SOFTWARE USED FOR A COMPARISON BETWEEN HORIZONTAL AND VERTICAL DRAINAGE SYSTEMS IN ANISOTROPIC SOILS

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Abstract

Choosing an appropriate drainage system on an agricultural land has always been discussed and analyzed from several points of view. But in the case of anisotropic soils, this problem is more sensitive. In this study, a comparison was made between a horizontal and a vertical drainage system in anisotropic soils. For this purpose, using the DrenVSubIR software, the distance between horizontal and WellDrain vertical pipes was determined, as well as calculus of resistance coefficient at water entry in drain tube, with and without filter, the drainage verifying operation calculus in sub-irrigation and the specific investment calculus and for establishing the optimum technical-economic solution of drainage.

Key words: software, water drainage, underground drainage systems, design, groundwater control

INTRODUCTION

The design of the horizontal and vertical drainage, that is to say the arrangement of the channels or the underground drainage pipes, their depth and the determination of the space between them is done by the relation of Hoogdhout. This also takes into account the effect of pressure losses at the entrance of the water into the drainage channels with or without filtering materials, a value calculated using the experimentally established coefficients given by the Ernst formula completed by David. This allows checking the conventional reversibility of the drainage in the controlled drainage and in sub-irrigation but, only after calculating the distance between the drainage channels and the values determined when designing the distance between the drainage channels.

The calculation of drainage and subirrigation in the frame of reversible functioning of drainage arrangements implies the application of the general concepts of hydraulic leakage of groundwater towards horizontal agricultural drains. So, for sizing horizontal drainage induced in pipes (the principal element in achieving reversible arrangements of drainage – sub-irrigation) are used relations: Hooghoudt, Ernst and David for permanent functioning regime and verifying mode in impermanent regime. Starting from Ernst and David relation the loss of hydraulic losses have been detailed in closed horizontal drainage with working tubes that lead to thoroughgoing study of theoretical fundaments researches on total head pressure loss.

A. Wehry et al in 1980 determined the time-dependent drainage from the root zone of a plant and the drainage coefficient at different levels of irrigation management for an underground drainage project in Jud. Timiș and 10 years later realized and presented the underground drainage on an agricultural land in the Western Plain of Romania cultivated with maize.

David (1983), using a field approach to wetland drainage design, improved Ernst's formula by adding an index to estimated runoff coefficients. Thus, we can use a simple flow resistance model that manages secondary drainage/irrigation systems.

With the help of the water drainage equation, analyzed the evolution of the groundwater level in the field studied both permanently and non-permanently. The results obtained with the derivative equation proved to be in close correlation with those obtained from numerical simulations. Using the finite element method, he calculated the constant heights of the water level in the drained soils and determined the variation of the hydraulic conductivity at depth in the drained lands and the design of the drainage installations. (Youngs, 1975, 1985)

Orlescu (1986) investigated in his studies the hydrogeological aspects of agricultural drainage from Timis County. Molen and Wesseling (1991) presented a solution to replace the tables for the equivalent layer thickness in the formula for determining the distance between Hooghoudt's drainage pipes. Thus, the effect of using continuously submerged drainages that have been resisted due to the modified permanent drainage equations in different soil types determined in the underground drainage has been studied. Comparing the drainage equations on a field in permanent regime with those on an equivalent depth in a non-permanent regime it is found that they give results only when used in design using the optimum radius of drain given by the hydrography analysis for a given depth of soil.

The hydrological study conducted by Polse Terras (2000) determined the use curves of the aquifer of the well from several tests given all heterogeneous environments. Hanson and Ayars (2002) presented strategies for reducing underground drainage in agriculture by improving irrigation. Sabau N.C. et al (2002) discussed the depth of groundwater level in homogeneous drained anisotropic soils.

Hunt (2005) discussed the flow of water extracted from the vertical and oblique wells in the aquifer layers from which water can be extracted. Sabău N.C. et al (2006) modeled an underground drainage surface to determine the salt load in the N-V Plain of Romania.

O'Kelly (2006) compared the anisotropy of soft soils. Sabău et al (2007) make comparative forecasts of analytical models and field measurements for water drainage by pumping in an un-configured aquifer layer. Bodog et al (2007) presented in the doctoral thesis software for designing an underground drainage system successfully used in several systems in Romania. In this software a few simple elements of analysis are used to predict the height of the groundwater level used in the underground drainage.

Bodog, 2009, presented numerical simulations of the underground drainage in permanent regime, with hydraulic conductivity in vertical decrease. The presented results will be used to estimate the depth of the groundwater level resulting from the vertical variations of the hydraulic conductivity.

Man et al., 2010, estimated the unsaturated hydraulic parameters following the infiltration of water in the anisotropic soil and of the internal drainage experiments on the stand made at Fac. Hydrotechnics of the "Politehnica" University of Timisoara. Subsequently, the team evaluated the efficiency of the prefabricated vertical drains using dynamic testing on the same stand. Halbac, 2010, studied agricultural land drainage as a comprehensive research in his own PhD thesis.

Domuța, Sabău et al., 2010, studied the role and importance of water and irrigation development on agricultural land in NW of Romania, Bihor County for 40 years till 2008. Man et al., 2015, studied in depth the application of drainage and irrigation on agricultural lands demonstrated the effectiveness and social and environmental impact of hydro-improvement projects.

Older drainage models predicted relatively rapid dissipation of stored but undrained water, while it showed degradation throughout the entire pumping test. The results indicated that the water level limitation conditions used in these analytical models did not adequately reproduce the mechanisms that control the behavior of water from atmospheric precipitation and infiltrate the earth's crust.

The present study designs a cost-effective horizontal and vertical underground drainage system that can be applied immediately in the field.

MATERIAL AND METHOD

In this study we use two softwares DrenVSubIR and WellDrain for horizontal and vertical drainage respectively. The calculations on the distance between the drains are based on Darcy and the groundwater level equations, budget or drainage water retention equations. In addition, the results obtained for the space between the drains were manually verified.

Three different layers of soil with different hydraulic conductivity and permeability were considered: one layer above and two below the drainage tube placement level. The last two layers had different horizontal and vertical hydraulic conductivity or permeability (anisotropy).

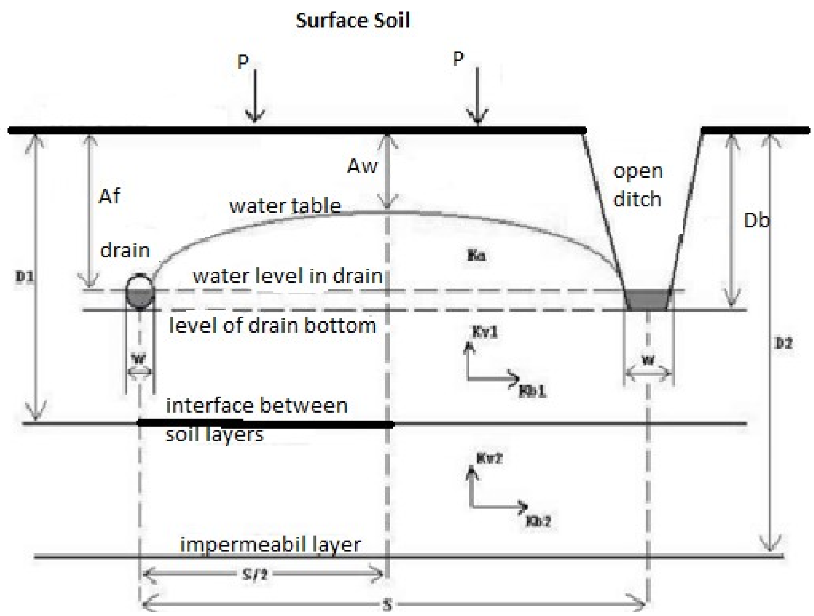

Fig. 1. Graphic of horizontal drainage

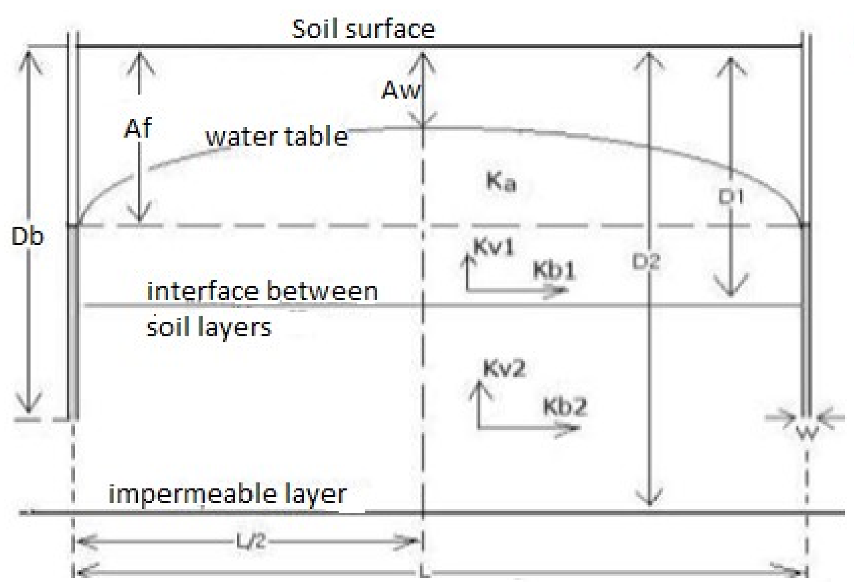

Fig. 2. Graphic of vertical drainage

RESULTS AND DISCUSSION

The table below represents the calculation of the distance between drains for different values of hydraulic conductivity. According to table 1, if the hydraulic conductivity is changed, the type of drain and the distance between the drains are changed. The largest changes in the initial conditions (Δs/s = 0) were related to that hydraulic conductivity above the runoff depth (Ka) which was very low (0.1 meters per day) and below the runoff depth (Kb) was very large (10 meters a day).

In this situation, the quantities of water drained and the distance between the wells remain at the initial ones, which were 572.72%, respectively 169.19%.

However, the vertical drainage systems, due to the not so large changes of the spacing, in the anisotropic soils were suitable for the situation in which the hydraulic conductivity of the soil could change. Therefore, given that the hydraulic conductivity of the soil is unstable and can give significant changes over time, the use of vertical drainage will give maximum efficiency if used.

The interpretation of the results was done according to the graphs in figures 3 and 4. Thus 90% of the groundwater was lost on the first 5 meters according to figure 3 and in figure 4, 5 meters away from the first well; a loss of less than 30% was produced from the amount of water. Also, in the vertical drainage, due to the amount of groundwater lost at the first extraction, the hydraulic conductivity values were less efficient in determining the distance between wells than between drains.

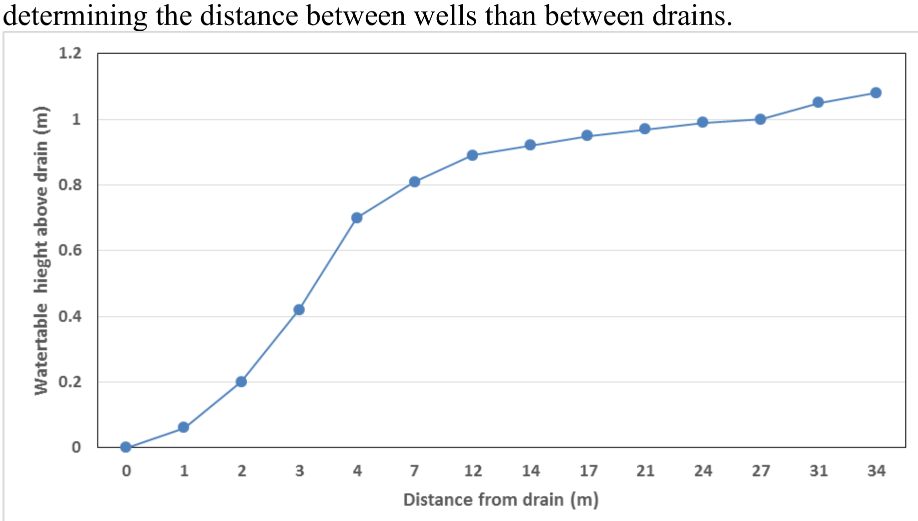

Fig. 3. Horizontal drain action

Table 1

Calculation of distance between drainages for different values of hydraulic conductivity

Time (m/day)	**Af (m)**	**Db (m)**	**W (m)**	**Aw (m)**	**D1 (m)**	**D2 (m)**	**Ka (m/day)**	**Kh1 (m/day)**	**Kv1 (m/day)**	**Kh2 (m/day)**	**Kv2 (m/day)**	**Dh (m)**	**Δs/s**	**Dv (m)**	**Δs/s**
0.0011	2.0	4.0	0.4	1.0	2.9	5.0	2.0	1.3	1.5	0.9	1.0	173.05	0.0	67.08	0.0
0.0011	2.0	4.0	0.4	1.0	20.0	21.0	2.0	1.3	1.5	0.9	1.0	403.47	132.8	90.76	33.7
0.0011	2.0	4.0	0.4	1.0	2.1	21.0	2.0	1.3	1.5	0.9	1.0	335.43	94.4	78.37	15.5
0.0011	2.0	4.0	0.4	1.0	2.9	5.0	10.0	1.3	1.5	0.9	1.0	241.33	39.7	92.65	36.4
0.0011	2.0	4.0	0.4	1.0	2.9	5.0	0.1	1.3	1.5	0.9	1.0	151.57	123	60.0	10.5
0.0011	2.0	4.0	0.4	1.0	2.9	5.0	2.0	10.0	0.1	10.0	0.1	471.53	172.5	160.37	135
0.0011	2.0	4.0	0.4	1.0	2.9	5.0	2.0	0.1	10.0	0.1	10.0	125.88	261	51.73	21.4
0.0011	2.0	4.0	0.4	1.0	20.0	21.0	0.1	0.1	0.1	10.0	10.0	139.76	180	74.68	10.18
0.0011	2.0	4.0	0.4	1.0	2.9	5.0	0.1	10.0	10.0	10.0	10.0	570.70	230.8	168.17	147.3
0.0011	2.0	4.0	0.4	1.0	10.0	21.0	0.1	0.5	0.7	1.0	1.5	334.40	100.1	54.69	17.19

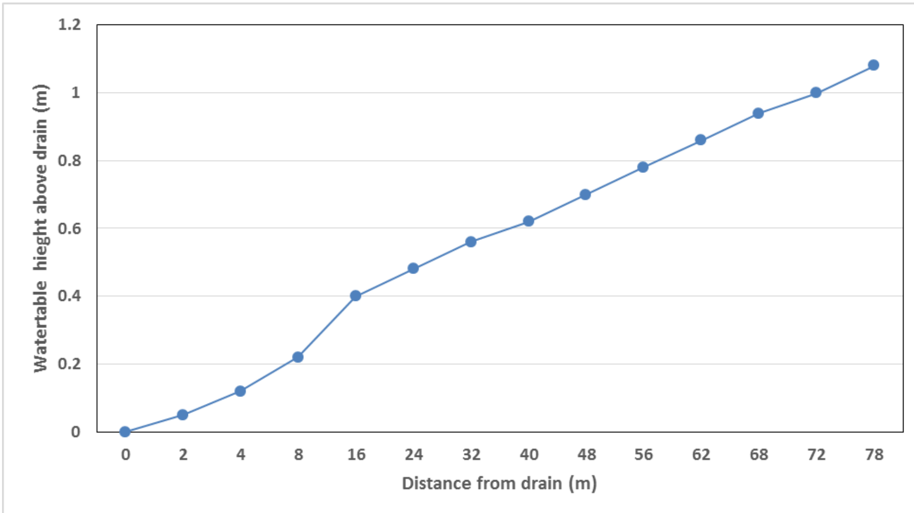

Fig. 4. Vertical well action

CONCLUSIONS

The results showed that, in the same situation, the horizontal drainage systems, due to the larger spacing of the drainage channels respectively the underground pipes were more efficient than the vertical drainage systems.

However, vertical drainage systems, due to the small spacing between wells (wells), in different anisotropic soils, have been adequate to the anisotropic conditions, in which the hydraulic conductivity of the soil may change.

The results of the experiment showed that the controlled drainage (sub-irrigation) of a land improvement system significantly reduced both the volume of run-off water and the quantities of salt in the water compared to the unmanaged systems. However, there have been significant increases in soil salinity, which will need to be carefully monitored and managed.

The results obtained with this software are approximately the same as Hooghoudt analytical solution for the distribution of the total water flow in the ideal drainage channels and for calculating the total flow at half the distance between the drainage channels.

Therefore, it was concluded that the proposed software is good for practical situations and could be used in future work with large scale hydrological models. This software was useful for designing an underground drainage system on a soil with three horizons from which the upper one is slightly permeable. The study showed that the location of soil horizons influences the water flow.

In all previous researches, the design of horizontal and vertical drainage systems was performed separately, and these two systems have never been compared in anisotropic soils. In this article, both horizontal and vertical drainage systems are theoretically compared in anisotropic soils.

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