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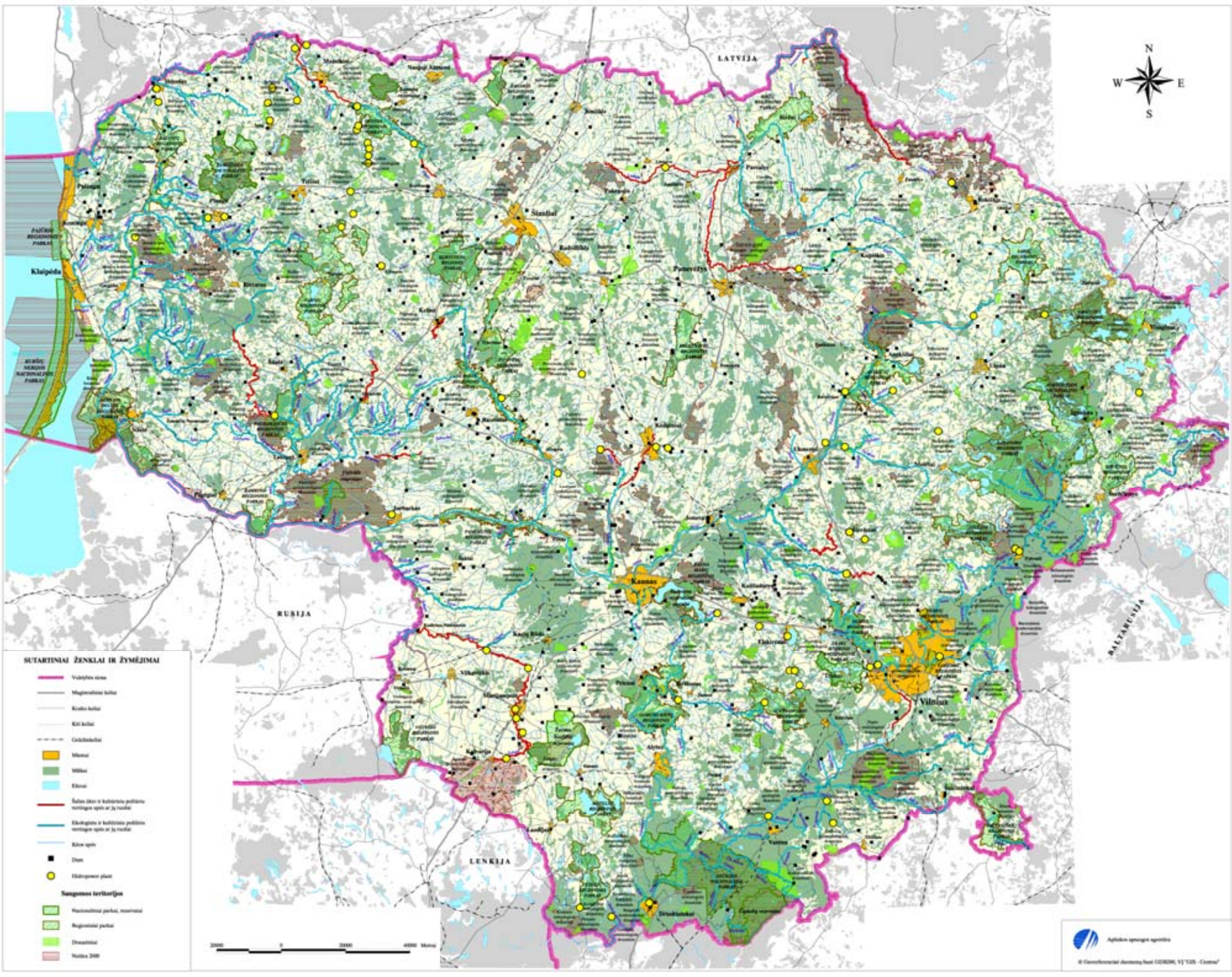
ANALYSIS of THE FUNCTIONING AND CONDITIONS OF DRAINAGE SYSTEMS WITHIN A LONG-TERM PERIOD

Introduction

In Lithuania is 3.9 mln.ha of arable lands. For better productivity of this Lands about 3.4 mln.ha need for drainage. It's the main reason why so big area was drained in Lithuania. At this moment we have total 2,98 mln.ha arable land. In 2.58 mln.ha of this land we have drainage systems. For how long time all this systems can work effectively, it's very difficult to say.



Experimental plot is in central part of Lithuania, Kedainiai district. This region has good types of soil – light sandy loam, and loam. Experimental plot was drained for first time at 1959-1960. The north part of this system was reconstructed in 1994. The main reason for this decision was high water level in crop fields. This system was divided into 6 separate parts systems Nr 2, 3, 4, 5 and 6.

The new system was installed with multiscoop dither. All pipes protected with organic and synthetic materials.

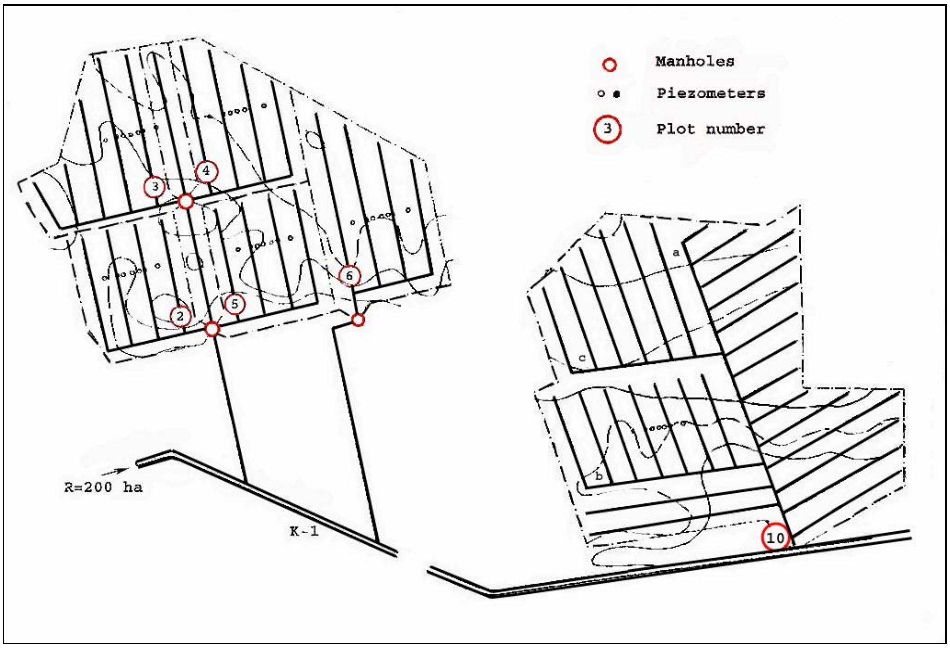


Fig.1 Experimental field

In experimental fields are installed clay pipes. Diameter of laterals - 55 mm. The deep of installed drainage 0.9 - 1.2 m. Distance between the drains - 22 m.

In experimental field are installed drainage constructions:

- Clay pipes with cover of straw around the pipe.
- Corrugated plastic pipes with cower of straw around the pipe.
- Corrugated plastic pipes with cower of textile material “Melita” around the pipe.
- Clay pipes with cover of flax hards around the pipe.
- Clay pipes with cover of glass matting around the pipe.

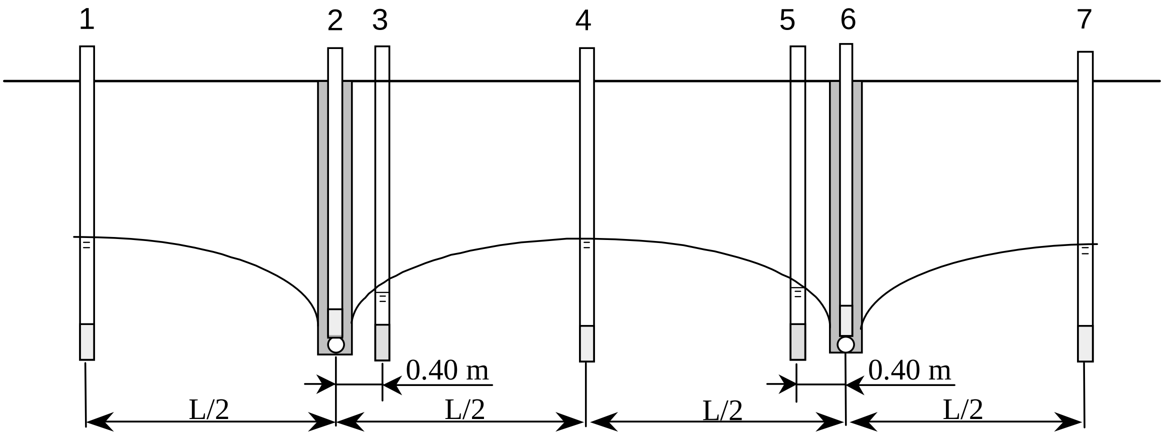


Fig.2 Plan of Piezometers observation between two drains.

Objective of the studies – on the basis of the observation data, to verify the hydrologic functioning of the most typical drainage systems, substantiate indices and criteria of drainage functioning evaluation, and give the main reasons of bad functioning of drainage systems.

The studies were carried out in study objects arranged on light, semi-heavy and floury loam soils in Kedainiai.

To obtain reliable result, a longer observation period is needed under the conditions of wide distribution of data within a study period. Having rejected false data, squared values of polynomial equations will be obtained from the measurements of water discharges. Those values allow us to evaluate the adequacy or non-adequacy of design criteria of drainage systems.

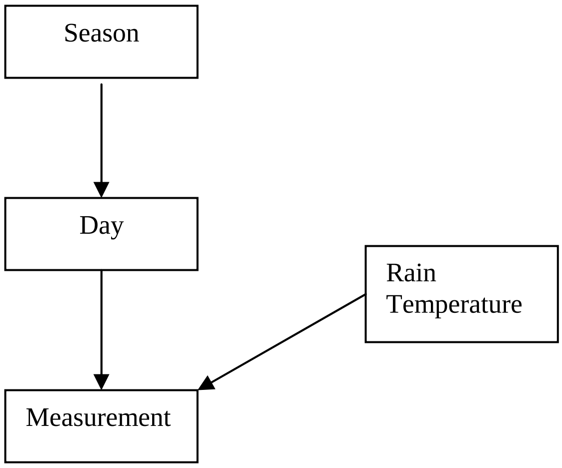
To evaluate or compare different materials used for the arrangement of drainage systems, the so-called loss of pressure of drainage inflow water needs to be measured. In principle, the connection between drainage system and runoff discharges and loss of pressure of drainage inflow water should be linear, and the calculated regression coefficient should estimate the resistance of water inflow in drains.

The resistance of water inflow in drains depends on the hydraulic conductivity of soil and does not allow comparing directly different materials. In this case the constant of water flow or non-dimensional flow resistance related to drainage materials are to be calculated.

The connection between the loss of pressure of water on the drains and total water pressure in-between drains is linear. Thus, the gradient of the regression line shows the amount of losses of pressure of water inflow in drains. This parameter specifies the effects of water flow and drainage materials. Therefore the comparison of the real state of water flow that might be different for separate materials is also possible.

Data description

Diagram of the hierarchical structure



The numbers of units are:

Seasons – *spring, autumn (2000 – 2005)*
Days – *175*
Measurements – *outflow - **q** l/s ha- from 5 drainage systems)*
***h** - Water level between the laterals from 5diferent drainage systems)*

Structure of table.

Data	Season	Nr of days	SystNr	Temp C	Rain	q l/s ha	h-11	sist-0.4	sist-21.60	Year	day	sine	cosine
3/3/2000	2000.1	1	2	0.7	6	10000	69	33	8	2000	62	0.8829	0.4695
3/7/2000	2000.1	2	2	4.2	11.5	10000	83	35	19	2000	66	0.9135	0.4067
3/10/2000	2000.1	3	2	-1.03	7.4	10000	64	26	11	2000	69	0.9336	0.3584
3/14/2000	2000.1	4	2	3.1	1.9	10000	42	21	2	2000	73	0.9563	0.2924
3/17/2000	2000.1	5	2	-0.3	9.4	10000	62	28	12	2000	76	0.9703	0.2419
3/21/2000	2000.1	6	2	1.7	1.1	10000	64	26	7	2000	80	0.9848	0.1736

$$\text{resp}_{1jkl} \sim \text{N}(XB, \Omega)$$

$$\text{resp}_{2jkl} \sim \text{N}(XB, \Omega)$$

$$\text{resp}_{1jkl} = \beta_{0jkl}\text{cons.q l/s ha}_{ijkl} + -0.02182(0.01011)\text{SystNr\_3.q l/s ha}_{ijkl} + 0.00740(0.01010)\text{SystNr\_4.q l/s ha}_{ijkl} + -0.00785(0.01039)\text{SystNr\_5.q l/s ha}_{ijkl} + -0.00138(0.01104)\text{SystNr\_6.q l/s ha}_{ijkl}$$

$$\beta_{0jkl} = 0.12624(0.01859) + f_{0l} + v_{0kl} + u_{0jkl}$$

$$\text{resp}_{2jkl} = \beta_{1jkl}\text{cons.h-11}_{ijkl} + -6.90740(1.53060)\text{SystNr\_3.h-11}_{ijkl} + -8.60949(1.53628)\text{SystNr\_4.h-11}_{ijkl} + 8.91069(1.53060)\text{SystNr\_5.h-11}_{ijkl} + 9.32759(1.53060)\text{SystNr\_6.h-11}_{ijkl}$$

$$\beta_{1jkl} = 39.44217(5.32309) + f_{1l} + v_{1kl} + u_{1jkl}$$

$$\begin{bmatrix} f_{0l} \\ f_{1l} \end{bmatrix} \sim \text{N}(0, \Omega_f) : \Omega_f = \begin{bmatrix} 0.00153(0.00130) & \\ 0.49980(0.34959) & 211.56050(117.72040) \end{bmatrix}$$

$$\begin{bmatrix} v_{0kl} \\ v_{1kl} \end{bmatrix} \sim \text{N}(0, \Omega_v) : \Omega_v = \begin{bmatrix} 0.01845(0.00239) & \\ 2.36390(0.35661) & 618.99580(74.23256) \end{bmatrix}$$

$$\begin{bmatrix} u_{0jkl} \\ u_{1jkl} \end{bmatrix} \sim \text{N}(0, \Omega_u) : \Omega_u = \begin{bmatrix} 0.00721(0.00045) & \\ 0.14217(0.05244) & 194.46480(10.68874) \end{bmatrix}$$

*-2*loglikelihood(IGLS Deviance)* = 6095.00700(1490 of 1750 cases in use)

$$VPS_{season} = \frac{0.49980}{\frac{\sqrt{0.00153}}{\sqrt{211.56050}}} \cdot 100 = 87.56\%$$

$$VPS_{Nrofdays} = \frac{2.36390}{\frac{\sqrt{0.01845}}{\sqrt{618.99580}}} \cdot 100 = 69.95\%$$

$$VPS_{sysday} = \frac{0.14217}{\frac{\sqrt{0.00721}}{\sqrt{194.46480}}} \cdot 100 = 12.01\%$$

Significance between the systems in outflow level, we can separate into two groups – systems Nr 3, 4, 5 and system Nr 6. Significance between the systems in first group is very low. Maybe we can except system Nr 4 and 6. The significance of this systems are very low, but if we compeer with systems Nr3 and 5 it's a little bit higher.

Significance between the systems in h-11 level is higher. The biggest influence of this is direct connection between the rain and water level in soil. The small influence between the systems could be explained by orientation system Nr3 and 5 in experimental field and slop of surface.

Correlation between water level and outflow in season level and day level it's still very high – 87.5%. It could be explained by drainage intensive work in spring and autumn time.

If we look to correlation between water level and outflow in system level correlation are going down till 12.01%. It can be explained that it was eliminated another two systems 0.4 and 21.6 which have very big influence to system work.

$$\mathrm{resp}_{1jkl} \sim \mathrm{N}(XB,\ \Omega)$$
$$\mathrm{resp}_{2jkl} \sim \mathrm{N}(XB,\ \Omega)$$
$$\mathrm{resp}_{1jkl} = \beta_{0jkl}\mathrm{cons.q\ l/s\ ha}_{ijkl} + 0.00024(0.00903)\mathrm{SystNr\_3.q\ l/s\ ha}_{ijkl} + 0.02329(0.00903)\mathrm{SystNr\_4.q\ l/s\ ha}_{ijkl} + 0.00571(0.00903)\mathrm{SystNr\_5.q\ l/s\ ha}_{ijkl} + 0.01763(0.01065)\mathrm{SystNr\_6.q\ l/s\ ha}_{ijkl} + 0.00746(0.00133)\mathrm{Rain.q\ l/s\ ha}_{ijkl}$$
$$\beta_{0jkl} = 0.04703(0.01671) + f_{0l} + v_{0kl} + u_{0jkl}$$
$$\mathrm{resp}_{2jkl} = \beta_{1jkl}\mathrm{cons.h\text{-}11}_{ijkl} + -2.78334(1.43046)\mathrm{SystNr\_3.h\text{-}11}_{ijkl} + -3.42818(1.43885)\mathrm{SystNr\_4.h\text{-}11}_{ijkl} + 13.39576(1.43046)\mathrm{SystNr\_5.h\text{-}11}_{ijkl} + 7.74181(1.43045)\mathrm{SystNr\_6.h\text{-}11}_{ijkl} + 1.26032(0.27990)\mathrm{Rain.h\text{-}11}_{ijkl}$$
$$\beta_{1jkl} = 22.80099(4.47983) + f_{1l} + v_{1kl} + u_{1jkl}$$

$$\begin{bmatrix} f_{0l} \\ f_{1l} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_f)\ :\ \Omega_f = \begin{bmatrix} 0.00075(0.00075) & \\ 0.23961(0.19964) & 88.23538(63.26577) \end{bmatrix}$$

$$\begin{bmatrix} v_{0kl} \\ v_{1kl} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_v)\ :\ \Omega_v = \begin{bmatrix} 0.00772(0.00123) & \\ 1.28617(0.19389) & 368.97830(39.76622) \end{bmatrix}$$

$$\begin{bmatrix} u_{0jkl} \\ u_{1jkl} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_u)\ :\ \Omega_u = \begin{bmatrix} 0.00341(0.00028) & \\ 0.03577(0.03528) & 108.45250(7.46339) \end{bmatrix}$$

*-2*loglikelihood(IGLS Deviance)* = 3360.29200(916 of 1750 cases in use)

Variance Partition Coefficient in season level:

$$VPS_{season} = \frac{0.23961}{\frac{\sqrt{0.00075}}{\sqrt{88.23538}}} \cdot 100 = 93.14\%$$

Variance Partitinion Coeficient in day level:

$$VPS_{Nrofdays} = \frac{1.28617}{\frac{\sqrt{0.00772}}{\sqrt{368.97830}}} \cdot 100 = 76.21\%$$

Variance Partition Coefficient in system level:

$$VPS_{sysday} = \frac{0.003577}{\frac{\sqrt{0.00341}}{\sqrt{108.45250}}} \cdot 100 = 6.0\%$$

Significiance between the systems a little bit increase when we add one more factor - Rain. This factor has no big influence to significance between the systems. Maybe we can except systems Nr 4 and 6 again. The significance between this systems are very low, but if we compeer with systems Nr3 and 5 it's a little bit higher in both level.

Correlation between the water level and outflow in season and day levels after adding one more factor it's still high.

Correlation in system level still are very low.

$\text{resp}_{1jkl} \sim \text{N}(XB, \Omega)$

$\text{resp}_{2jkl} \sim \text{N}(XB, \Omega)$

$$\text{resp}_{1jkl} = \beta_{0jkl}\text{cons.q l/s ha}_{ijkl} + 0.00023(0.00904)\text{SystNr\_3.q l/s ha}_{ijkl} + 0.02330(0.00904)\text{SystNr\_4.q l/s ha}_{ijkl} + 0.00566(0.00903)\text{SystNr\_5.q l/s ha}_{ijkl} + 0.01766(0.01065)\text{SystNr\_6.q l/s ha}_{ijkl} + 0.00748(0.00132)\text{Rain.q l/s ha}_{ijkl} + -0.00377(0.00154)\text{Temp C.q l/s ha}_{ijkl}$$

$$\beta_{0jkl} = 0.06459(0.01736) + f_{0l} + v_{0kl} + u_{0jkl}$$

$$\text{resp}_{2jkl} = \beta_{1jkl}\text{cons.h-11}_{ijkl} + -2.78335(1.43003)\text{SystNr\_3.h-11}_{ijkl} + -3.43194(1.43842)\text{SystNr\_4.h-11}_{ijkl} + 13.39575(1.43003)\text{SystNr\_5.h-11}_{ijkl} + 7.74138(1.43003)\text{SystNr\_6.h-11}_{ijkl} + 1.25879(0.27795)\text{Rain.h-11}_{ijkl} + -0.79757(0.30843)\text{Temp C.h-11}_{ijkl}$$

$$\beta_{1jkl} = 26.56725(4.65454) + f_{1l} + v_{1kl} + u_{1jkl}$$

$$\begin{bmatrix} f_{0l} \\ f_{1l} \end{bmatrix} \sim \text{N}(0, \Omega_f) : \Omega_f = \begin{bmatrix} 0.00062(0.00066) & \\ 0.21911(0.18580) & 85.48883(61.52621) \end{bmatrix}$$

$$\begin{bmatrix} v_{0kl} \\ v_{1kl} \end{bmatrix} \sim \text{N}(0, \Omega_v) : \Omega_v = \begin{bmatrix} 0.00759(0.00121) & \\ 1.26487(0.19142) & 363.76240(39.32035) \end{bmatrix}$$

$$\begin{bmatrix} u_{0jkl} \\ u_{1jkl} \end{bmatrix} \sim \text{N}(0, \Omega_u) : \Omega_u = \begin{bmatrix} 0.00342(0.00028) & \\ 0.03684(0.03528) & 108.38830(7.45856) \end{bmatrix}$$

*-2*loglikelihood(IGLS Deviance)* = 3353.28800(916 of 1750 cases in use)

Variance Partition Coefficient in season level:

$$VPS_{season} = \frac{0.21911}{\frac{\sqrt{0.00062}}{\sqrt{85.48883}}} \cdot 100 = 95.17\%$$

Variance Partitinion Coeficient in day level:

$$VPS_{Nrofdays} = \frac{1.26487}{\frac{\sqrt{0.0759}}{\sqrt{363.76240}}} \cdot 100 = 24.1\%$$

Variance Partition Coefficient in system level:

$$VPS_{sysday} = \frac{0.03684}{\frac{\sqrt{0.00342}}{\sqrt{108.38830}}} \cdot 100 = 6.1\%$$

After adding one more factor – temperature, we haven't any big transformation of values. We can except only correlation between water level and outflow in day level.

Conclusions:

As we notice before, according significance between the systems in outflow level we can separate into two groups – systems Nr 3, 4, 5 and system Nr 6. Significance going up between the system, when we add some extra factors as Rain and Temperature.

Correlation between the systems in season level and day level stay more or less the same after adding extra factors. Maybe we can except correlation in day level when we added temperature factor. For explanation dropping down this value it’s necessary to make more deep research of this factor influence to water filtration thru the soil.

According the model data the outflow has not big influence from the water level between the drains. For detail explanation of this conclusion is needed more deep research.