WATER BALANCE IN THE TILE DRAINAGE SYSTEM IN THE SOIL WITH EXCESSIVE MOISTURE FROM BAIA DEPRESSION–SUCEAVA PLATEAU

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Abstract

The conservation and the sustainable use of the soil's resources also includes the capacity to differently implement hydro ameliorative works depending of how the limitative factors of the soil's fertility manifest themselves. The formation of water excess in the soil represents a complex process that is determined be a series of natural factors like alimentation, withholding, circulation and elimination of water in the soil – underlying rock complex. In the pedoclimatic conditions of the Suceava Plateau, the excessive humidity of the soil manifested itself periodically and/or permanently depending of the volume, the duration and the intensity of the rain fall. For optimizing the water regime from the soils affected by excessive humidity, more precisely, the agricultural soils from Suceava County, a series of measures have been taken over the years like draining systems and underground pipe drainage systems. The hydro ameliorative drainage systems based on opened channels and underground pipe drainage to which locally, was also added the embankment of the water courses covered a surface of almost **55 thousand ha.** From the total area prepared for drainage – underground drainage, on almost 27 thousand ha systematic networks of underground pipe drainage have also been created. The experimental research performed for more than 30 years (1978 – 2010) in the conditions of the *albic stagnic glossic luvosoil* from Baia depression, were meant to contribute at the familiarization with the water balance from the soil prepared for drainage. The hydro technical scheme for organizing the underground drainage system based on ceramic pipes and plastic materials consisted in **six experimental solutions** that were executed in 1978 on an area of **3.50 ha**. After arranging the underground pipe drainage system the drained soil was moulded into wide ridged sections (*variant A*). All the variants for organizing the underground drainage (*A, B, C, D, E, F*), were deeply broken up for improving the permeability of the drained soil. The long term efficiency of the underground pipe draining system was analyzed under the hypothesis of a non permanent functioning rate. The accumulation and the elimination of the water excess from when the underground pipe drainage system was working was assessed relying on the average multiannual volume, caused by rain, its value being of 325 mm or 3250 $m^3 \cdot ha^{-1}$.

Key words: water balance, underground pipe drainage, soils with excessive humidity.

In order to eliminate the foul and/or permanent excess water from the agricultural fields, a series of measures like draining works with opened ditches and underground tile drainage systems have been implemented over the years. The hidroameliorative drainage systems must provide the best collection and elimination of the water excess from the soil profile. From the types of works that have been performed in various climatic areas of Romania, the most representative ones, are, among others: *land shaping in slopes, land shaping in the bedding system with ridges and furrows, mole drainage consists of galleries of 8 to 14 cm, deep loosening of soil profile at depth of 0.4 to 0.8 m, tile drainage* (Cazacu, E., et al., 1985).

The tile drainage was dimensioned, considering the working hypothesis of non-permanent or permanent working regime depending of the water balance in the soil (Haret, C., Stanciu, I., 1978).

The geographical distribution of the agricultural fields affected by excessive humidity in Suceava Plateau was generally characterized by their prevalence from East to West and from South to North, respectively.

Among the areas where the water excess is widespread on the agricultural fields we can mention: **Baia Depression**, **Fălticeni Plateau**, the waterside and the terraces from **Siret Valley** and **Moldova Valley**; **Dragomirna Plateau** and **Rădăuți Depression** (Moca, V., et al., 2008).

The draining and drainage system from Suceava County are characterized by a relatively long evolution in time if compared to other areas.

The oldest draining works associated to tile drainage were performed towards the end of the 19^{th} century and the beginning of the 20^{th} century in Rădăuți Depression, by the Agricultural Society in Viena (Moca, V., et al., 2010).

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The drainage and subsurface drainage works included several development stages, which took place, particularly between 1950 and 1990. In the first stages, from 1950 to 1975, were designed drainage systems and river regularization with dikes. In the second period that ranges between 1976 and 1990, some older systems were improved and resized. Also, in some hydrographic basins were executed new works, which included the hydro-ameliorative systems with canal drainage and subsurface drainage. In Suceava County, surface drainage systems were set up on 55,100 ha, tile drainage networks on 26,300 ha and systems of embanking and protection against floods on 7,400 ha between 1960 - 1990 to remove this excess moisture (Bucur, D., Moca, V., 2012). Surface drainage and pipe drainage works have contributed on the one hand, to reduce excess soil moisture and stagnogleice gleyic and secondly to increase production capacity of these soils. Drainage systems reduces the volume of drainage water leaving a field by 20-30% on average; however, outflow varies widely depending on soil type, rainfall, type of drainage system and management intensity (Ramoska et al., 2011). Drainage systems must cost-effectively manage flooding, control streambank erosion, and protect water quality (Lukianas et al., 2006). To do this, designers must integrate conventional flood control strategies for large, infrequent storms with three basic stormwater quality control strategies for small, frequent storms: infiltrate runoff into the soil, retain/detain runoff for later release, and convey runoff slowly through vegetation.

MATERIAL AND METHOD

Water excess in soil is a complex process that is determined by some factors like water uptake, circulation and removal in the system soil-subjacent rock. For removing water excess from soil profile, drainage systems were planned for improving soil aeration regime and field cultivation.

a. Soil genetic conditions

The Baia Depression is located in the Sub-Carpathian Basin of the Moldova River, which is located in Suceava County, Romania. The total area of the Baia Depression is approximately 15,000 ha, 5,000 ha of which have excess soil moisture owing to rainfall or groundwater capillary rise.
Relief: high terrace plateau, slope of 2-5 %;
Parental material: dusty clay stratifications, 10-15 m;
Natural global drainage: weak to very weak;
Soil-ground water: average depth of 0.20-0.50 m;
Ground water: average depth of 9-10 m;
Average annual temperature: 7.9oC;
Average annual rainfall: 806 mm;
Average annual potential evapotranspiration: 599 mm
Average annual rainfall excess: 207 mm;
Natural vegetation: association of Agrostis tenuis with sub-association of Deschampsia caespitosa, Juncus effuzus, Carex sp., etc;
Soil unit: albic stagnic glossic Luvisol (SRTS-2003); albeluvisoil (World Reference Base for Soil Resources WRB-2006).

b. Tile drainage experimental variants

To optimize the air and water regime of soil in the area, an experimental field containing a tile drainage system designed to remove excess water was constructed in 1978. During the study period (1978-2010), six different tiles drainage systems were installed and the effect of the removal of excess moisture from the soil by these systems was evaluated (Table 1).

Table 1

Materials used for construction of the Baia drainage experimental site

Tile drainage variant	Spacing between drain lines /depth drain (m)	Drain line number	Pipe type and diameter (mm)	Type and thickness of complex drain + filter (cm)
A	20/1,0	1	Tile Ø 70	Ballast (20) + Flax stems (50)
		2	Tile Ø 125	Ballast (70) + Green sods
		3	Tile Ø 70	Ballast (20) + Green sods
B	15/1,0	4	Tile Ø 70	Flax strains (30)
		5	Tile Ø 70	Ballast (12) + Flax stems (20)
		6	Tile Ø 70	Ballast (15) + Green sods
C	12/1,0	7	Corrugated plastic Ø 65	Ballast (12) + Green sods
		8	Smooth plastic Ø 63	Ballast (12) + Green sods
		9	Tile Ø 70	Ballast (15) + Green sods
D	20/0,8	10	Corrugated plastic Ø 65	Ballast (20) + Flax stems (40)
		11	Smooth plastic Ø 110	Ballast (60) + Green sods
		12	Tile Ø 70	Ballast (20) + Green sods
E	15/0,8	13	Tile Ø 70	Flax strains (30)
		14	Tile Ø 70	Ballast (12) + Flax stems (20)
		15	Tile Ø 70	Ballast (15) + Green sods
F	12/0,8	16	Corrugated plastic Ø 65	Ballast (12) + Green sods
		17	Smooth plastic Ø 63	Ballast (12) + Green sods
		18	Tile Ø 70	Ballast (15) + Green sods

Moreover, in variant A, the tile drainage was combined with the land forming in the bedding system with ridges and furrows. In this variant, furrows were constructed upon tile drains with spacing at 20 m. On the drainage variants (B, C, D, E, F) deep loosening was applied to improve soil permeability. Each drainage variant includes three drain lines. The length of each drain was 100 m and the slope of the drain lines was 0.2%. Hydrotechnical scheme of the Baia drainage experimental site was sized to optimize the basic design elements, used routinely in the design of tiles drainage systems.

- *Spacing between drain lines*: 20 m (variants A and D), 15 m (variants B and E) and 12 m (variants C and F) were determined assuming a non-permanent flow regime.

- *The depth of the tile drains*: 1.0 m (A, B, C variants); 0.8 m (D, E, F variants) was sized taking into account the horizontal position of the hard permeable soil profile. If the soil is albic stagnic - glossic Luvosol, the Bt1W textural horizon is located at a depth of 0.9 to 1.0 m.

- *Pipe type and diameter* that was used for the construction of all 18 drain lines included the following materials: tile drain (pipe are from ceramic) with inner diameter of 70 mm and 125 mm, smooth plastic drain with external diameter of 63 and 110 mm; corrugated plastic drains with linear waves and external diameter of 65 mm.

- *Filter material* that was put on top and around the drainage tube consisted of the following: river ballast, and, for some certain drain lines, ballast with flax stems and green sods.

Implementation of drainage tubes was performed using E.T.T. 202-A equipment, a mechanic system that performed: digging trenches with a width of 50 cm, variable depth of 0.8 – 1.5 m and laying tile drainage pipes and / or plastic.

RESULTS AND DISCUSSION

Tile and/or plastic drainage of different sizes can ensure the elimination of excess water caused by rainfall, with stagnant nature on the land surface or accumulated as a layer on top of pedofreatic soil profile.

a. Hidrometeorological balance

In the local natural conditions of the Baia drainage experimental field, with land use as natural pasture, soil excess moisture caused by rainfalls was analyzed on the basis of the observations made on the following factors.

Annual rainfall regime (P) was the main source of excess water from the ground, being based on the alternation between periods of intense rainfall and, respectively, dry periods may.

- *Average multi-annual rainfall* throughout the period examined in the years 1978-2010 recorded an annual average value of **806 mm** (50% assurance).

- *In the hot season (V-X)* the annual average year, rainfall was recorded 549 mm (68%), and in winter (XI-IV), 257 mm (32%).

- *Average and maximum monthly rainfall* recorded multi-annual, usually, recorded the largest amounts of water in June and July and lowest in January-March.

- *Rainfall in periods of 1-5 consecutive days* were characterized, throughout the study period, by the size and distribution on everyday, 2 days, 3 days and 5 days, depending on the overall progress of the climatic conditions (Table 2).

Annual evapotranspiration regime (ET), ranged between the limits of normal distribution of the wet weather conditions.

- *Average annual evapotranspiration regime* throughout the period examined in the years 1978-2010 recorded an average of **599 mm** per year which varied in size according to the general trend of climatic factors and the use of agricultural land.

- *Distribution of average annual evapotranspiration* on the two growing seasons, differentiate significantly separately. In the warm season (V-X), which corresponded to wet land with vegetation period of crops, has developed a water consumption of **481 mm**, which means 80% of annual average. In winter (XI-IV), evapotranspiration recorded in terms of annual average, water consumption of **118 mm** (20%).

- *Average monthly evapotranspiration* was characterized by maximum values during the months of summer season with a 90-142 mm consumption, small to medium in the months of spring - autumn, with a consumption of 1-76 mm.

- *Evapotranspiration and diurnal periods of up to 3-5 consecutive days*, was typically, below the rainfalls in these intervals, which resulted in a surplus in the hydrometeorological water balance.

Annual hydrometeorological regime balance ± ΔP = (P - Et) of the period under review (1978-2010) recorded a surplus of **207 mm** water, characterized by the following features on the seasons, months and characteristic times of the year.

- *Distribution of the two growing seasons* of the year differenced between **139 mm** (67%), in the hot season of the year annual average and **68 mm** (33%) in winter.

- *Annual distribution of water surplus* resulted from the hydrometeorological balance was characterized in terms of environment, positive in almost all months of the year.

- *The average values* of the determined period were employed between **0-11 mm** minimum quantities, made in July, September and October and **31-40 mm** maximum on the other months of the year, except August.

Table 2

Multiannual precipitation, average and maximum, monthly and on intervals of 1-5 consecutive days

Month of the year	Monthly precipitation (mm)		Rainfall in consecutive intervals of 1-5 days (mm)							
			1 day		2 days		3 days		5 days	
	average	max.	average	max.	average	max.	average	max.	average	max.
I	33	69.3	12	25.7	16	31.3	18	36.5	20	49.2
II	34	80.2	11	18.9	14	23.2	16	30.0	18	33.5
III	33	63.0	11	25.1	12	25.1	14	25.1	16	28.3
IV	80	12.3	26	41.3	33	53.6	38	65.5	45	79.9
V	97	199.1	32	95.1	43	95.1	46	97.5	50	97.5
VI	133	193.2	49	72.0	65	96.5	78	140.8	89	153.8
VII	133	236.5	40	89.1	51	100.7	54	109.6	62	137.0
VIII	82	186.2	32	43.6	39	81.8	45	118.5	53	158.7
IX	63	125.8	21	37.5	28	59.8	30	59.8	35	66.5
X	41	127.5	16	39.5	21	73.4	21	75.8	24	98.2
XI	41	105.1	18	38.5	23	59.4	24	61.4	26	62.2
XII	36	103.8	12	25.6	16	39.9	17	41.0	20	43.7
Annual	806	-	280	-	361	-	401	-	458	-

b. Soil water balance

Temporarily excess moisture with stagnant nature, caused by precipitation, is specific to farm land with small slopes and local unevenness in humid and subhumid climates with clayed soils hardly permeable.

The water balance during periods of excess moisture has the following form:

$$\mathbf{P - ET > S + I + W_{max}},$$ where:

P - average annual rainfall;
ET - average annual evapotranspiration;
S - surface water drainage of land;
I - the amount of water infiltrated in the soil profile, below the plant roots;
W_{max} - the maximum amount of water that can accumulate in the soil in the plants root zone.

The water balance during periods of excess moisture has the following form: $P\text{-}ET > S+I+W_{max}$

In practical terms, this formula in a simplified form of soil water balance equation is complete in terms of knowledge of natural factors causing excess moisture in the soil and established necessary drainage work. In this case, the excess water volume can be expressed by the relationship: $\mathbf{Ve = P - (Et + S + I + W_{max})}$, (Figure 1).

Agricultural land drainage fitting sizes, in general, for non-permanent or permanent regime, depending on soil water balance, respectively, of the elements considered for calculation of specific flow discharged through drains network.

In the natural conditions of this wetland, the **albic stagnic - glossic Luvosol,** which is used as a natural pasture, presented the following morphological features in the horizon succession :

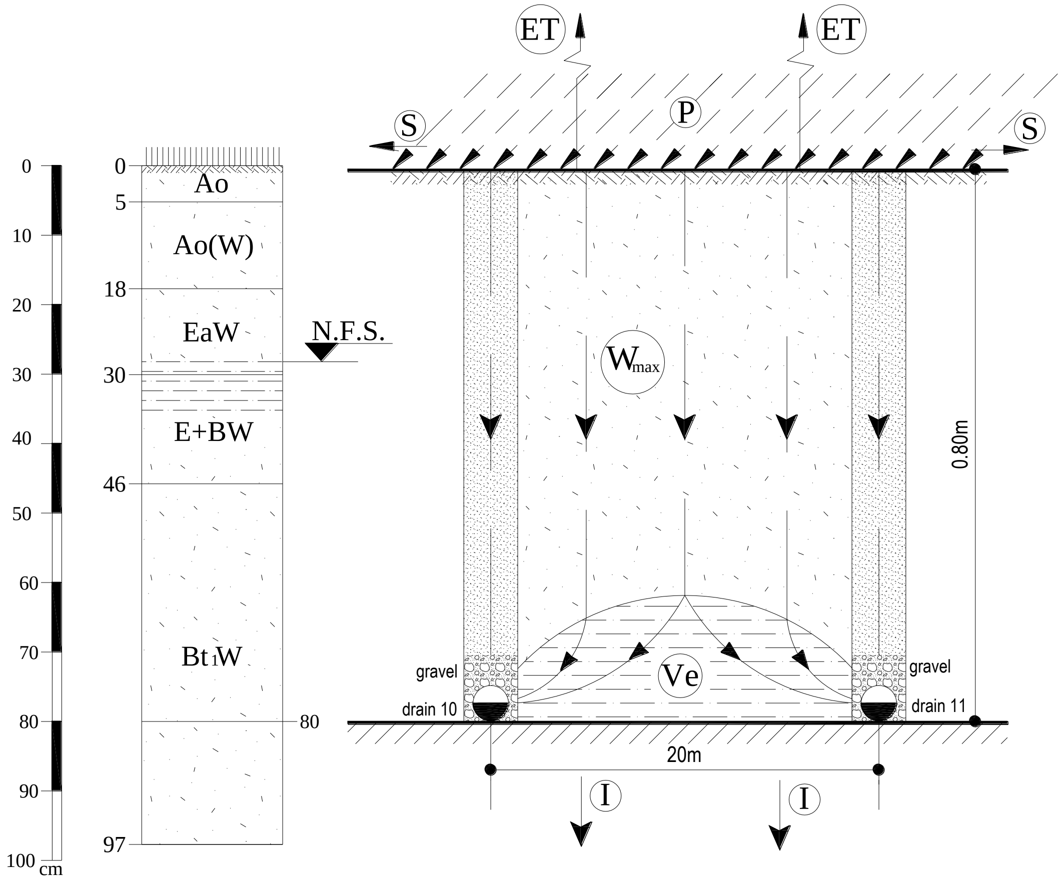
A_0 (0 - 5 cm) - strongly unreclaimed stratum; silt loam; very dark brown grey 10 YR 4/2 (wet) and light grey 10 YR 7/2 (dry); small polyhedral angular structure, moderately developed; very friable in wet state, quite hard in dry state; weakly plastic; weakly adherent; very frequent roots.

A_0 (W) (5 - 18 cm) - silt loam; dark greyish brown 10YR 4/2 (wet) and light greyish brown 10YR 6/2 (dry); small polyhedral angular structure, moderately developed, friable in wet state and easily compacted when dry; weakly plastic; weakly adherent; frequent coarse and medium pores; thin and very thin frequent roots; clear contact with the horizon below.

E_aW (18 - 30 cm) - silt loam; light olive colour 7.5Y 6/2 with small yellowish brown spots 10 YR 6/6 (wet) and white 7.5 Y 8/2 with yellowish brown mottles 10 YR 6/8 (dry); small polyhedral angular up to lamellar structure, weakly developed, friable in wet state and easily compacted when dry; weakly plastic; weakly adherent; frequent medium pores; rare very thin roots; diffuse irregular contact with the horizon below.

E+BW (30 - 46 cm) - clayey loam; greenish gray 5GY 6/1 with small and medium frequent mottles, light yellowish brown 10 YR 6/4 (dry) and white 7.5 Y 8/1 with brown yellowish spots 10 YR 6/6 (dry); medium polyhedral angular structure, moderately developed; clay films on the faces of structural aggregates; small and medium ferromanganese spots and concretions; tough when wet and compacted in dry state; plastic; adherent; frequent pores; diffuse irregular contact with the horizon below.

Bt_1W (46 - 97 cm) - loamy clay, greenish gray 5GY 6/1 with frequent large yellowish brown mottles 10 YR 5/6 (wet) and light gray 7.5 Y 7/1 with light yellowish brown 10 YR 6/4 and brown-yellowish 10 YR 6/6 mottles (dry); large prismatic structure, moderately developed; coarse clay films on the faces of the structural aggregates; medium ferromanganese spots and concretions; hard in wet state and very compacted when dry; plastic; adherent (Figure 1).



LEGEND: P – average annual rainfall;
ET - average annual evapotranspiration;
S – surface water drainage of land;
I – the amount of water infiltrated in the soil profile;
W_{max} – the maximum amount of water than can accumulate in the soil;
V_e – the excess water volume;
N.F.S. – pedophreatic water level.

Figure 1 **The water balance in the albic *stagnic* glossic Luvosoil, in the conditions of temporary foul water excess caused by precipitations**

c. The capture capacity of drain pipes

The excess stagnant water from the surface of the field and/or as pedophreatic water in the upper part of the soil structure must be evacuated in a relatively optimal period of time.

Before the descendent water current from the soil structure gets into the drain pipe it encounters a series of resistances that in general depend of the following natural factors and arrangement conditions:

- the permeability of the soil arranged with pipe drainage works;
- the permeability of the soil in the cross-sections of drain lines;
- the type and thickness of complex drain + filter;
- the pipe type and diameter;
- the distribution and the surface of the joints / perforations that allow the water to enter into the drain pipes.

According to *van Someren (1964)*, ***the total energy losses in pipes (Δh)*** that are due to the resistances that appear when the water enters the drain pipe and that is measured at the middle of the distance between the drains, can be divided into the following three categories.

- ***Horizontal energy losses (Δh_0)*** that are to the resistances encountered by the water current at the passage through the soil, up to approximately 1.0 m away from the drain pipe.

- ***Radial energy losses (Δh_r)*** that is due to the convergence of the water current lines, from the immediate area of the drain pipe.

- ***Entrance energy losses (Δh_i)*** that are determined by the resistances encountered by the water current when entering into the drain pipe.

For the water current to enter into the drain pipe, the total energy losses *(Δh)* from the middle of the spacing between the drain lines must be higher than the sum of the partial energy losses:

$$\mathbf{\Delta h > (\Delta h_0 + \Delta h_r + \Delta h_i)}$$

The studies made on the ***total energy losses (Δh),*** under the conditions of a non-permanent regime were analyzed in the hypothesis of knowing the period of time (t days) in which the water level must be lowered from the maximum height (h_0) to the minimum height (h_t).

The effect of **the total energy losses** (**$\Delta h = h_0 - h_t$**) was followed in the piezometric pipe situated at the middle of the spacing between the drain pipes, **with the distance between them of 12 m and the medium depth of 0.8 m**. At different periods of time (t), the total energy loss was represented, in general, by the decrease of the excess water level at the maximum height of the depression curve **of 60 - 70 cm**, the best height of **15 - 20 cm**. At the same periods of time (t) the drained flows decreased from 9 - 10 l/minute to 0.1 l/minute (Figure 2).

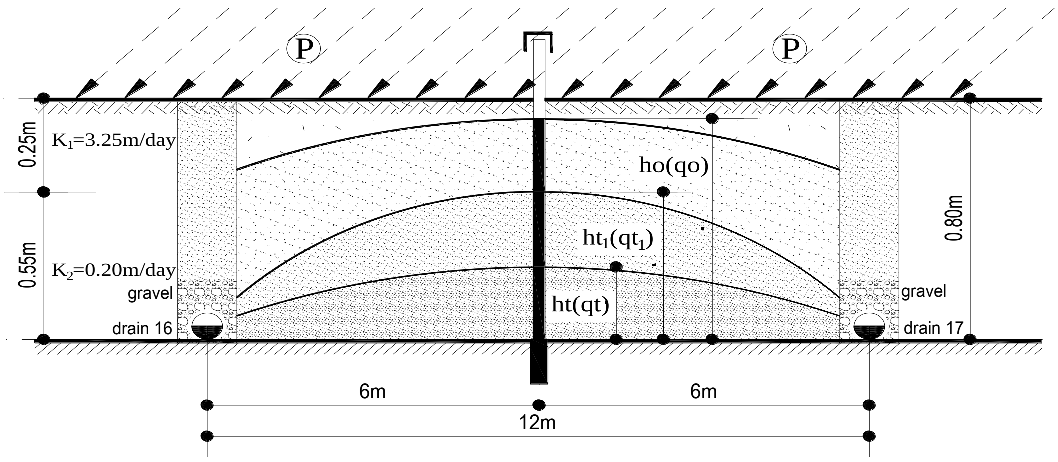


Figure 2 **Scheme of the drainage process with non-permanent regime, in the conditions of water excess, caused by precipitations**

- *The factor of the draining intensity* (a = 1/J)) was determined in the base of the measured levels in the piezometer from the middle of the spacing between the drain lines, at the beginning and the end of the draining's functioning periods, with the help of the following relation:

$$a = \frac{1}{J} = \frac{2.3\,(\log h_o - \log h_t)}{t} \quad (days^{-1})$$

where: a - factor of the draining intensity ($days^{-1}$)

h_o - maximum height of the pedophreatic water level

h_t - minimum height of the pedophreatic water level

t - period of time (days).

Depending of the amount of rain that fell, that in periods of 3 - 5 consecutive days, registered values of up to 60 - 140 mm, there were differentiated as well the values of the intensity draining factors. So, depending of **the total energy losses (Δh)**, after the previously mentioned rains, the values of the draining intensity were of 4 - 6 days, during the hot season, and of 6 - 14 days, during the cold season (Table 3).

Table 3

The draining intensity factor depending of the total energy loss

Time (t)	The height of the depression curve at the middle of the spacing between the drain pipes		Total energy losses	Factor $a = \frac{1}{J}$	Coefficient $J = \frac{1}{a}$
days	h_0 (mm)	h_t (mm)	Δh (mm)	$days^{-1}$	-
5	690	300	390	0.167	6.0
7	660	200	460	0.171	5.8
5	620	290	330	0.152	6.6
4	620	270	350	0.208	4.8
5	620	190	430	0.236	4.2
11	520	240	280	0.070	14.3
2	380	250	130	0.209	4.8
4	320	200	120	0.117	8.5

- *The filtration coefficient (K)* was characterized by a very good permeability, in the arable layer (3.25 $m \cdot day^{-1}$), fact that assured the high degree of efficiency of the process of draining the excess water. In the case of the underlying horizon, the permeability was lower (0.2 $m \cdot day^{-1}$), fact that determined the execution and the periodical renewal of the soil loosening process until the necessary depth of 70 - 80 cm (Figure 2).

d.Drained water volumes

In periods of drainage operation with non-permanent flow regime, **rainfalls volume (P)** exceeded the water consumption by **evapotranspiration (Et), deep infiltration (I) and drain the land surface (S)**. In periods of excess water removal (ΔP), drained soil is working functionally as a reservoir, which records under the effect of heavy rains filling, respectively, depletion under the effect of drainage.

Depending on the size of specific drainage daily flow of the area served by the drainage lines (1, 2, 3, …, 18) and respectively, of the six experimental drainage variants (A, B, C, D, E, F), volumes of drained water were calculated, expressed in mm or $m^3 \cdot ha^{-1}$ (Figure 3).

To calculate the volume of drained water areas were used areas of 0.60 ha (variants A and D), 0.45 ha (variants B and E), and 0.36 ha (variants C and F).

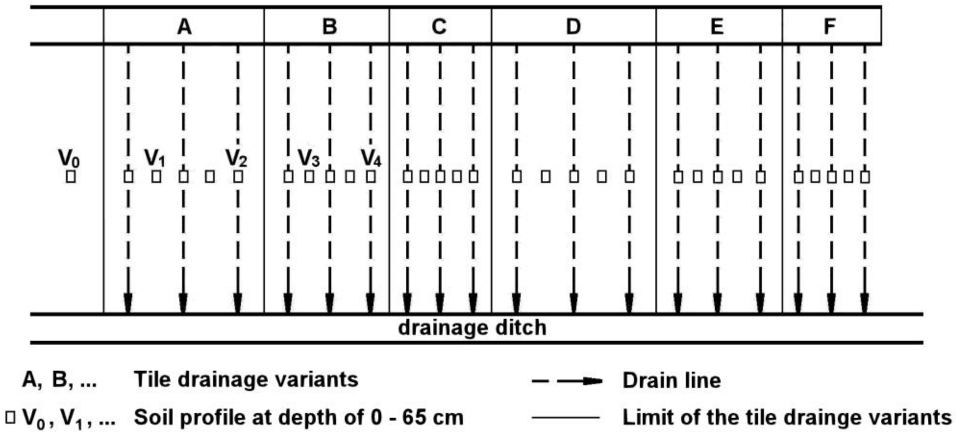


Figure 3 **Hydrotechnical scheme of the Baia drainage experimental site**

In the case of the soils with excessive rain water, the functioning system of the drain pipes is determined by the size and the aleatory distribution of the rain water quantity. In a series of successive periods of time water excess appears in the soil and/or on the surface of the soil, excess that must be evacuated through a drainage system.

The evaluation of the water survey in the conditions of the existent 18 draining lines and respectively, of the six experimental drainage variants was analyzed taking into consideration the long time observations that were realized on the following factors:

- the daily precipitations;
- the average daily temperature of the air;
- the real maximum daily evapotranspiration;
- the daily water flow evacuated by drain pipes;
- the water volumes evacuated by drainage.

The annual dynamic of the climatic factors from **the period 1978 - 2010** that was also presented in the previous paragraphs respected the characteristics of the areas from the wet climate area of Romania, area that includes the Baia Depression as well.

The synthesis of the results obtained during the entire period of time when pipes drain experiments were made, can be characterized according to the annual and the seasonal dynamic of the climatic factors and the functional efficiency of the drainage system, as follows:

- *The multiannual precipitation regime* - it was characterized by a medium quantity of **806 mm**, with an annual distribution between the maximum quantity of **968 mm** (1981), with a 5 % assurance, and the minimum quantity of **455 mm** (1986), with a 95% assurance.

- *The real maximum evapotranspiration*, having a medium multiannual value of **599 mm** situated between the limits of the normal distribution from the wet areas.

- *Effective water surplus* that resulted from the equation of the water survey from the drained soil, from the periods of time the drainage system with pipes worked registered a medium multiannual value of **3250 $m^3 \cdot ha^{-1}$** (Table 4).

- *The medium volumes of drained water* differentiated, in general, according to the dimensional elements and the nature of the construction materials used at the draining system.

In the conditions of the equipping the 18 draining lines, **the maximum norm of drained water 2070 $m^3 \cdot ha^{-1}$** (64 % of the medium water excess) was reached at the drain 17/variant F. **The minimum norm of 1110 $m^3 \cdot ha^{-1}$** was found at drain 12/variant D with the distance between the drains of 20 m and the medium depth of the pipes of 0.80 m.

- *The medium daily water flow* was individualized between the maximum values of up to **3.5 mm $m^3 \cdot day^{-1}$** (17/ F) and the minimum values of **1.8 mm day^{-1}** (12/D).

Table 4

The regime of the volumes of drained water in the period 1978 - 2010

Variant and spacing between drain lines /depth drain (m)	Drain line number	Surface of the pipes joints / perforations ($cm^2 \cdot m^{-1}$)	Drained soil water balance			
			Mean water excess ($m^3 \cdot ha^{-1}$)	Mean drained water		Mean daily water flow ($mm \cdot day^{-1}$)
				$m^3 \cdot ha^{-1}$	%	
A 20/1.0	1	10-15	3250	1830	56	3.0
	2	13-20		1610	50	2.7
	3	10-15		1390	43	2.3
	Average	-	-	**1610**	**50**	**2.7**
B 15/1.0	4	10-15	3250	1370	42	2.3
	5	10-15		1460	45	2.4
	6	10-15		1440	44	2.4
	Average	-	-	**1423**	**44**	**2.4**
C 12/1.0	7	15-30	3250	1870	58	3.1
	8	15-30		1850	57	3.1
	9	10-15		1770	55	2.9
	Average	-	-	**1830**	**57**	**3.0**
D 20/0.8	10	15-30	3250	1260	39	2.1
	11	30-40		1360	42	2.3
	12	10-15		**1110**	**34**	**1.8**
	Average	-	-	**1243**	**38**	**2.1**
E 15/0.8	13	10-15	3250	1800	55	3.0
	14	10-15		1840	57	3.1
	15	10-15		1790	55	3.0
	Average	-	-	**1810**	**56**	**3.0**
F 12/0.8	16	15-30	3250	1900	58	3.2
	17	15-30		**2070**	**64**	**3.5**
	18	10-15		1750	54	2.9
	Average	-	-	**1907**	**59**	**3.2**

CONCLUSIONS

Effective water surplus that resulted from the equation of the water survey from the drained soil, from the periods of time the drainage system with pipes worked registered a medium multiannual value of **325 mm** or **3250 m3·ha-1**.

The growth of **the drains depth from 0.8 to 1.0 m** and **keeping the spacing between the drain lines to a constant level of 12 m** contributed at the decrease of the functional efficiency of the drainage system, with an **average of 11 %**.

The growth of **the spacing between the drain lines from 12 to 20 m** and **keeping of the drains depth at 0.80 m** determined a decrease of the functional efficiency, with **16%**.

The surface of the drain pipes joints/perforations determined the growth of the functional efficiency, with an average of **11 - 12%**.

The association of the pipe drainage system with the land shaping in the bedding system with ridges and furrows, with an **average** of **23%**.

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