we need for calculating. References of the manual were previous researches of authors: van Genuchten, Šimunek, Vogel and others. The Hydrus numerical models are widely used for water flow simulation and solution transportation in variably saturated soils and groundwater [5]. In this paper, they offer a brief overview of the Hydrus code, which data can be used for built optimization routine. These previous researches describe using, opportunity, and theory about Hydrus-1D but our article shows a practical view. Min Chen et al. [6] used Hydrus-1D for modelling soil moisture dynamic within two catchments. They write about soil types and leaf area index effects on model performance and found that point-scale soil moisture data and simulations for predicting the soil wetness status over a drainage area of significant size (up to 1000 km^2). Other researchers studied soil moisture storage in the subsurface and water infiltration rate in loess soil [7]. They used Hydrus-2D/3D in their research for two soil columns filled salty clay loam texture. Their results show that loess cavity significantly decreased the infiltration rates and was effectively ameliorated. While water moves through water repellent horizon (illuvial), which has a significant effect on infiltration [8] can stop layers. Minasny and McBratney [9] investigate that organic material has a small effect on soil water content. It made according to soil textures, so decreases the number of errors. Water movement simulated by Hydrus-1D could have a small error [10]. Last authors find out that simulation compared to real observation have errors no more than ± 10 %. Hydrus-1D is one of the rated program, which can predict hydraulic soil parameters for monitoring. Modelling stays one of the main methods of prediction, because it creates an observation object in better scale for us and it is faster, than real observation, but it always has some errors, which we can decrease through entering additional information.

2. Materials and methods

In modelling, we studied two soil types, location in Prut-Dniester area: Grey Forest Soil and Chernozem Podzolized (Haplic Luvisol and Luvic Chernozem according to WRB classification); below in text – Luvisol and Chernozem. At first, these soils have great quantitatively differences in texture as the vivid illuvial horizon in Luvisol profile that is a waterproof horizon. It has decisive influence for stagnation moisture and genesis of the gleying process. Secondly, Luvisol is located under pasture agroecosystem while Chernozem is located on arable land. Podzolization process has an easy effect on soil texture. Sampling was according to [11]. Soil texture (Table 1) analyses by Kaczynski`s method [12]. Kd was calculated as ratio between clay content in *n* horizon to clay content in parent material. The texture of Luvisol is loam. Clay content (Table 1) from upper horizons (Hd, He, Eh) are poor on fine dispersion particles comparatively to lower horizons (below than 49 cm) (less than 20 %).

Table 1
Soil texture

Number[1]	Horizon	Deep, cm	Sand, %		Silt, %			Clay, %	∑ <0.01 mm, %
			1-0,25 mm	0,25-0,05 mm	0,05-0,01 mm	0,01-0,005 mm	0,005-0,001 mm	<0.001 mm	
Haplic Luvisol, Loam									
1	Hd	0-12	4.83	34.61	23.69	9.27	14.73	12.87	36.87
2	He	12-34	5.0	35.37	21.47	7.23	12.77	17.46	37.46
3	Eh	34-49	4.37	38.17	20.08	7.36	10.81	19.21	37.38
4	I(h)(gl)	49-75	2.67	34.39	16.37	7.19	9.39	29.99	46.57
5	I(gl)	75-105	3.55	36.52	13.67	6.07	10.56	29.63	46.26
6	Pikgl	105-142	6.88	52.18	10.81	2.94	4.67	22.52	30.13
Luvic Chernozem, Silty clay loam									
1	H(e)	0-29	0.80	0.20	37.9	20.49	9.86	30.75	61.10
2	H(i)	29-44	0.70	0.14	21.28	26.40	10.08	41.40	77.88
3	Hpi	44-69	0.30	0.90	30.3	8.20	20.10	40.20	68.50
4	Phi(gl)	69-96	0.50	1.25	22.27	20.63	17.55	37.80	75.98
5	Pk	96-126	0.40	0.80	31.67	12.19	14.74	40.20	67.13

[1] The number of horizons according points on Figures 1 and 2

It confirms elluvial process in this soil profile. The fine particles transferred down and deposit in lower horizons, which created water repellent horizon (from below 49 cm). In these horizons are increasing clay percentages with growing up soil texture (clay loam) – illuvial process [13].

Elluvial and Illuvial processes are binding because fine soil particles leaked from upper horizons – formed elluvial horizon, and deposit in subsoil illuvial horizons [14, 15]. As a result, appear a gleying process, which shows that water held in these horizons as well as parent material. Unlike soil texture, remind upper loam horizons [16]. Gley (gl) horizons unless drained with reducing environment affect in the saturated layers, which become mottled greyish-blue or greyish-brown because of ferrous iron and organic matter content [17].

Meanwhile, the texture of Chernozem is heavier; it classified as Silty clay loam from surface to deeper horizons and it is Silty clay in parent material. Elluvio-illuvial process more expressed in Luvisol than in Chernozem. Clay distribution is more homogenous in Chernozem, than in the Luvisol. The slight signs of the gleying process is locally out were observed in Phi(gl) horizon of Chernozem, but in all low horizons (deeper 49 cm) of Luvisol. Organic material in Chernozem is spreading to the beginning of parent material while Luvisol to Eh horizon (49 cm) and locally appear deeper as effect of solute stagnation [18, 19]. Therefore, Chernozem has not waterproof horizons, but has heavier texture, which in fluencies on drainage. Kd confirms the removal of clay from upper elluvial horizons of Luvisol and accumulation of clay particles in illuvial horizons of Luvisol, compared to the parent material this soil (Table 2). At the same time, distribution of clay content in Chernozem is homogeneous. Some removal of clay from the upper horizon could be a result of natural process (elluvial) as an impact of annual ploughing [20].

Table 2
Kd[1] for profiles of soils

Haplic Luvisol				Luvic Chernozem			
Horizon	Deep, cm	Clay, %	Kd	Horizon	Deep, cm	Clay, %	Kd
Hd	0-12	12.87	0.57	H(e)	0-29	30.75	0.76
He	12-34	17.46	0.78	H(i)	29-44	41.40	1.03
Eh	34-49	19.21	0.85	Hpi	44-69	40.20	1.00
I(h)(gl)	49-75	29.99	1.33	Phi(gl)	69-96	37.80	0.94
I(gl)	75-105	29.63	1.32	Pk	96-126	40.20	1.00
Pikgl	105-142	22.52	1.00	-	-	-	-

[1] Kd was calculated as ratio of clay content in *n* horizon to clay content in parent material

In prediction modelling we used six parameters which calculated by SSC (Sand, Silt and Clay) model [21]. There are next parameters: θ_s – Residual soil water content; θ_r – Saturated soil water content; α – Parameter α in the soil water retention function [L^{-1}]; n – Parameter n in the soil water retention function; K_s – Saturated hydraulic conductivity K_s [LT^{-1}]; I – Tortuosity parameter in the conductivity function [non-dimensional] in our research I = 0.5 (Table 3).

Table 3
Parameters of the SSC[1] model

Horizon	θ_r	θ_s	α	n	K_s
			Haplic Luvisol		
Hd	0.0502	0.4015	0.0069	1.5740	23.5
He	0.0584	0.4004	0.0089	1.5157	12.2
Eh	0.0609	0.4027	0.0109	1.4798	9.73
I(h)(gl)	0.0773	0.4249	0.0137	1.4024	5.85
I(gl)	0.0764	0.4192	0.0155	1.3836	5.78
Pikgl	0.0632	0.3878	0.0258	1.3389	15.68
			Luvic Chernozem		
H(e)	0.0906	0.4810	0.0083	1.520	8.94
H(i)	0.1018	0.5075	0.0117	1.4256	11.29
Hpi	0.1005	0.5044	0.0113	1.4365	11.09
Phi(gl)	0.0978	0.4979	0.0104	1.4586	10.65
Pk	0.1005	0.5044	0.0113	1.4365	11.09

[1] SSC – Sand, Silt, Clay – model [21]

Graphical models calculated by Hydrus-1D, which used the van Genuchten-Mualem model [21]:

1) Pressure head (h) [22]

$$h = H(\theta) - z \tag{1}$$

where z– vertical coordinate which is observation point [L]; θ – water content [L^3L^{-3}]; H – pressure head of soil moisture relative to atmospheric pressure (H ≤ 0).

2) Water content θ [21]:

$$\theta(h) = \begin{cases} \theta_r + \frac{\theta_s - \theta_r}{[1+|\alpha h|^n]^m}, & h < 0 \\ \theta_s, & h \geq 0 \end{cases} \tag{2}$$

3) Hydraulic conductivity K [21]:

$$K(h) = K_s S_e^l \left[\left(1 - S_e^{l/m}\right)^m\right]^2 \tag{3}$$

$$m = 1 - 1/n, \quad n > 1$$

where h_s – air-entry value [L]; θ_s– saturated water content [non-dimensional]; θ_r – residual water content [non-dimensional]; *α, m, n* – empirical parameters [1/L], [non-dimensional]; S_e – effective water content [non-dimensional], K_s – saturated hydraulic conductivity [L/T]; K_r – relative hydraulic conductivity [non-dimensional]; $K_k(h_k)$ – unsaturated hydraulic conductivity at pressure head (h_k) [L/T].

4) Hydraulic capacity (C) show amount on infiltration moisture in soil subsurface [21]:

$$C = \delta\theta / \delta h \tag{4}$$

where h – pressure head [L]; θ – water content [L^3L^{-3}].

Sequences of prediction: 1) prepare step – we need to choose major processes (water flow, root water uptake, root growth, heat transport and solute transport); Geometric information (the number of horizons, soil depth, and soil texture); Time information (the number of observation days, the period between observations). After that we calculated only water flow, with real geometric information took from soils texture (Table1) and the same parameters calculated with precipitation data. Rainfall was observed on such days and in such quantities: 03.10.2018 – 8,3 mm; 24.10.2018 – 0,3 mm; 25.10.2018 – 2,5 mm; 14.11.2018 – 3,8 mm; 15.11.2018 – 3,8 mm; 16.11.2018 – 4 mm; 17.11.2018 – 0,5 mm; 20.11.2018 – 6,0 mm; 21.11.2018 – 0,2 mm; 22.11.2018 – 1,8 mm; 27.11.2018 – 17,5 mm; 28.11.2018 – 8,3 mm; 29.11.2018 – 0,3 mm (there was no rain on other days). Duration of simulation in days: 1.10.2018 – first day; 15.10.2018 – 15th day; 30.10.2018 – 30th day; 14.11.2018 – 45th day; 29.11.2018 – 60th day. These dates we took from archive of Meteorological station of Chernivtsi (Ukraine) for 2018, from 1th October to 29th November. Time information printed in 0th, 15th, 35th, 45th and 60th days.

2) Setup step – entering the water flow parameters (θ_s, θ_r, α, n, K_s, and l). These parameters calculated by Hydrus using soil texture. Then we choose boundary conditions (upper and lower). For upper parameters, we chose Atmospheric BC with surface layer while lower boundary is free drainage. For initial condition, Pressure head (Fig. 1) has argument 100 in whole profiles for both soils. Nevertheless, programme propose other boundaries such as constant flux, drainage parameters, atmospheric BC etc.; line on the models (Fig.1 – 2) denote: solid line shows base boundary parameters in 0th day before modelling; long-dash line – observation parameters on 15th day; dotted line – observation parameters on 30th day; dot-dash line – observation parameters on 45th day; double dot-dash line – observation parameters on 60th day.

3) Modelling step – building model of a soil profile; enter depth and location of soil horizons. Here we can add other information: Pressure head calculation, root water uptake and/or speciality of water movement etc. As a result, we will have a summary table where we can correct all data about the profile. In this table, we can see information about soil, which based on water flow parameters (Table 3).

4) Calculating step – the modelling according to previously entered (see the third step) data.

Consequently we will get graphical models, with characteristics of dynamic parameters: 1) Pressure head distribution (h) (Fig.1A) – within energy pressing on soil in pore space (line value show mechanic solute energy in flux point); 2) Water content (θ) (Fig. 1B) – the quantity of water contained in a soil; 3) Hydraulic conductivity (K) (Fig. 1C) – the ability of soil to pass water through pore space; 4) Hydraulic capacity (C) (Fig. 1D) – the rate of infiltration of water into soil.

3. Results and discussion

The focus of the simulation results is the dynamic of soil water in the upper horizon. Under the same climatic conditions, the difference in texture and use of two types of soils can significantly effect on the parameters of soils water regime. Let us consistently characterize the dynamics of these indicators over time and radially, down the profile, paying particular attention to the top horizons of soils. Results of simulation with Hydrus 1-D give us some interesting facts.

Pressure head (h).The absolute values of Pressure head (Fig. 1A) in the Chernozem are from -125 to -250 cm (in the upper horizon – from -170 to -240 cm); the ranges are from -90 to -190 cm (in the upper horizon – from -130 to -170 cm) in Luvisol. Thus, the Pressure head is higher in Luvisol, especially in the upper horizon (in Chernozem – arable horizon). Key to understanding this fact is genesis of illuvial horizons that reason of these are elluvial-illuvial processes. More discussion focused on temporal dynamics of Pressure head: there is a sharp decrease in pressure during the first 15 days (for the upper horizon – from -100 to -140 cm in Luvisol and from -100 to -160 cm for Chernozem). In the future (more than 15 to 60 days), the decrease in Pressure head becomes almost equally regardless of the genetic horizons (Fig. 1A).

The following changes in Pressure head found down the soil profile to the parent material: an increase in its quantity is characteristic of both soils, but in Luvisol this increase is significantly, then in Chernozem, in which such changes are smoother (Fig. 1A). We noted, that at the bottom of the Luvisol profile, the value of Pressure head on the 15th and 30th days is greater, than at the beginning (0 day) of simulation (for the Luvisol parent material, such dynamic of Pressure head were: -100; -90; -95; -105; -115 cm, respectively; for the Chernozem parent material the values of Pressure head were: -100; -150; -175; -200 cm, respectively). Therefore, in the illuvial horizons and in the parent material of Luvisol, the Pressure head increases during the first 30 days compared to the initial one, whereas in the elluvial part of Luvisol the value of Pressure head sharply decreases (Fig. 1A).

Water content (θ). The beginning of the simulation (day 0) is immediately characterized by a significant differentiation of water content across the genetic horizons (Fig. 1B). In Chernozem, it is almost homogeneous distribution, with a significant decrease of (θ) from the day 0 to 15-th day and, subsequently, a slight coherent decrease in the water content, more marked in the upper horizon: the ranges of changes were: day 15th – 0.36-0.40; day 30th – 0.35-0.38; day 45th – 0.34-0.37 and day 60th – 0.33-0.36). For Luvisol (Fig. 1B), even at the beginning of the experiment, the water content was more differentiated, with expressed two maxima (in Ih horizon, ≈ 0.34 and in Hd horizon, 0.35) and two minima (in Pi horizon, 0.28 and in Eh horizon, 0.33).

In time (up to the 60th day), there is mainly a decrease in the range of (θ), and this decrease for Luvisol is characterized by sharp differences compared to Chernozem. Smaller and absolute values water content of Luvisol likened to Chernozem (0.35-0.28 and 0.42-0.34, respectively). The main changes of (θ) (in particular its decrease), we found for the top of the Luvisol profile (Hd – He – Eh), whereas in the Illuvial horizons these changes are not significant.

Hydraulic conductivity (K) substantially different by genetic horizons, even at the beginning (day 0) of the simulation (Fig. 1C). Apparently, the texture (and soil density associated with the texture) has a distinct effect on the Hydraulic conductivity. In general, the K minimum in Chernozem at the beginning of the simulation ranges from 0.30 (genetic horizons Hi, Hpi, Pк) to 0.50 cm/day (horizon He). On day 15th of modelling K is significantly reduced compared to the beginning of the simulation (Fig. 1C). In the future (30-45-60th days) changes of K are already insignificant with some increase of its value down the profile to the lower transition horizon (Phi). It is noteworthy that over time the profile differentiation of Hydraulic conductivity in Chernozem is leveled (Fig. 1C).

Luvisol differs significantly from Chernozem in range and profile distribution of hydraulic conductivity (Fig. 1C). For Luvisol, absolute values of K varies from 0.10 to 2.20 cm/day, while in Chernozem it deviates from 0.10 to 0.50 cm/day (Fig. 1C). Note that at the beginning of the simulation (day 0), Hydraulic conductivity sharply decreases down for Luvisol profile from 2.0 cm/day (horizon Hd) to 0.65 (horizon He) and to 0.30 cm/day (horizon Eh) and even up to about 0.10 cm/day in the below located illuvial horizons (Ih-Igl-Pi). Hence, the main differences, compared to Chernozem, relate to the two upper Luvisol horizons. That soil has a maximum hydraulic conductivity in the upper horizon that is explained by the saturation of this horizon by root systems of herbaceous plants. The minimum values of K observed in the compacted illuvial horizons (Fig. 1C). The temporal dynamics of Hydraulic conductivity below the three upper horizons in Luvisol is almost unheard of and becomes similar to that in Chernozem.

Water capacity (C), like other model parameters, is less differentiated as by genetic horizons of profile, as in time for Chernozem than for Luvisol (Fig. 1D). The major changes in C for Chernozem occur from the beginning of the simulation to the 15th and the 30th days, and subsequently the temporal dynamic is almost declining. In absolute values, it ranges from $8\cdot10^{-4}$ 1/cm (day 0) to $4\cdot10^{-4}$1/cm (day 60th).

For Luvisol the start of the simulation is characterized by a water capacity value of $5{,}9\cdot10^{-4}$1/cm (parent material) to $6{,}8\cdot10^{-4}$ 1/cm (genetic horizon Eh). Over time, Water capacity decreases to $4{,}6\cdot10^{-4}$ 1/cm (in the upper horizon) and almost to $5\cdot10^{-4}$1/cm (genetic horizon Ip). The temporal dynamics of this parameter appear to us somewhat stochastic, although in general Water capacity increases downstream of the Luvisol profile (Fig. 1D).

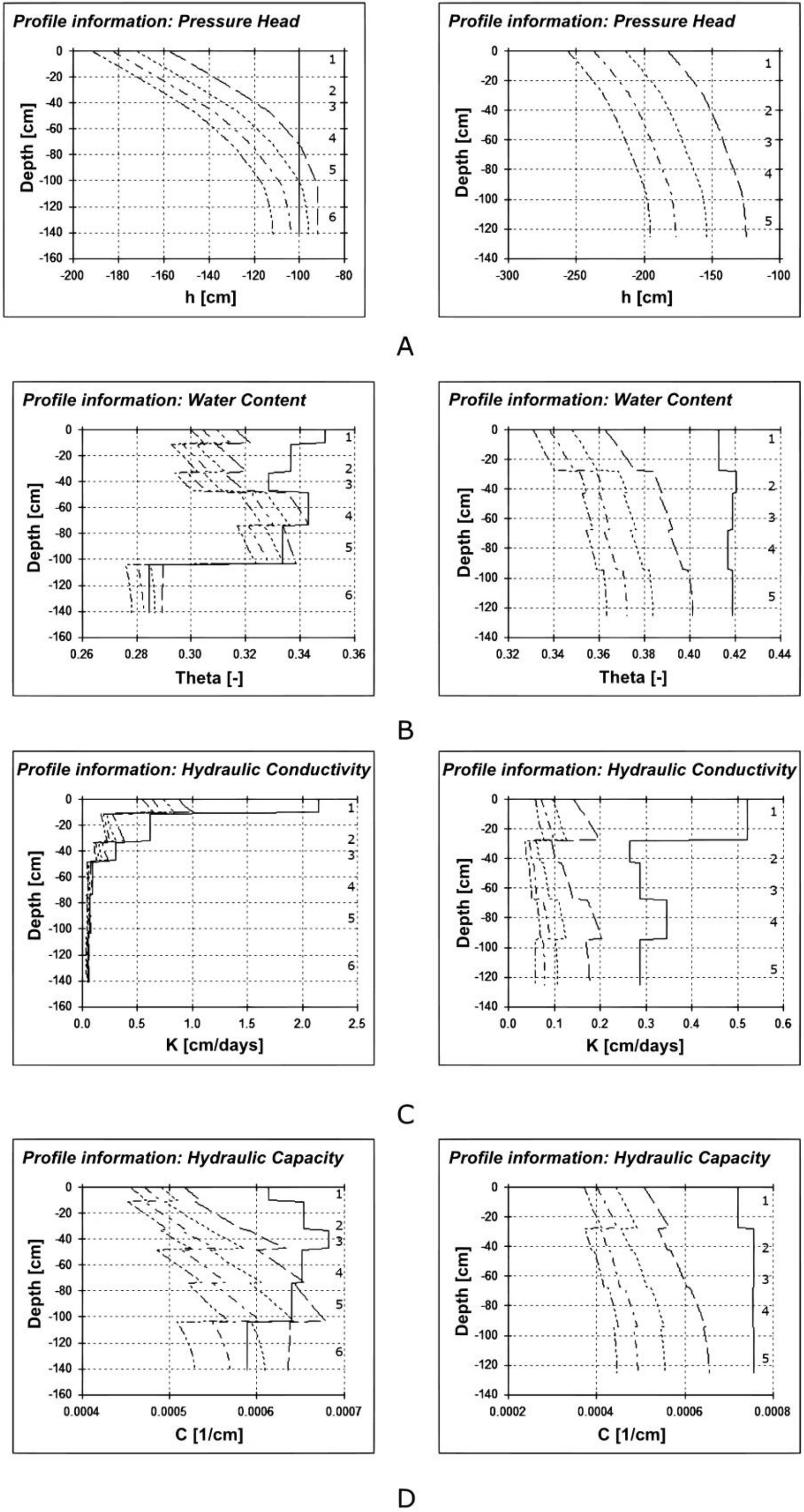

***Figure 1**. Models: A – Pressure head; B – Water content; C – Hydraulic conductivity; D – Hydraulic capacity; on left for Luvisol, on right for Chernozem*

Additionally, for better understanding water regime for two researching soil types, we include in model parameter of precipitation (Fig. 2).Therefore, Pressure head (h) in Luvisol (Fig. 2A) has great changes on 45th and 60th days. While 15th and 30th days are equal to Pressure Head without precipitation (Fig. 1). Obviously of 15th and 30th days far from rainfall days. In 45th day we are witnessing start of rain period, which prolong 3 next days. Thus, Pressure head increase in upper horizons to illuvial part of profile, where *h* stabilized and became like standard Pressure head models (without precipitation).

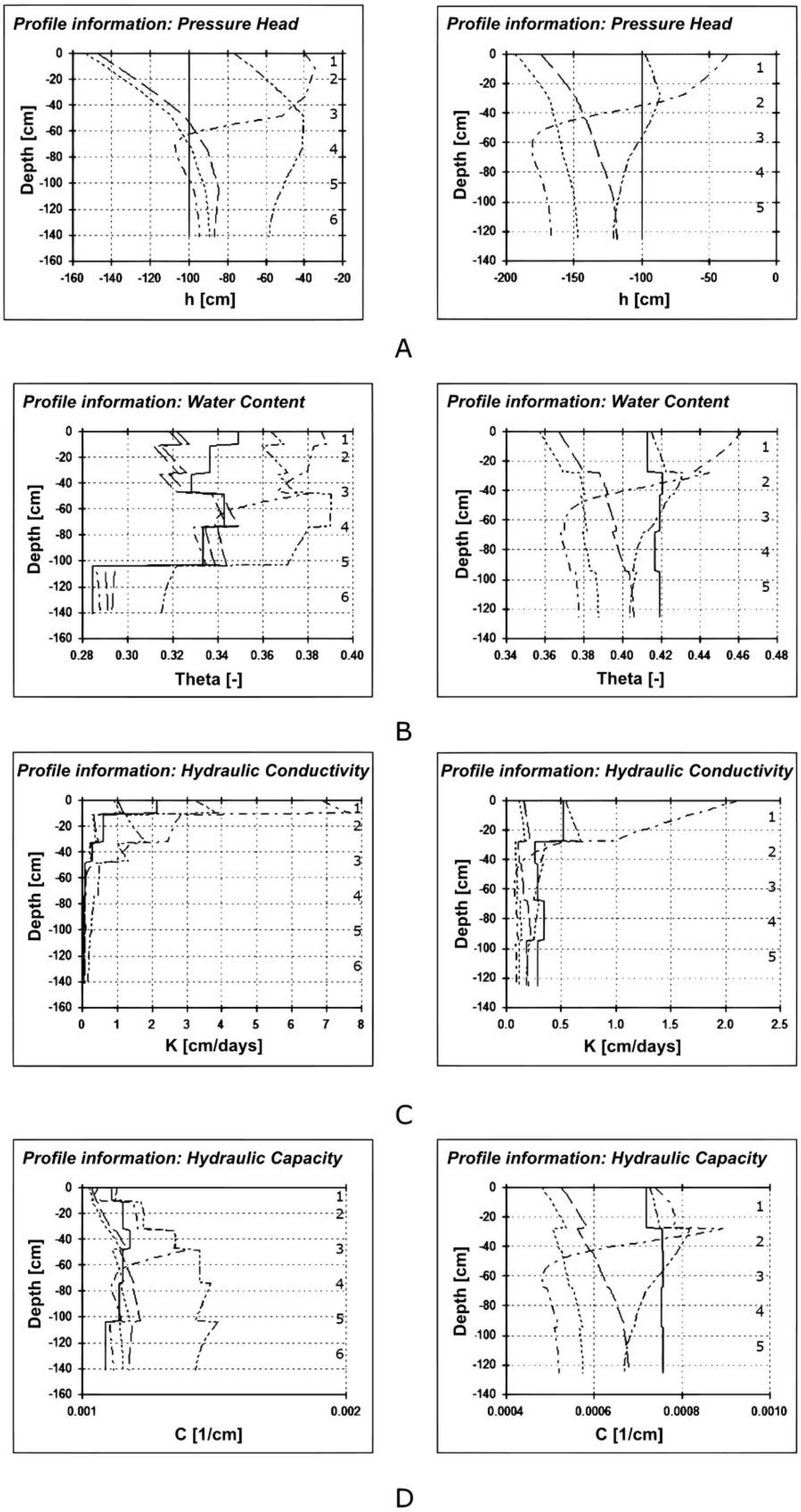

Figure 2. *Models for rainfall (see Sequences of prediction): A – Pressure head; B – Water content; C – Hydraulic conductivity; D – Hydraulic capacity; on left for Luvisol, on right for Chernozem*

Both soil types has the same changes in other days in modelling (θ, K and C), on 45th and 60th days same as Pressure head had, compare to models without precipitation (Fig. 1).

On 60th day, we are observing the last day of rainfall period (from 27th to29th November). With respect to rain Pressure head increase in whole profile with maximum in illuvial horizons (Fig 2A). For Chernozem, we have been witnessing different changes with the same precipitation data. 15th day reflect to Pressure head without precipitation (Fig. 1). However, in 30th day Pressure head deviates because of evidence of rainfall during 3 days before it; 45th day demonstrate similar dynamic grow as Luvisol in this day, but changes more linear than for Chernozem due to the fact heavier texture. On 60th day Pressure head increase more in whole profile (Fig. 2A), compare to models without precipitation in this day (Fig. 1A), and has a light maximum in subsurface horizon.

This situation we understand through the equation where Pressure head has an impact on Water content and Hydraulic conductivity (equation 3) and then on Capacity (equation 4) through Water content. But the biggest changes reflecting in Hydraulic conductivity models, which has nearly seven times increase from surface in Luvisol and four times in Chernozem for 45th day compare to model without precipitation; deeper this parameter decrease to illuvial horizons (I(h)(gl) and H(i) respectively) in both soils. On 60th day they have nearly the same qualitative of differences.

More significantly modelling with precipitation, we get some information about influence the fine particles in soil profile on water regime. So Silty clay loam texture (Chernozem) passes three times less water than Loam texture (Luvisol) according to Hydraulic conductivity models (Fig. 2). In addition, Chernozem texture is better for water distribution. Water retain only on surface and upper horizons, which is well for agriculture using. While Luvisol has maximum values of parameters in subsoil’s horizons often in illuvial genetic horizons.

4. Conclusions

Many of the above predictions by our researching indicate significant results achieved in the simulation by Hydrus-1D during the first 30 days. Later, the parameters of the water regime in the simulation do not change significantly. Therefore, for modelling it is advisable to choose periods of control over parameters of the Water regime in 5-10-20-30 days.

Compared to Luvisol, Chernozem, despite the ploughing, have the optimal indices of its texture, due to the natural genesis of this soil. Characteristics of texture provide better parameters of water regime (greater θ and K, at close h and C), which is due to the higher content of fine particles, which lend higher water content and hydraulic conductivity of Chernozem.

Illuvial clay of Luvisol, associated with elluvial-illuvial processes, has an indicated effect on the vertical distribution (down the profile) of such a parameter of the water regime as water content and less influence on the hydraulic capacity.

Inclusion in simulating of the precipitation that occurred during the observation time indicates that the model reflects the corresponding changes as a result of rain for hydraulic conductivity, and less for pressure head; water content and hydraulic capacity have changed slightly in such rainfall. It is likely that the more displayed effect of rain on day 45th than in other periods maybe explained by the nature of the precipitation (downpour rather than prolonged rain).

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Можливості програми Hydrus-1D в оцінюванні водного режиму ґрунтів

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Проблема забезпечення прісною водою постає все гостріше, і її посилюють кліматичні зміни, які спостерігаються у світі. Зростання температур повітря спричинює істотні пертурбації, які зачіпають всі аспекти життя людей. Проте особливої гостроти ця проблема набуває для сфери агровиробництва. Важливість водного режиму ґрунтів, як одного з їх компонентів, пояснюється не тільки власне функціонуванням екосистеми як такої. Насамперед через ґрунтову вологу забезпечується живлення рослин, а також міграція хімічних елементів як в межах профілю (радіально), так і між ґрунтовими педонами (латерально). Апріорі зрозуміло, що різні ґрунти володіють іманентними особливостями водного режиму, який залежить від розміщення ґрунту в конкретних умовах (всі чинники ґрунтогенезу) та характеру ґрунтоутворення. Метою виконаного дослідження є порівняльна оцінка водного режиму різних ґрунтів (сірий лісовий та чорнозем опідзолений), які просторово межують між собою, а тому немає підстав говорити про достовірну різницю кліматичних умов (температура повітря, кількість опадів, гідротермічний коефіцієнт). Проте різниця в материнських породах цих ґрунтів і, як наслідок, в кінцевому результаті генезису зумовила низку відмінностей за їх показниками, найперше – за гранулометричним складом. Саме останній є одним з основних чинників впливу на водний режим ґрунту, що власне й враховує програма Hydrus-1D. Ця програма широко використовується закордонними дослідниками, проте в Україні вона якщо й відома, то немає достатньої бази даних про результати такого моделювання. У процесі останнього нами оцінювалися такі параметри: тиск води, її вміст, гідравлічна провідність та гідравлічна ємність. У модель включено дані про грансклад генетичних горизонтів досліджуваних ґрунтів, на основі яких вказані вище параметри ґрунтів оцінювали: на початок моделювання, 15-й, 30-й, 45-й і 60-й дні від початку. Встановлено, що протягом періоду спостереження ці параметри істотно відрізняються для сірого лісового ґрунту і чорнозему опідзоленого, незважаючи на тотожні кліматичні показники. Причому виявлено, що різниця між ґрунтами більша щодо профільного розподілу аналізованих параметрів, а потім вже за їх кількісними значеннями. Результати нашого дослідження демонструють істотну динаміку параметрів симуляції в процесі моделювання протягом перших 30 днів, а надалі різниця між ними практично нівелюється. Тому для моделювання такого характеру доцільно вибирати періоди контролю параметрів водного режиму через 5-10-20-30 днів. Показники гранскладу чорнозему опідзоленого (важчий гранулометричний склад завдяки більшому вмісту дрібнодисперсних часток,), забезпечують кращі параметри водного режиму, порівняно з сірим лісовим ґрунтом. Елювіально-ілювіальні процеси, які формували сірий лісовий ґрунт та призвели до утворення ілювіальних горизонтів з підвищеним, порівняно з іншими генетичними горизонтами вмістом мулу, істотно вплинули на вертикальний розподіл такого параметра водного режиму, як вміст води та менше на гідравлічну ємність. При включенні в моделювання реальної кількості опадів, які припали на час спостереження, одержано дані моделі щодо відповідних змін для гідравлічної провідності та менше для тиску води. Цілком ймовірно, що більш виражений ефект дощу на 45-й день, ніж в інші періоди, пояснюється характером опадів (зливи, а не тривалий помірний дощ). Отже, дані, одержані нами в процесі симуляції, зважаючи на розміщення ґрунтів в агроекосистемах, можуть застосовуватися для впровадження конкретних агротехнологій та оцінювання їхніх результатів. Зокрема, є можливості передбачення інтенсивності процесів вилуговування, які істотно залежать від вертикального переносу води. Результатом є ризики як втрати поживних речовин з ґрунту, так і забруднення підґрунтових вод. Використання Hydrus 1D дає змогу прогнозувати забруднення ґрунтів, що надважливо для організації дієвого моніторингу стану ґрунтового покриву і ареалів антропогенних імпактів.

Ключові слова: Hydrus-1D; модель, сірий лісовий ґрунт; чорнозем опідзолений; гранулометричний склад, моделювання.

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