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Hidrologija
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Space distribution of low runoff and hydrophysical-hydrochemical properties of surface water in the Dovinė River basin

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INTRODUCTION

The Dovinė River is a second biggest tributary (length 47 km, catchment area 588.7 km^2) of the Šešupė River. A characteristic feature of the basin is lakes taking 7.3 % of the total area. In early 1970s, three lakes (Dusia, Simnas and Žuvintas) located in the upper and middle reaches of the Dovinė River were dammed trying to increase the low runoff of the heavily polluted Šešupė River at the Marijampolė City (Baltrušaitienė, Bridickaitė, 1979). As a lot of undesirable hydrological and ecological consequences of the damming arose in the lakes (Kilkus, 2003), the possibilities to return them to the natural state have been discussed often enough of late years. In 2003, the project *Renaturalisation of the Dovinė River basin* sponsored by the PIN/MATRA foundation has been started on, and some new data on the hydrology as well as hydrochemical and hydrophysical properties of surface water in the basin have been collected during field studies in the summer of 2004. A so-called hydrometrical survey (Januškis, 1981) has been carried on during a short period of continuous drought to estimate the space distribution of low runoff, groundwater discharge sites as well as ephemeral streams. Some hydrophysical and hydrochemical parameters such as water temperature (T), pH and electric conductivity (C) have been measured at the same sites, too.

MEASURED DISCHARGES

On 16–17 August 2004, the stream hydrograph follow-ed the form of the normal dry weather depletion curve, and 22 water discharges of the Dovine River and its tributaries were measured and / or estimated visually (Fig. 1). Catchment areas to the discharge measuring sites vary from 0.2 km^2 to 560 km^2; 13 catchments are smaller than 10 km^2, 5 catchments are lager than 100 km^2, and the areas of four catchments are from 10 to 100 km^2.

Hydrometrical conditions for discharge measurements were unfavourable because of the overgrowth of the channels by macrophytes, and water current velocities were weak enough (mean velocities varied from 0.04 to 0.37 m/s) even in the cleaned channels due to the small slopes. Moreover, five ephemeral springs were dried up and the discharges of six springs were less as 0.001 m^3/s (visual estimation). The measurement of current velocity by means of the Otto V type current meter (the minimum measuring velocity 2.8 cm/s) was accomplish-ed in 11 hydrometric sites. In the wider channels (Dovine River), the number of sampling verticals for point velocity measurements amounted to 7–9 and in the narrower channels it was less. Six discharges of the Sutrė River – Spernia River – Bambena River – Dovinė River hydrographic system were measured. The remainder dis-tributed as follows: nine discharges of inlets of Lake Dusia, three discharges of inlets of Lake Amalvas, one discharge of an inlet of Lake Žuvintas (the Bambena River excluding) and three discharges of small tributaries of the Dovine River (Table 1).

Because of the especially bad velocity measurement conditions (the wide channel was overgrown by dense water vegetation and the current velocities were less than the minimum measuring velocity), the discharge of the Amalvė River was not estimated at all. It should be

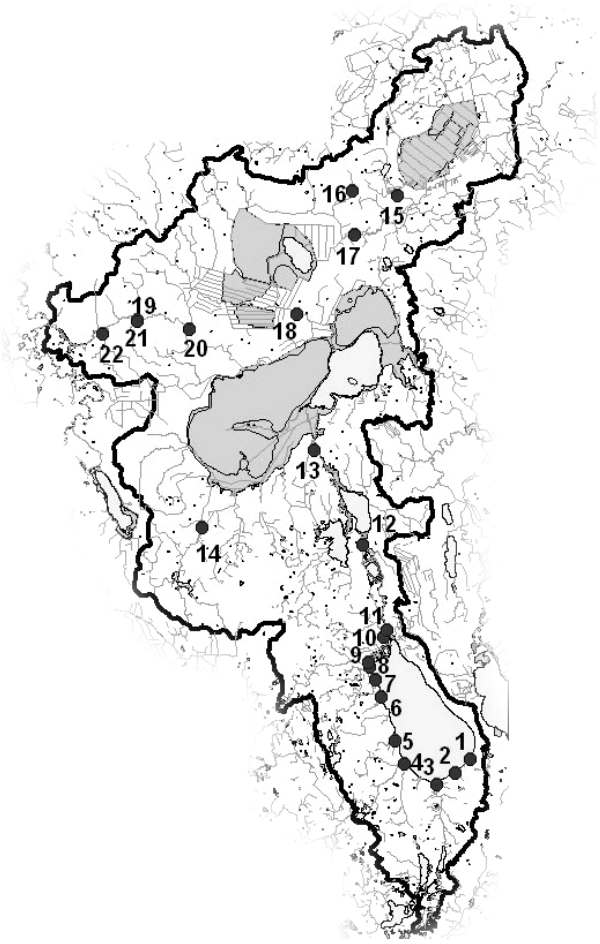

Fig. 1. Distribution of discharge measuring sites (numbers at the dots) in the Dovinė River basin
1 pav. Debitų matavimo skersainių (skaičiai prie taškų) išsidėstymas Dovinės baseine

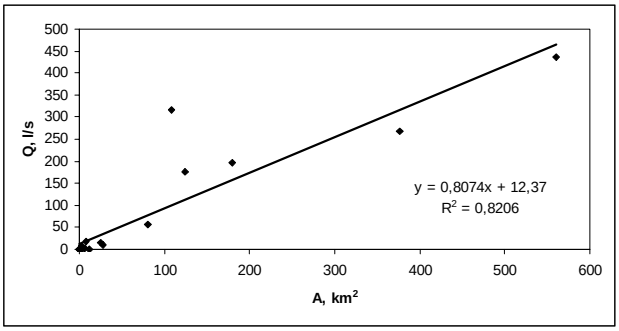

Fig. 2. Relationship between minimum discharge of stream (Q) and catchment area (A); Dovinė River basin, 16–17 08 2004)
2 pav. Upelių minimalaus debito (Q) (2004 08 16–17) priklausomybė nuo maitinančiojo baseino ploto (A); Dovinės upės baseinas, 2004 08 16–17

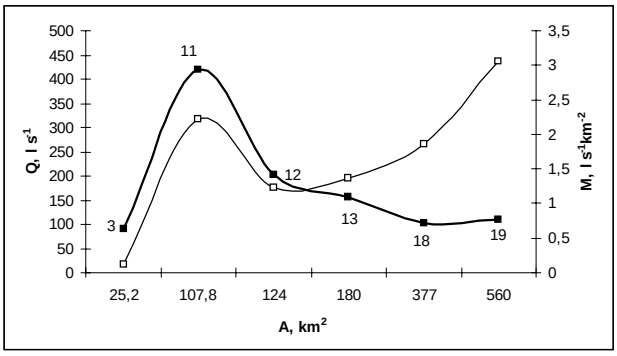

Fig. 3. Distribution of minimum discharges (Q, white squares) and specific runoff (M, black squares) downstream the Sutrė – Spernia – Bambena – Dovinė hydrographic system, plotted on the catchment area scale (A); numbers at the squares are hydrometric sites according to Table 2
3 pav. Minimalių paros debitų (Q, balti kvadratėliai) ir jų modulių (M, juodi kvadratėliai) pokyčiai Sutrės – Spernios – Bambenos – Dovinės upelių sistemoje didėjant maitinančiojo baseino plotui (A); skaičiai prie kvadratėlių – hidrometrinių skersinių numeriai pagal 2 lentelę

also noted that despite the increase of the catchment area, the discharge of the Spernia River near Simnas, on the contrary, decreased significantly (about 45%). The infiltration of river water to the reservoir digged close to the Spernia River channel as well as water losses in the fish-ponds located upstream of Simnas should be the reasons for the phenomenon.

RUNOFF

According to the measured discharges, the specific low runoff in the Dovine River catchment varied from 0.00 to 2.93 l s^{-1} km^2 during 16–17th August 2004 (Table 2). Springs with the catchment area A = 0.2–11.5 km^2 had been dried up at all, and the catchments less as 3 km^2 prevailed among them.

There is a good correlation between the measured discharges and catchment areas (Fig. 2), but the discharge of the Spernia River, which has been measured down Lake Dusia, is an exception of the rule. The discharge is especially great and could be predetermined by the water accumulated in the lake during the earlier rainy period. On the other hand, the discharge of the same Spernia River decreases about 45% at Simnas and, as mentioned above, the reasons could be the infiltration of water to the new reservoir as well as the divertion of river water to the fish-ponds upstream of the Simnas. These are reflected in the distribution of minimum discharges along the system of the Sutrė River – Spernia River – Bambena River – Dovinė River (Fig. 3).

Both shallow Lake Simnas and Lake Žuvintas are evaporators of inflowing water; besides, the inseepage of groundwater to the lakes is poor; it explains why the specific low runoff down to the lakes decreases noticeably (Fig. 3). In the Dovinė River, the increase of discharge in the section between Daukšiai and Padovinys amounts to 169 l/s and is caused by the inflow of the right tributatory of the Amalvė River (catchment area A = 137.4 km^2) as well as the groundwater discharged between the mentioned sites. Assuming that the specific low runoff of the Amalvė River catchment is

Table 1. **The measured discharges (16–17 2004 08): Q – discharge, F – cross-sectional area, V_{max} – maximum velocity, V_{av} – mean velocity, W – channel width, D_{av} – mean depth, b. v. – nameless stream**
1 lentelė. **2004 08 16–17 išmatuoti Dovinės upės ir jos intakų debitai (Q – debitas, F – hidrometrinio skersainio plotas, V_{max} – didžiausias greitis, V_{av} – vidutinis greitis, W – vagos plotis, D_{av} – vidutinis gylis, b. v. – bevardis upelis)**

Site No Skersainio Nr.	River Upė	Q, m^3/s	F, m^2	V_{max}, m/s	V_{av}, m/s	W, m	D_{av}, m
1	b. v.	0					
2	b. v.	0.0005					
3	Sutrė	0.016	0.39	0.066	0.041	1.75	0.22
4	Peèiagrinda	0.0026	0.015	0.22	0.17	0.25	0.06
5	b. v.	0					
6	b. v.	0.0005					
7	b. v.	0.0005					
8	b. v.	0					
9	Pryga	0.0005					
10	Zurzupë	0.007	0.038	0.27	0.18	0.48	0.08
11	Spernia (Dusia)						
	0.316	4.64	0.203	0.068	8.67	0.53	
12	Spernia (Simnas)	0.176	3.31	0.133	0.053	3.8	0.87
13	Bambena	0.196	1.53	0.186	0.128	2.15	0.71
14	Kiaulyèia	0.011	0.063	0.216	0.175	0.9	0.07
15	Yglë	0.017	0.0465	0.481	0.366	0.8	0.06
16	b. v.	0.0002					
17	Ðlavanta	0.055	0.815	0.097	0.067	2.87	0.28
18	Dovinë (Daukðiai)	0.267	4.95	0.125	0.054	8.86	0.56
19	Dovinë (Padovinys)	0.436	1.85	0.593	0.236	6.6	0.28
20	b. v.	0					
21	Pelëdupis	0.0002					
22	b. v.	0					

Table 2. **Specific low runoff (M) in the Dovinė River catchment during 16–17 August 2004**
2 lentelė. **Sausmečio (2004 08 16–17) nuotėkio hidromoduliai (M) Dovinės upės baseine**

Site No Skersainio Nr.	River Upė	Catchment area, km^2 Baseino plotas km^2	M, l/sec km^2 M, l/s km^2
1	b. v.	0.70	0.00
2	b. v.	0.46	1.00
3	Sutrė	25	0.63
4	Peèiagrinda	6.5	0.40
5	b. v.	1.1	0.00
6	b. v.	0.82	0.52
7	b. v.	0.20	2.50
8	b. v.	1.34	0.00
9	Pryga	11.5	0.04
10	Zurzupë	3.26	2.14
11	Spernia (Dusia)	108	2.93
12	Spernia (Simnas)	124	1.42
13	Bambena	180	1.09
14	Kiaulyèia	28	0.42
15	Yglë	7.5	2.26
16	b. v.	0.74	0.27
17	Ðlavanta	80	0.69
18	Dovinë (Daukðiai)	377	0.71
19	Dovinë (Padovinys)	560	0.76
20	b. v.	1.5	0.00
21	Pelëdupis	2.9	0.07
22	b. v.	2.7	0.00

the same as of the Dovinė River catch-ment at the Daukšiai site, the inflowing Amalvė River discharge (Q_A) may be estimated as 0.098 m^3/s. The input of the groundwater discharging directly to the Dovinė River channel inside the Daukšiai–Padovinys section (q_1) would then be calculated as a remainder:

$$q_1 = Q_P - (Q_D + Q_A) = 0.071 \ m^3/s, \qquad (1)$$

where Q_P and Q_D are discharges of the Dovinė River at the Padovinys and Daukšiai sites, respectively; Q_A is the discharge of the Amalvė River.

Despite of the fact that small springs were dried up during the period of field studies, the measured discharges reflect a low runoff of a wet summer, and the exceedence of the flow was about 60%. The estimation was made on the basis of records of minimum daily discharges measured in the Šešupė River at the Kalvarija site (Gailiušis et al., 2001). According to the data of the Lithuanian Hydrometeorological Survey, the daily discharges of the Šešupė River on 16–17 August were 1.68 and 1.63 m^3/s, respectively, and the 50% exceedence of minimum daily discharge at the same site was estimated as 1.05 m^3/s.

HYDROPHYSICAL AND HYDROCHEMICAL PROPERTIES OF THE STREAMS

As mentioned above, water temperature, electric conductivity and pH have were measured in each hydrometric site (Table 3). It follows from the collected data that electric conductivity as well as water temperature and pH are the best indicators of groundwater discharging to the rivers.

Table 3. **Hydrophysical and hydrochemical parameters of the streams**

3 lentelė. **Upelių hidrofiziniai ir hidrocheminiai rodikliai**

Site No Skersainio Nr.	Stream Upelis	T,°C	pH	C, μS $cm^{-1}s^{-1}$
3	Sutrė	17.3	7.63	674
4	Peèiagrinda	16.7	8.18	733
6	b. v.	15.7	8.40	924
7	b. v.	14.3	8.03	763
9	Pryga	15.9	8.30	814
10	Zurzupë	16.7	8.39	807
11	Spernia	19.7	8.17	335
12	Spernia	18.3	7.46	360
13	Bambena	18.3	7.35	443
14	Kiaulyèia	16.5	8.35	691
15	Yglë	17.9	7.99	626
16	b. v.	16.1	8.35	797
17	Ðlavanta	15.7	7.88	687
18	Dovinë	17.8	7.47	512
19	Dovinë	18.2	8.16	547
21	Pelëdupis	13.9	8.30	974

Low electric conductivity values (less than 500 μS cm^{-1} s^{-1}) are characteristic of the outlets of Lake Dusia, Lake Simnas and Lake Žuvintas (the Spernia River, the Bambena River and the Dovinė River, respectively). In the lower reaches of the Dovinė River, the incision of the channel is deeper and the part of groundwater in the total discharge of the river increases, so water electric conductivity increases too (Fig. 4). During the period of hydrometric survey, the flow of small rivers was caused by discharging groundwater exceptionally, and this is why there was a close correlation between river discharge and electric conductivity (Fig. 5). Larger catchments can supply more humic acids, and water pH values in such rivers are lower than in small springs. In other words, catchment area, discharge, electric conductivity and water temperature are interrelated parameters (Figs. 6, 7).

The mean value of water electric conductivity of small catchments (Nos 4, 6, 7, 9, 10, 16, 17) is 830 μS $cm^{-1}s^{-1}$ and may be treated as a regional value of shallow groundwater electric conductivity (Cq). As the latter is an indirect measure of salinity (Wetzel, 1983), the dilution gauging

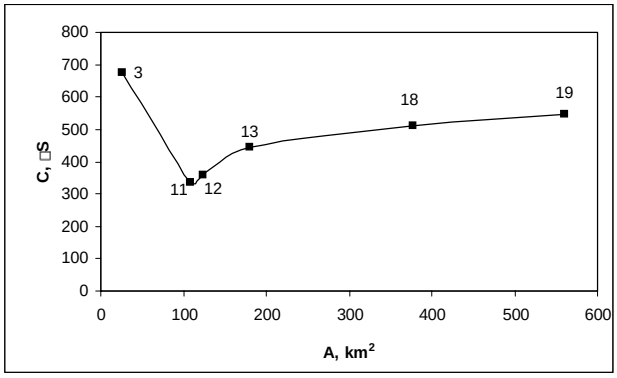

Fig. 4. Distribution of water electric conductivity (C) downstream the Sutrė – Spernia – Bambena – Dovinė hydrographic system, plotted on the catchment area scale (A); numbers at the squares are hydrometric sites according to Table 3

4 pav. Vandens savitojo elektros laidžio (C) kaita Sutrės – Spernios – Bambenos – Dovinės upelių sistemoje didėjant maitinančiojo baseino plotui (A); skaičiai prie taškų – hidrometrinių skersinių numeriai pagal 3 lentelę

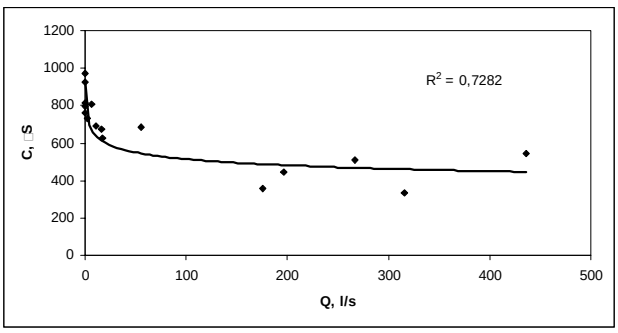

Fig. 5. Relationship between discharge (Q) and water electric conductivity (C); the Dovinė River basin, 16–17 08 2004

5 pav. Ryšys tarp upelių vandens savitojo elektros laidžio (C) ir debito (Q) (Dovinės baseinas, 2004 08 16–17)

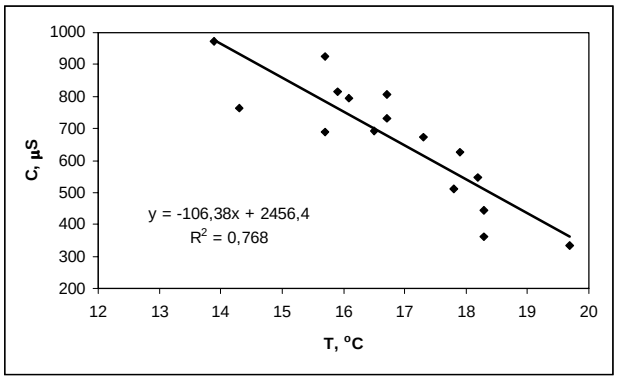

Fig. 6. Relationship between water electric conductivity (C) and water temperature (T); the Dovinė River catchment, 16–17 08 2004

6 pav. Ryšys tarp vandens savitojo elektros laidžio (C) ir temperatūros (T) (Dovinės baseino upeliai, 2004 08 16–17)

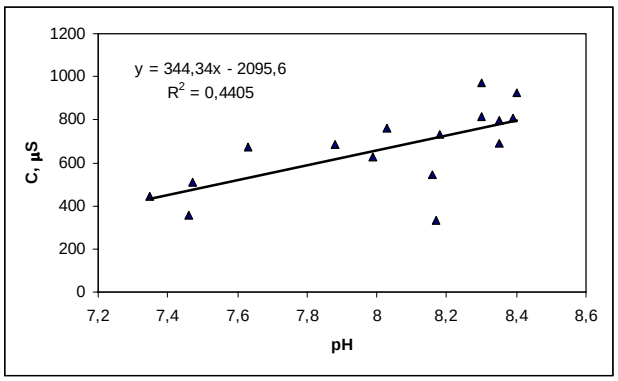

Fig. 7. Relationship between water electric conductivity C and pH (the Dovinė River catchment, 16–17 08 2004)

7 pav. Ryšys tarp vandens savitojo elektros laidžio C ir pH (Dovinės baseino upeliai, 2004 08 16–17)

method (Shaw 1994) for estimation of groundwater discharging directly into the Dovinė River inside the Daukšiai–Padovinys section can be used:

$$(Q_D + Q_A)\, C_D + q_2\, C_q = (Q_D + Q_A + q_2)\, C_P, \qquad (2)$$

where Q_D, Q_P and Q_A are the same as in eq. (1); C_D and C_P are surface water conductivities at the Daukšiai and Padovinys sites, respectively (Table 3); Cq is the regional value of shallow groundwater electric conductivity.

Simple calculations according to equation (2) result in $q_2 = 0.046$ m^3/s, i. e. about 35% less in comparison with q_1 which was estimated by the water balance method. It is impossible now to discuss which result is more reliable, because both calculations include the term Q_A, which was estimated hypothesizing that the specific low runoff of the Amalvė River catchment is the same as in the Dovinė River at the Daukšiai site. On the other hand, it is obvious that water electric conductivity data cannot replace reliable hydrological data, but their interpretation has to rely on them and at least on additional hydrogeological information, too.

CONCLUSIONS

1. The measured discharges reflect a wet summer minimum daily flow (the exceedence of the flow was about 60%).

2. Even in wet summer, small tributaries (catchment areas less than 3 km^2) of the Dovinė River dry up completely.

3. A rather strong correlation (r = 0.906) between minimum daily discharge and catchment area was established.

4. During the period of hydrometric survey the specific low runoff of the whole Dovinė River catchment (at the Padovinys site) amounted to 0.76 l/s km^2.

5. Water electric conductivity, pH and temperature are inter-correlated in the Dovinė River basin, and there are close relationships among the mentioned parameters and the catchment area as well as the discharge during low flow in summer.

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SAUSMEČIO MINIMALAUS NUOTĖKIO IR PAVIRŠINIO VANDENS HIDROFIZINIŲ-HIDROCHEMINIŲ SAVYBIŲ PASISKIRSTYMAS DOVINĖS BASEINE

S a n t r a u k a

Dovinė yra antrasis pagal dydį (baseino plotas 588,7 km^2, ilgis 47 km) Šešupės intakas. Jos baseine telkšo dideli ežerai (Dusia, Simnas, Žuvintas), kurie prieš kelis dešimtmečius buvo patvenkti. Ilgainiui išryškėjo nepageidaujamos šio tvenkimo pasekmės ežerų ekosistemoms, ir mokslininkai pradėjo diskusiją apie ežerų renatūralizaciją. 2003 m. gimė PIN/MATRA fondo remiamas projektas *Dovinės baseino renatūralizacija*, turėjęs ir hidrologinę dalį, kurioje buvo numatyti baseino

ekspediciniai tyrimai. Šiame darbe apibendrinami pastarųjų duomenys apie sausmečio minimalaus nuotėkio ir upelių vandens hidrofizinių-hidrocheminių savybių (temperatūros, pH, vandens savitojo elektros laidžio) pasiskirstymą Dovinės baseine.

Apie minimalaus nuotėkio erdvinį pasiskirstymą, mažų upelių išdžiūvimo ribas, požeminio vandens drenažo ypatumus ir kt. sprendžiama iš ekspedicijos matavimų, atliktų per trumpą ir pagal mitybos (nuotėkio formavimosi) sąlygas vienarūšį laikotarpį be kritulių. 2004 08 16–17 d., esant tokioms sąlygoms, buvo įvertinti 22 debitai Dovinėje ir jos intakuose (1 pav.). Maitinančiųjų baseinų plotai iki debitų matavimo skersainių buvo nuo 0,2 iki 560 km^2, iš jų 13 – mažesni nei 10 km^2, 4 – nuo 10 iki 100 km^2 ir 5 – didesni nei 100 km^2 (1 lentelė). Tuose pačiuose skersainiuose buvo matuojama vandens temperatūra (T), pH ir savitasis elektros laidis (C).

Ekspedicijos metu išmatuotus būdingus debitus atitinkantys hidromoduliai Dovinės baseine kito nuo 0,00 iki 2,93 l/s km^2 (2 lentelė). Visai buvo išdžiūvę upeliai, kurių baseinų plotai A = 0,2–11,5 km^2, tačiau tarp jų vyravo upeliai su A < 3 km^2.

Išmatuotieji debitai gerai koreliuojasi su maitinančiųjų baseinų plotais (2 pav.), išskyrus Spernios upelio žemiau Dusios ežero. Pastarojo debitas yra itin didelis ir galėtų būti nulemtas anksčiau buvusio lietingo laikotarpio vandens, sukaupto Dusios ežere. Kita vertus, tos pačios Spernios debitas ties Simnu sumažėja (baseino plotui padidėjus apie 45%), ir tai galima būtų paaiškinti vandens infiltracija į kasamą šalia upelio tvenkinį ir galbūt vandens nuostoliais žuvininkystės tvenkiniuose. Šitą rodo ir minimalių debitų pasiskirstymas Sutrės – Spernios – Bambenos – Dovinės sistemoje nuo aukštupio link žemupio (3 pav.). Seklūs Simno ir Žuvinto ežerai yra nuotėkio garintojai, be to, menkai drenuoja gruntinius vandenis, todėl nuotėkio hidromoduliai žemiau jų pastebimai sumažėja (3 pav.). Dovinės atkarpoje tarp Daukšių ir Padovinio debito prieaugis yra 169 l/s, ir jį nulemia Amalvos baseino (A = = 137,4 km^2) nuotėkis bei požeminio vandens prietaka į giliau įsirėžusios upės vagą. Dėl pastarosios priežasties vandens savitasis elektros laidis didėja Dovinės žemupio link (3 lentelė, 4 pav.). Kadangi neišdžiūvę mažieji upeliai hidrometrinės nuotraukos metu plukdė tik požeminį vandenį, yra ganėtinai glaudus ryšys tarp upelių debito ir vandens savitojo elektros laidžio (5 pav.). Kita vertus, pastarasis gerai koreliuojasi su vandens temperatūra ir pH (6, 7 pav.), t. y. visi šie rodikliai yra tarpusavyje susiję.