Original Research Article

Estimation of Transient Drainage Discharge from Subsurface Pipe Drainage System in City Park Next to Mseno Dam (Czech Republic)

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Abstract

The aim of this study has been to demonstrate the way of determination of drainage discharge by the method of De Zeeuw-Hellinga in the transient drainage flow conditions. For comparison and verification of numerical experiment of calculation of drainage discharge by equation of De Zeeuw-Hellinga with measured daily values of drainage discharge was selected subsurface pipe drainage system in experimental drained area, placed in the local city park next to the Mseno Dam, in the city of Jablonec nad Nisou, Czech Republic. The results showed a good conformity between calculations and measured data, the differences between De Zeeuw-Hellinga's approximations and measured daily values of drainage discharge fluctuated from 0.6 (mm.day⁻¹) to zero, and confirmed that the De Zeeuw-Hellinga's formula is a suitable tool for approximation of the drainage discharge in the transient flow conditions. It was confirmed again that De Zeeuw-Hellinga theory is also applicable for the shallow subsurface pipe drainage system.

Keywords: transient drainage discharge, pipe drainage system, De Zeeuw-Hellinga theory, Mseno Dam.

INTRODUCTION

Drainage discharge, developed by subsurface pipe drainage system, plays an important role in soil and environmental hydrology. This hydrological phenomenon is essential especially in connection with control and management of water regime for the protection of soil and water resources and for producing of retention capacities of soil surface layers. It can mitigate the negative impacts of hydrological extremes like surface runoff, floods and erosion processes (Kulhavy, 2007).

For the study of non-steady state drainage flow in these conditions the analytical solution of linearized Boussinesq's Equation (Boussinesq, 1904), final expression of Glover-Dumm (Ritzema, 2006; Štibinger, 2003) based on Boussinesq (1904) was used. It describes the lowering of water table in time.

Stimulating work in this area was presented by Zavala et al. (2007), Fuentes et al. (2009) or Singh (2009). The author of this article used the analytical solutions of drainage processes in water engineering practice (Stibinger, 2009; Stibinger and Kulhavy, 2010; Stibinger 2011).

In the tested period of the transient drainage processes, De Zeeuw and Hellinga used certain limited time intervals Δt (T) with the same length, where constant drainage recharge R (M) in each interval (T) is to be supposed. Drainage discharge q (M.T⁻¹) is calculated separately for individual time intervals, where the drainage discharge will be directly

proportional to the excess drainage recharge (R – q) (M). The coefficient of proportionality is α (day⁻¹), named also drainage intensity factor or De Zeeuw-Hellinga drainage intensity factor.

Similar procedures, by the method of superposition, were presented by Kraijenhoff (1958) and Maasland (1959).

These methods were simplified by Dieleman and Trafford (1976) for engineering drainage practice. Practical example of the application of the De Zeeuw-Hellinga's theory to approximate landfill drainage discharge has been shown by Stibinger (2006, 2009) and Stibinger and Kulhavy (2010).

Application of the De Zeeuw-Hellinga theory enables a correct approximation of the drainage discharge from the very beginning of the subsurface flow to drains.

Application of the often used other final formulas (e.g. Glover-Dumm Equation) can generate errors at the description of the beginning of the drainage processes. This is the reason why the equations derived by similar analytical procedures from this sphere, are limited by time T_L (T), which is represented as a starting point. J. P. Dieleman (1976) recommends time $T_L = 0.4 / \alpha$ (day⁻¹), H. Ritzema (2006) recommends $T_L = 0.2 / \alpha$ (day⁻¹). Application of the De Zeeuw-Hellinga procedure is not limited to this area in any way.

The aim of the research of this field of drainage hydrology is the analysis the of drainage discharge q (M.T⁻¹) by the method of De Zeeuw-Hellinga (De Zeeuw and Hellinga, 1958; Ritzema, 2006; Stibinger, 2006; Stibinger and

Fig. 1. Situation of Mseno Dam in Jablonec nad Nisou City, with marked position of experimental drained area next to Mseno Dam (region Liberec, Czech Republic)

Kulhavy, 2010) in the transient drainage flow conditions. The symbol M (or T) represents a unit of length (or time unit). Comparison of the results of this numerical experiment with the real measured data of drainage discharge is inseparable part of the research.

Experimental subsurface pipe drainage system, situated in the area of 0.45 hectares in the southern part of the city green park near by the Mseno Dam (see Fig. 1), was originally built in 1963 to eliminate the great wetting around 30 – 60 litres per second from eroded basement of the dam (Simm et al., 2001).

During the complex reconstruction of Mseno Dam basement, successfully finished in 2000, the present subsurface pipe drainage system was renovated. At the same time, measurement of the daily values of the drainage discharge and precipitations by TBD-Vodní díla (2011) was also started. The values of the drainage discharge from subsurface pipe drainage system are not affected by any seepage from Mseno-Dam. All existing potential leakages of the dam's bedrock are controlled and drained by special sealing and monitoring gallery placed under the basement of the dam.

In these hydrological conditions it is possible to consider the recharge R ($M \cdot T^{-1}$) to the subsurface pipe drainage system in the form of precipitations that have a strong stochastic character and all the drainage process can be definitely defined as transient.

The importance of drainage system in water management, particularly the subsurface pipe drainage system is

indisputable. For some very large areas in the regions of Asia, Africa, India or China, the presence of the subsurface pipe drainage systems is a necessity. This is particularly true when their specific natural conditions can bring about permanent waterlogging (Ritzema 2006, ALTERRA 2008, Stibinger 2011). Very good examples of the importance of drainage policy in Europe are some countries such as the Netherlands, Lithuania or Denmark, where the ratio of the drained area to the total area of the country is 0.72, 0.4, and 0.37, respectively.

The floods, which affected the Czech Republic in the 1997, 2002, 2006, 2009 and 2010 and local waterlogged areas in the spring period of 2012 and 2013, clearly demonstrated the importance and the reason for the drainage systems and infiltration capacity of surface layers in the landscape. Regarding the drainage systems, a very important temporary problem of the water management in the Czech Republic is the long-lasting lack of proper maintenance of the older subsurface drainage pipe systems in the agricultural landscape and the estimation of its hydraulic efficiency and cost-effectiveness.

De Zeeuw-Hellinga theory was developed and verified by drainage hydrology researchers J. W. De Zeeuw and F. Hellinga (De Zeeuw and Hellinga, 1958) for subsurface pipe drainage systems placed in porous soils environment with a deep level of low permeable layer (Ritzema, 2006). These soil and geology conditions are typical of the majority of land in the Netherlands. In such soil conditions, the average thickness of aquifer H (m) in a De Zeeuw-

Fig. 2. Scheme of layout of subsurface pipe drainage system in the park next to Mseno Dam, city Jablonec nad Nisou (after Vodní díla – TBD 2012)

Hellinga drainage intensity factor can be substituted by a Hooghoudt's equivalent layer d (m), representing the imaginary impermeable layer placed between the drains and real impervious soil layer.

Nevertheless, the results of drainage hydrology research, presented in this paper, proved and confirmed the applicability of the De Zeeuw-Hellinga drainage theory also in the case of the shallow subsurface pipe drainage system. The average thickness of aquifer H (m) was in this case substituted by the average thickness of aquifer layer, which has to be logically situated above the drain level. This fact was shown several times (Stibinger, 2006; Stibinger, 2009), however, still neither defined, nor published. Another confirmation of these findings by analysis of the results of De Zeeuw-Hellinga equation used in the Mseno Dam drainage hydrology conditions can be considered as the one of the most important contributions of this study.

MATERIALS AND METHODS

Study area

Subsurface pipe drainage system in the local city park in the Jablonec nad Nisou is situated just next to the Mseno Dam, in the region of the Jizera Mountains, in northern part of the Czech Republic. Long-term annual average precipitation of this area amounts to 1000 mm, the altitude above the sea level is 555 meters.

Hydrology of subsurface pipe drainage system is not influenced by any seepage from Mseno-Dam, because the leakage of the dam's bedrock is monitored and drained by special sealing gallery, placed under the basement of the dam. Final control and recording of the possible dam leakages are carried out by the single monitoring toe pipe drain, equipped by manhole with apparatus for measurement of drainage discharge.

Layout of present subsurface pipe drainage system with drain spacing $L = 14$ m, average drain depth h_d (m) = 0.9 m, and with radius of the drain $r_0 = 0.065$ m is shown in Fig. 2.

Fig. 3. Subsurface pipe drainage system parameters of the city park next to the Mseno Dam, in Jablonec nad Nisou (Czech Republic)

The thickness of impervious layer under the drain pipes is $D = 0.15$ m. The lateral drain pipes are placed almost on the clay-gravel compacted layers with very low permeability,

a typical example of the shallow subsurface drainage system. The initial position of the water table level above the drain pipes is determined by $h = 0.7$ m (see Fig. 3).

The upper layer above the drain pipes was formed by mixing of the local soil materials and backfill, the thickness of the layer rounds about one meter. From the hydraulic point of view, it is possible to consider this upper layer as a homogenous isotropic porous soil environment. It is characterized by the hydraulic conductivity $K = 0.25$ (m.day⁻¹) and effective porosity (drainable pore space) $P = 6\%$ of volume for the whole drained area of the 0.45 hectare.

The subsurface drain discharges were measured by ninety-degree triangular notch weir. Behind this weir a reservoir with a plastic float is situated. It is connected to an automatic level recorder. From the water-stage recording chart the course of the drainage discharges in time t was estimated. The measurements mentioned above, were set up on the single gravity outlet of the whole subsurface pipe horizontal drainage system with drained area of 0.45 hectares. The initial position of the water table level was calculated and at the beginning of the tested period it was also approximated from records of the water levels in piezometers.

For verification of numerical experiment of the determination of drainage discharge based on De Zeeuw-Hellinga theory, the period from October 27 to November 11, 2003 was selected. Constant time interval was defined as $\Delta t = 1$ day.

Theoretical background

For comparison of numerical experiment of determination of drainage discharge by the method of De Zeeuw-Hellinga with the measured daily values of drainage discharge the test period from October 27 to November 17, 2003, with a constant time interval $\Delta t = 1$ day was selected.

On several occasions (October 30, November 11, November 3 and 4, November 16 and 17, 2003) of the tested period we recorded some recharges R (M.T⁻¹) to the drainage system in the form of precipitation upon experimental drained area of 0.45 hectares, placed in the southern part of local park next to the Mseno Dam in the city of Jablonec nad Nisou.

The test period for monitoring from October 27 to November 17, 2003 was selected as a suitable example of rain-free long-term interval with individual stochastic precipitation inputs as the recharges R (M.T⁻¹), which demonstrated a transient character of this process and its application in the De Zeeuw-Hellinga drainage theory.

Similar periods from 2001 to 2012, recorded at the Mseno Dam meteorological station, with a transient character of precipitation are analysed within the research of water regime and drainage flow at the department of Land Use and Improvement, Faculty of Environmental Sciences, CULS

Prague with the aim to estimate the possibility of use these periods in a De Zeeuw-Hellinga model.

The saturated drainage flow, developed by subsurface pipe drainage system, has a transient character and can be described by transient drainage flow using the De Zeeuw-Hellinga theory. De Zeeuw-Hellinga approximation considers the impact of the recharge in the transient drainage process. The derivation of the final formula for calculation of the subsurface drainage discharge q (M.T⁻¹) in transient drainage flow was performed by means of the De Zeeuw-Hellinga theory based on the following assumptions.

The period with non-uniform distribution of drainage recharge R (M.T⁻¹) was divided into time intervals of equal lengths (minute, day, week, month). Then the subsurface drainage discharge q (M.T⁻¹) could be calculated gradually, step by step for every time interval. De Zeeuw and Hellinga found (Ritzema, 2006) that if the drainage recharge R (M) in each time interval Δt (T) is assumed to be constant, the change in the drainage discharge is directly proportional to the excess drainage recharge $(R - q)$ (M) in this time interval.

The constant of proportionality is De Zeeuw-Hellinga drainage intensity factor $\alpha(T^{-1}) = \pi^2 K H (P L^2)$, which depends on the parameters of subsurface pipe drainage system, on the hydraulic properties of the soil environment, on the position of the water table level and on the position of the impervious layer (Dieleman and Trafford, 1976).

Symbol K (M.T⁻¹) is the hydraulic conductivity of the drained soil environment, H (M) is an average thickness of aquifer, P (-) represents effective porosity (drainable pore space) of the drained soil and L (M) represents the drain spacing. The value of the drainage intensity factor α (T⁻¹) also shows the hydraulic efficiency of the subsurface pipe drainage system.

The initial equation, described in the De Zeeuw-Hellinga theory, can be expressed as follows:

$$\frac{\partial q}{\partial t} = \alpha(R - q) \quad (1)$$

The De Zeeuw-Hellinga's expression in the form of equation (1) actually constitutes an ordinary differential equation where the drainage factor α (T⁻¹) and recharge R (M.T⁻¹) are the constants and q (M.T⁻¹) is the unknown function of variable t .

The equations of this type can be solved by separation of variables (Mls, 2002). Detailed description of the procedure of the analytical solution of equation (1) presented Stibinger (2009) and Stibinger and Kulhavy (2010). The final formula of De Zeeuw-Hellinga can be formulated as follows:

$$q_t = q_{t-1} e^{-\alpha \Delta t} + R(1 - e^{-\alpha \Delta t}) \quad (2)$$

The first term q_{t-1} of equation (2) has the dimension of drainage rate, drainage intensity (M.T⁻¹) and the second term $e^{-\alpha \Delta t}$ is dimensionless. It is a well-known fact that the description with analytical solutions of the drainage

processes contain relatively large errors at the beginning of the course for the small time t (T), where time t (T) converges to zero ($t \rightarrow 0$). For example, Dieleman (1976) shows the like criteria of validity of final formulas, derived from analytical solutions of Boussinesq equation (Boussinesq, 1904) by the method of Glover-Dumm (Dumm, 1964; Glover, 1964; Ritzema, 2006), time $\tau(\text{day}) \geq 0.4/\alpha$, where α (day^{-1}) is a constant, which represents De Zeeuw-Hellinga factor of drainage intensity depending upon the basic design parameters of subsurface pipe drainage system and on the soil hydrology conditions of the investigated locality.

The solution based on De Zeeuw-Hellinga theory does not contain this problem. Approximation of the beginning value of drainage discharge q_{t-1} (M.T^{-1}) in the De Zeuw-Hellinga theory is based on the following idea: In a limited constant time interval Δt (T) the steady state drainage flow is considered and for calculation of the value of the drainage discharge q_{t-1} (M.T^{-1}) Hooghoudt equation (Hooghoudt, 1940; Ritzema, 2006; Stibinger and Kulhavy, 2010) can be applied as follows:

$$q_{t-1} = \frac{8.K.h.d}{L^2} + \frac{4.K.h^2}{L^2} \quad (3)$$

In a constant time interval Δt (T), symbol h (M) is the initial water table level above the drain pipes, d (M) is a Hooghoudt's equivalent layer (Hooghoudt, 1940), in this case of the shallow subsurface drainage system $D = d$, and D (M) is the thickness of impervious layer under the drain pipes (see Fig. 2).

This procedure is used in water engineering practice (Ritzema, 2006; Stibinger, 2009; Stibinger and Kulhavy, 2010) and it was successfully verified by the results of this research of drainage hydrology as a suitable method for description of the beginning of the real drainage processes.

By equations (3) and (2) and with the knowledge of recharge R (M.T^{-1}) in each time interval Δt (T) it is possible for the basic design parameters of subsurface pipe drainage system (drain spacing, drain depth and drain radius) and for soil hydrology characteristics (K , P , D , h , H), to calculate the drainage discharge q_t (M.T^{-1}) gradually in any time interval Δt (T). It means practically in any certain time $t > 0$.

RESULTS AND DISCUSSION

To solve the drainage problem, the Research Institute for Soil and Water Conservation (RISWC) Prague-Zbraslav, Czech Republic, the Czech Academy of Agricultural Sciences – Water Management Section and the Czech Committee of ICID (International Commission on Irrigation and Drainage) are arranging meetings and workshops with drainage hydrology researchers and with drainage engineering practitioners. It is obvious that all

the cases will need appropriate application of the drainage policy.

The article shows the results which follow up the analysis and determination of drainage discharge from subsurface pipe drainage system, situated in the southern part of the city park, in the neighbourhood of the Mseno Dam in Jablonec nad Nisou, under the transient drainage flow conditions.

In the conditions of shallow subsurface drainage system the thickness of impervious layer under the drain pipes $D = 0.15$ m is identical with Hooghoudt's equivalent layer d (m), i.e. $D = d = 0.15$ m.

The initial water table level above the drain pipes $h = 0.7$ m, the supposed minimum value of water table level midway the drains above the drain pipes is $h_m = 0.05$ m.

The value of average thickness of aquifer H (m) was approximated by expression presented by Dieleman

$$\text{(Dieleman and Trafford 1976)} \quad H = d + \frac{h-h_m}{2 \ln \frac{h}{h_m}} = 0.27 \text{ m}.$$

Homogenous isotropic soil porous environment is characterized by hydraulic conductivity $K = 0.25$ (m.day^{-1}) and effective porosity (drainable pore space) $P = 6\% = 0.06$ (-). For drain spacing $L = 14.0$ m and in a homogenous isotropic soil conditions with the hydraulic conductivity $K = 0.25$ (m.day^{-1}) and effective porosity (drainable pore space) $P = 0.06$ (-) was determined De Zeeuw-Hellinga drainage intensity factor $\alpha = [\pi^2 K.H / (P.L^2)] = 0.0566 \text{ day}^{-1}$.

The value of the beginning drainage discharge $q_{t-1} = 0.0036$ (m.day^{-1}) = 3.6 (mm.day^{-1}), for $L = 14$ m, $h = 0.7$ m, $d = D = 0.15$ m (see Fig. 2) and under the given soil conditions, was calculated by Hooghoudt equation of steady state drainage flow (3).

The calculated values are the necessary input data (with recharges R / mm.day^{-1}) for calculation of drainage discharges q_t (mm.day^{-1}) by De Zeeuw-Hellinga Equation, represented by formula (2), in the monitored period from October 27 to November 11, 2003.

The values of drainage discharges were calculated by equation (2). The recorded values of the drainage discharges were measured in litres per second and with regard to the size of the drained area (0.45 hectares) were transferred in millimetres per day. Measured and calculated values of drainage discharges in a period from October 27 to November 11, 2003 are presented in Table 1 and Fig. 4.

From the comparison of the daily values of the drainage discharge q_t (mm.day^{-1}) determined according to equation (2) for the experimental field conditions next to the Mseno Dam and the measured daily values of the drainage discharge from the same field (Fig. 4) it is obvious that the shape of the curve of formula (2) and the shape of the curve of the measured daily values is identical, even the certain differences between the curves are apparent.

Fig. 4. Measured and calculated values of drainage discharges, October - November 2003, city park next to the Mseno Dam in Jablonec nad Nisou (Czech Republic)

Table 1. Measured and calculated daily values of the subsurface drainage discharges from the city park next to the Mseno Dam in the City of Jablonec nad Nisou, Czech Republic (October - November, 2003).

Date	Number	Drainage discharge - measured values (l/sec)	Drainage discharge - measured values (mm/day)	Drainage discharge - calculated values by de Zeeuw-Hellinga (mm/day)	Precipitation - measured values (mm/day)
27.10.2003	0	0.18	3.5	3.6	0.0
28.10.2003	1			3.4	0.0
29.10.2003	2			3.2	0.0
30.10.2003	3			3.0	0.2
31.10.2003	4			2.8	0.0
1.11.2003	5			2.7	0.6
2.11.2003	6			2.6	0.0
3.11.2003	7	0.16	3.1	2.5	1.5
4.11.2003	8			2.4	0.6
5.11.2003	9			2.3	0.0
6.11.2003	10			2.1	0.0
7.11.2003	11			2.0	0.0
8.11.2003	12			1.9	0.0
9.11.2003	13			1.8	0.0
10.11.2003	14	0.09	1.7	1.7	0.0
11.11.2003	15			1.6	0.0
12.11.2003	16			1.5	0.0
13.11.2003	17			1.4	0.0
14.11.2003	18			1.3	0.0
15.11.2003	19			1.3	0.0
16.11.2003	20			1.2	0.2
17.11.2003	21	0.08	1.5	1.3	2.4

The number of measured points is not inadequate with calculated values, because of measurement of the weekly values of drainage discharge. Nevertheless, the trend of the measured and calculated values is almost identical, slightly decreasing with small local transient peaks. Differences

between calculated and measured values are not larger than 0.6 mm.day⁻¹.

The largest difference at the observation No. 7 is probably caused by precipitation (recharge) of 1.5 mm per day. The drainage reacted by drainage discharge well, compared to

Fig. 5. Absolute magnitude of differences between measured and calculated values of drainage discharges, October - November 2003, city park next to the Mseno Dam in Jablonec nad Nisou (Czech Republic)

the De Zeeuw-Hellinga formula, where, just this recharge, had not a significant response.

The course of the time series of the absolute magnitude of the differences (absolute magnitude from the daily measured values of the drainage discharge minus q_t (mm.day⁻¹) calculated by equation (2)) is oscillating and probably slightly decreasing. The largest daily difference of 0.6 mm.day⁻¹ from all large experimental 0.45 hectare drained area in this tested time series will be in a time $t=7$ days. Other differences will be much smaller.

It should be noted that at time $t=14$ days the difference is zero (see Table 2). The course of the differences is shown in Fig. 5 and presented in Table 2.

Table 2. Absolute magnitude of differences between measured and calculated daily values of the subsurface drainage discharges from the city park next to the Mseno Dam in the City of Jablonec nad Nisou, Czech Republic (October - November, 2003).

Date	Number	Absolute magnitude of differences (mm/day)
27.10.2003	0	0.1
3.11.2003	7	0.6
10.11.2003	14	0.0
17.11.2003	21	

Approximation of the beginning value of drainage discharge q_{t-1} (mm.day⁻¹) in the De Zeeuw-Hellinga theory follows from steady state drainage flow conditions. In a constant time interval $\Delta t = 1 \text{ day}$ a steady state drainage flow is supposed, and for calculation of the value of drainage discharge, the Hooghoudt equation (3) can be used.

In this case the calculated beginning value of the steady

state drainage discharge q_{t-1} (mm.day⁻¹) by Hooghoudt is $q_{t-1} = 3.6$ (mm.day⁻¹), real measured value (from the 27.10.2003, see Table 1) is 3.5 (mm.day⁻¹). The difference 0.1 (mm.day⁻¹) is neglected and shows that the way of application the Hooghoudt's method, with very good approximation, is able to correctly solve this part of the beginning of the drainage process.

The use of Glover-Dumm equation in decreased water table conditions can bring evidently changes in the obtained results, especially in the beginning of tested period. The differences can be from the first to fifth day of the tested period in a range from 35% to 10%. A clear example of comparison of the use of Glover-Dumm and De Zeeuw-Hellinga formulas is shown by Stibinger (2009).

The results obtained from the drainage discharges by RISWC Prague-Zbraslav experimental field with soil conditions similar to Mseno Dam, have shown that the differences between calculated and real measured values on the first day of drainage process was 35.8% in case of Glover-Dumm and only 6.3% in the De Zeeuw-Hellinga application (Stibinger, 2009).

This fact was also one of the several reasons why the Glover-Dumm equation in the drainage hydrology research at the Mseno Dam conditions should not be used.

CONCLUSIONS

Verification of De Zeeuw-Hellinga's approximation of drainage discharge, formed in equation (2), showed a good conformity between calculations and measured data under the transient drainage flow conditions in the city park near by Mseno Dam in Jablonec nad Nisou. The results of the

numerical experiment of the determination of drainage discharge by equation of De Zeeuw-Hellinga, compared with measured daily values, confirmed that the De Zeeuw-Hellinga's formula is a very good tool for approximation of the drainage discharge in the transient drainage flow conditions.

The method of De Zeeuw-Hellinga needs only minimum input data of the soil hydrology from the investigated area and basic design parameters of tested subsurface pipe drainage system. By its use we can obtain immediate information about impact of subsurface pipe drainage system on water regime in landscape, necessary for soil and environmental protection.

The De Zeeuw-Hellinga theory can be also applied, in the same style as was executed in a case of the approximation of drainage discharge, for determination of the water level fluctuating midway between the drains in the certain time intervals.

In the larger drained areas with the potential complicated complex problems of waterlogged lands and water regime protection the use of the models as DRAINMOD (Skaggs, 1999) SWAP (Dam, 2000) MODFLOW (Mirlas, 2009) or the other available 2D or 3D drainage models of similar type may be necessary.

In some cases it was shown that the drainage discharge developed by existence of subsurface pipe drainage systems can harm the water regime in landscape. This is the reason, why the drainage systems are often negatively perceived by the ecologists.

Presently working subsurface pipe drainage system in the local city park in the Jablonec nad Nisou, situated next to the Mseno Dam in an average depth of 1.0 m under the terrain, has a good reason. It enables access to the park surface during unfavourable hydrological conditions (e.g. massive precipitations, snow thaw, etc.), but at the same time does not cause any harm to the local flora by undesirable desiccation (drying) in the soil profile either in the summer time.

Solcova (2008) discovered that in a herbal floor of the city park, directly under the subsurface pipe drainage system, there is a large number of wetland plants such as foxtail grass (*Alopecurus pratensis*), sedge (*Carex acutiformis*), buttercup (*Ranunculus repens*) and many others. This is a clear signal that the soil profile is not subject to drying.

The wise use of drainage policy, with the correct estimation of drainage discharge, plays a key role not only in the improvement of water management, but also in the soil and environmental protection. The values of drainage discharge directly determine the making of the retention capacities of surface soil layers, which can significantly mitigate the negative impacts of hydrological extremes like massive floods and erosion processes.

De Zeeuw-Hellinga's procedure clarified and presented in

this article can serve as a good tool, suitable to solve these problems.

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