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Determination of Relation between the Quaternary Sediments and Land Use Dissemination on the Basis of Šventoji River Basin

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Abstract. On preparing of the first management plans of River Basin Districts have been found that diffuse agricultural pollution is one of the most important causing factor and the most significant impact on the quality of water bodies. Diffuse agricultural pollution can be from 45% to 80% of nitrate nitrogen pollution load of water bodies. Pollution is transported by water surface and subsurface runoff through sediments from agricultural territories. This article aims at evaluating of relation between the Quaternary sediments and Land use dissemination. The lithological factor (sandy, loamy, argillaceous) of the basin was calculated based on Quaternary map of Lithuania M 1:200000 and Lithuanian river map M 1:50000. The land-use factor of the basin was calculated based on Corine Land cover M 1:100000 using ArcGis software. In order to carry out more thorough analysis of the determination of relation between the Quaternary sediments and Land use dissemination in given territories, sections of 0–50 m, 50–200 m, 200–500 m, 500–800 m, 800–1000 m and >1000 m were established, calculating the distance in meters from the riverbank.

Keywords: lithology, land use, basin.

Conference topic: Water engineering.

Introduction

On preparing of the first management plans of River Basin Districts have been found that diffuse agricultural pollution is one of the most important causing factor and the most significant impact on the quality of water bodies. Diffuse agricultural pollution is determined by land use factors. Climatic and bedrock surface factors determs runoff of rainfall from the basin into the river. Climate influences the overall wateriness during the year and runoff regime phase periods. Bedrock surface (the size of a river basin, its lithological composition, and areas of land use) might cause fundamental changes to the runoff regime formed by climatic factors (Pfister *et al.* 2004; Gailiušis *et al.* 2001; Uhlenbrook *et al.* 2001). In the context of global climate change, Lithuanian climatologists have not yet recorded fundamental changes in multi–annual precipitation patterns but have established its clear seasonal distribution, i.e. winter season precipitation has increased significantly while that of summer season has seen a significant decrease (Galvonaitė, Valiukas 2005; Bukantis *et al.* 2001; Bukantis, Rimkus 2005).

A number of researchers engage in the analysis of runoff formation conditions, particularly while analyzing the impact of land–use structures on river runoff (Jones, Grant 1996; Ashagrie *et al.* 2006). H. Pauliukevičius (2006) looked into the impact of land–use on small river basins runoff. The research has demonstrated slight and moderate inverse correlation of average annual runoff module with forest area and direct correlation with Arable land area in small river basins with varied land–use in the end of a low–wateriness period and the beginning of a higher wateriness period. The correlations between the runoff and precipitation of basins of diferent size were established and analysis of patterns of river runoff change considering to the size of the basin were done in Lithuania (Bagdžiūnaitė-Litvinaitienė *et al.* 2011).

However, the number of scientific research focusing on the aspects of runoff formation in terms of lithological structure of a river basin is scarce; moreover, the existing ones deal with it in terms of water quality since infiltration characteristics of lithological structures determine the quality of both runoff and water (Litvinaitis *et al.* 2015; Kevin *et al.* 2000; Alan *et al.* 2004).

The aim of article is to evaluate lithological and land use structure of Šventoji river basin.

Materials and Methods

Three parts of basin of Šventoji river were selected according to long–term water measurement stations: above Anykščiai, Anykščiai-Ukmergė, below Ukmergė (Fig. 1).

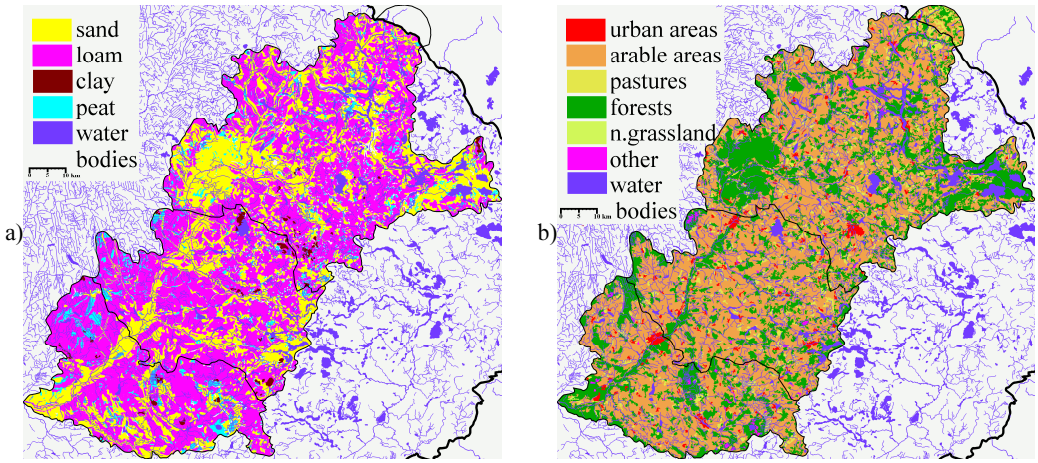

Fig. 1. Basin of Šventoji river, distribution of sediments (a) and land use (b)

The lithological and land use factor of the basin and parts of the basin was calculated based on Quaternary map of Lithuania M 1:200000, Corine land cover 2006 and Lithuanian river map M 1:50000 using ArcGis software. Four classes were identified according to soil composition: 1 sand, 2 loam–sandy loam (further on referred to as loam), 3 clay and 4 peat. Classes were identified according to land use: Urban areas, Arable and other agriculture areas, Pastures, Forests, Natural grassland and Other. Analysis of selected parts was carried out of the influence of land use in given territories, sections of 0–50 m, 50–200 m, 200–500 m, 500–800 m, 800–1000 m and >1000 m were identified, calculating the distance in meters from the riverbank. Each sections' land use and lithological structure was established.

Results and Discussion

The distribution of sections areas in the Šventoji basin was analysed. The calculation of the percentage of sections area in the parts of basin revealed that distribution of areas of sections are equivalent in all parts of the basin. More than 70% of the basin territory is covered by sections of 50–200 m, 200–500 m, and 500–800 m. 12–14% of basin territory is covered by sections 800–1000 m and over 1000 m, and 14–15% of basin is covered by section 0–50 m. This distribution of section areas is directly influenced by the density of hydrographic net (Jablonskis *et al.* 2007). This structure was considered in further calculations (Table 1).

Table 1. Areas of sections in percents of overall and parts of Šventoji basin

Parts of basin	0–50 m	50–200 m	200–500 m	500–800 m	800–1000 m	over 1000 m
All	14.5	23.4	27.5	20.4	6.3	7.9
above Anykščiai	15.3	22.4	26.8	20.9	6.6	8.0
Anykščiai–Ukmergė	14.7	24.3	28.1	20.4	6.4	6.1
below Ukmergė	14.2	26.5	28.8	18.7	5.2	6.6

Analysis of dispersion of sediment

Šventoji basin is covered by loam in 57% of the overall 6888.8 km^2 of basin area within its territory. Almost 33% is covered by sand, 1% is covered by clay and 9% is covered by swamps and peat bogs (Table 2). Clay is distributed in areas of an average from 0.5 to 4.8 km^2. The percentage of loam moving further from the riverbank increases gradually from almost 41% of the section 0–50 m area to 64% of the section 500–800 m area. The sand areas of sections cover more evenly, it decreases from more than 37% of the section 0–50 m to 30% of the section 500–800 m. All sections a covered by clay in 0.6–1.1%. Sections 0–50 m in 21% and 50–200 m in 13% are covered by swamps and peat bogs. Further sections are covered of 4–7% (Fig. 2).

The part above Anykščiai is covered by loam in almost 52% of the 3451.4 km^2 of part of basin area. More than 38% is covered by sand, 0.6% is covered by clay and 9% is covered by swamps and peat bogs. The loam increases from 34.5% of the section 0–50 m area to 62% of the section 800–1000 m area. The sand decreases from 42.5% of the section 0–50 m to 32% of the section 800–1000 m. The clay covers from 0.0 to 0.8% of areas of sections. Sections 0–50 m in 22.4% and 50–200 m in 12.8% are covered by swamps and peat bogs. Further sections are covered 4.8–8.4% (Fig. 3).

Table 2. Lithological structure of the of overall and parts of Šventoji basin

Parts of basin	Section	Lithological structure, %			
		sand	loam	clay	swamps and peat bogs
All basin	All	32.8	57.1	1.0	9.1
	0–50 m	37.4	40.7	0.9	21.0
	50–200 m	34.1	52.0	0.9	13.0
	200–500 m	30.9	62.5	1.0	5.6
	500–800 m	30.3	64.2	1.1	4.4
	800–1000 m	32.5	61.8	0.8	4.9
	over 1000 m	35.3	56.8	0.6	7.3
above Anykščiai	All	38.2	51.9	0.6	9.3
	0–50 m	42.5	34.5	0.6	22.4
	50–200 m	38.9	47.5	0.8	12.8
	200–500 m	35.6	57.7	0.8	5.9
	500–800 m	37.2	57.3	0.7	4.8
	800–1000 m	31.9	62.0	0.2	5.9
	over 1000 m	45.5	46.1	0.0	8.4
Anykščiai–Ukmergė	All	29.4	61.7	1.3	7.6
	0–50 m	36.3	44.6	0.7	18.4
	50–200 m	32.6	55.7	0.8	10.9
	200–500 m	28.5	65.8	1.2	4.5
	500–800 m	26.2	68.6	2.0	3.2
	800–1000 m	25.4	69.0	2.0	3.6
	over 1000 m	21.2	71.9	2.4	4.5
below Ukmergė	All	26.5	61.4	1.3	10.8
	0–50 m	29.6	46.4	1.7	22.3
	50–200 m	28.1	55.1	1.5	15.3
	200–500 m	25.2	67.4	1	6.4
	500–800 m	24.5	70.3	0.9	4.3
	800–1000 m	27.5	66.6	0.7	5.2
	over 1000 m	27.5	66.6	0.7	5.2

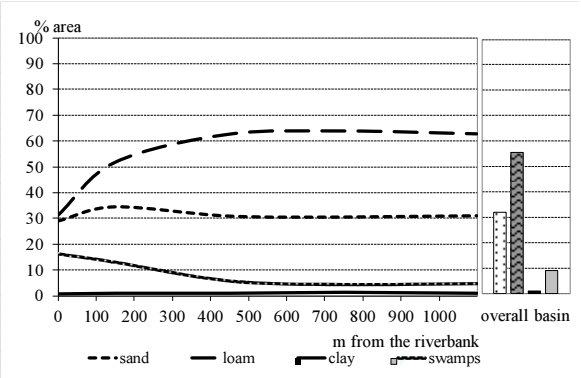

Fig. 2. Change of lithological formations of the Šventoji basin, distance from the bank

The part Anykščiai–Ukmergė is covered by loam in almost 62% of the 1903.2 km^2 of part of basin area. More than 29% is covered by sand, 1.3% is covered by clay and 7.6% is covered by swamps and peat bogs. The loam increases gradually from 45% of the section 0–50 m area to 72% of the section over 1000 m area. The sand decreases from 36% of the section 0–50 m to 21% of the section over 1000 m. The clay covers more than 2% of areas of sections from 500–800 m to overs 1000 m. Sections 0–50 m and 50–200 m in 18–11% are covered by swamps and peat bogs. Further sections are covered in 3.2–4.5%.

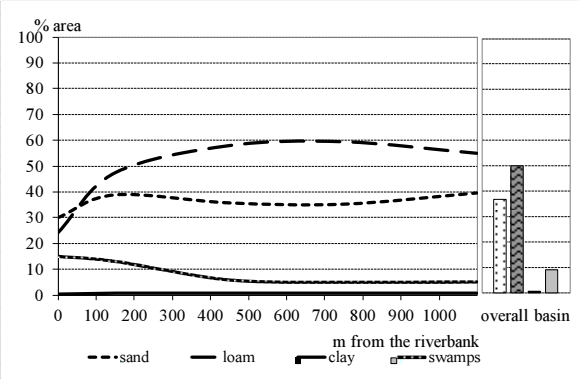

Fig. 3. Change of lithological formations of the Šventoji basin part above Anykščiai, distance from the bank

The part below Ukmergė is covered by loam in more than 61% of the 1534.2 km^2 of part of basin area. Almost 27% is covered by sand, 1.3% is covered by clay and 10.8% is covered by swamps and peat bogs. The loam increases from more than 46% of the section 0–50 m area to 70% of the section 500–800 m area. The sand decreases from almost 30% of the section 0–50 m to more than 24% of the section 500–800 m. The clay covers more than 1.5% of areas of sections 0–50 m and 50–200 m. Sections 0–50 m and 50–200 m in 22–15% are covered by swamps and peat bogs. Further sections are covered in 4.3–6.4%.

This basin and parts of basin structure considering infiltration characteristics of wet loam and clay is likely to influence rapid change of runoff in terms of precipitation.

Waters, especially rivers pollution depends on the run-off, and the nature of the mode is affected by factors such as climate, anthropogenic and natural geographical conditions. Pauliukevičius (2006) found that these factors lead to about 88% of the annual runoff in height, 85% of the maximum and the minimum 92% of the runoff change. The annual runoff most affected by climate factors, the maximum and minimum run-off the natural geographical and anthropogenic factors.

Analysis of dispersion of land cover

Šventoji basin is covered by Arable and other agriculture areas in almost 56% of the overall basin area within its territory. More than 28% is covered by Forest, 7.1% is covered by Pastures (Table 3). The percentage of Arable land and other agriculture areas moving further from the riverbank increases gradually from almost 45% of the section 0–50 m area to 61% of the section 200–500 m area. Further decreases to 48% of the section over 1000 m area. The Pastures decreases from more than 10% of the section 0–50 m to 3.6% of the section 800–1000 m. Forests increases gradually from 23% of the section 0–50 m area to more than 42% of the section over 1000 m area (Fig. 4).

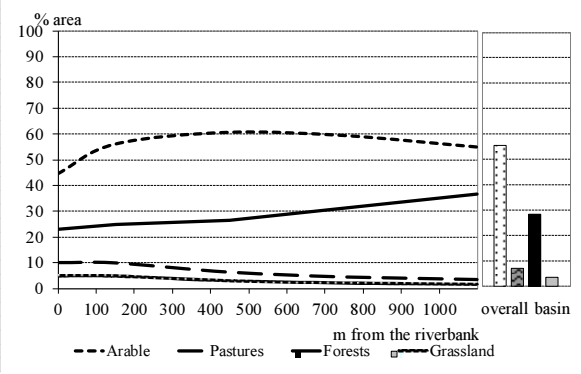

Fig. 4. Change of land use of the Šventoji basin, distance from the bank

The part above Anykščiai is covered by Arable and other agriculture areas in almost 52% of part of basin area. Almost 32% is covered by Forests, 7.5% is covered by Pastures and 3.4% is covered by Natural grassland. The Arable and other agriculture areas increases from more than 39% of the section 0–50 m area to almost 59% of the section 200–500 m area, further decreases to more than 48% of the section over 1000 m. The Forests increases from almost 24% of the section 0–50 m to almost 46% of the section over 1000 m. The patures decreases from 10% to 1.2% (Fig. 5).

Table 3. Land use structure of the of overall and parts of Šventoji basin

Parts of basin	Land use	% of all part	% of secion					
			0–50 m	50–200 m	200–500m	500–800 m	800–1000 m	over 1000 m
All basin	Urban areas	2.3	1.4	2.1	2.7	2.4	2.7	1.5
	Arable and other agriculture areas	55.6	44.5	56.0	60.6	59.3	54.8	48.4
	Pastures	7.1	10.1	10.0	6.4	4.6	3.6	4.5
	Forests	28.3	23.0	24.8	26.5	31.1	36.7	42.4
	Natural grassland	3.4	4.8	4.7	3.0	2.2	1.7	2.2
	Other	3.3	16.2	2.4	0.8	0.4	0.5	1.0
above Anykščiai	Urban areas	1.7	1	1.7	2	2	1.9	1.6
	Arable and other agriculture areas	51.5	39.1	52.2	58.9	56.3	51.8	48.3
	Pastures	7.5	10.2	10.9	7.2	4.9	4	2.5
	Forests	31.5	23.7	26.9	27.9	34.1	39.9	45.5
	Natural grassland	3.4	4.8	5.1	3.3	2.3	1.8	1.2
	Other	4.4	21.2	3.2	0.7	0.4	0.6	0.9
Anykščiai–Ukmergė	Urban areas	2.5	1.4	2.3	3.3	3.5	4.1	1.1
	Arable and other agriculture areas	63.1	50.1	61.7	64.7	65.1	63.9	56.4
	Pastures	6.6	9.9	9.7	5.5	4.3	2.6	2.8
	Forests	21.4	17.3	20.2	23.1	24.8	27.8	38.4
	Natural grassland	3.4	4.8	4.3	2.8	2.0	1.2	1.3
	Other	3.0	16.5	1.8	0.6	0.3	0.4	0.0
below Ukmergė	Urban areas	3.0	1.9	2.5	2.8	3.7	5.2	2.1
	Arable and other agriculture areas	58.5	49.9	60.8	56.2	57.4	55.1	51.6
	Pastures	6.5	10.0	9.9	4.9	3.7	2.3	1.3
	Forests	27.0	27.8	23.3	30.6	32.6	35.2	42.1
	Natural grassland	3.1	4.7	1.7	4.6	1.8	1.4	1.2
	Other	1.9	5.7	1.8	0.9	0.8	0.8	1.7

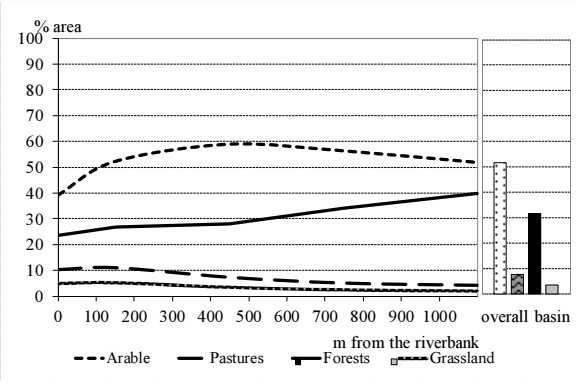

Fig. 5. Change of land use of the Šventoji basin part above Anykščiai, distance from the bank

The part Anykščiai-Ukmergė is covered by Arable and other agriculture areas almost 63% of the part of basin area. More than 21% is covered by Forests, 6.6% is covered by Pastures and 3.4% is covered by Natural grassland. The Arable and other agriculture areas increases from 50% of the section 0–50 m area to 65% of the section 500–800 m area. The Forests decreases gradually from more than 17% of the section 0–50 m to more than 38% of the section over 1000 m. The patures covers almost 10% of area of section 0–50 m and decreases to 2.8% of area of section over 1000 m.

The part below Ukmergė is covered by Arable and other agriculture areas in more than 58% of the 1534.2 km^2 of part of basin area. 27% is covered by Forests, 6.5% is covered by Pastures and 3.1% is covered by Natural grassland. The Arable and other agriculture areas increases from almost 50% of the section 0–50 m area to almost 61% of the section 50–200 m area and decreases to 52% of the section over 1000 m. Forest increases from more than 23% of the section 50–200 m to more than 42% of the section over 1000 m. Pastures decreases from 10 to 1.3% of areas of sections further from riverbank.

Analysis of dispersion of land cover on sand sediments

Šventoji basin is covered by Arable and other agriculture areas in more than 32% of the overall basin area on the sand sediments. Almost 32% is covered by Forests, more than 28% is covered by Urban areas. The percentage of Forests areas moving further from the riverbank increases gradually from 33% of the section 0–50 m area to more than 66% of the section over 1000 m area (Table 4). The Pastures decreases from almost 10% of the section 0–50 m to 1.4% of the section over 1000 m (Fig. 6).

Table 4. Land use structure on the sediments of the overall of Šventoji basin

Sedi-ments	Land use	% of all part	% of secion					
			0–50m	50–200m	200–500m	500–800m	800–1000m	over 1000 m
sand	Urban areas	28.3	2.7	3.4	4.2	4.1	3.9	2.0
	Arable and other agri-culture areas	32.4	44.2	47.4	46.8	41.6	36.5	29.0
	Pastures	4.2	9.6	8.1	4.8	3.5	2.5	1.4
	Forests	31.8	33.0	34.7	41.2	48.9	55.6	66.4
	Natural grassland	2.0	4.5	3.8	2.3	1.7	1.3	1.0
	Other	1.3	6.0	2.6	0.7	0.2	0.2	0.2
loam	Urban areas	1.8	1.1	1.5	2.0	2.1	2.3	1.5
	Arable and other agri-culture areas	68.6	65.3	67.8	70.2	69.5	67.5	66.7
	Pastures	6.4	9.3	8.5	6.8	4.9	3.7	2.7
	Forests	19.5	18.1	16.9	17.6	21.1	24.7	27.5
	Natural grassland	3.0	4.3	4.0	3.2	2.3	1.7	1.2
	Other	0.7	1.9	1.3	0.2	0.1	0.1	0.4
clay	Urban areas	1.6	0.0	0.5	2.4	2.7	1.3	0.0
	Arable and other agri-culture areas	46.5	41.6	47.1	46.2	53.1	43.9	23.6
	Pastures	9.6	14.0	14.3	10.5	5.3	0.0	0.0
	Forests	36.7	32.0	30.0	35.8	36.0	54.8	75.7
	Natural grassland	4.5	6.5	6.7	4.9	2.5	0.0	0.0
	Other	1.1	5.9	1.4	0.2	0.4	0.0	0.7

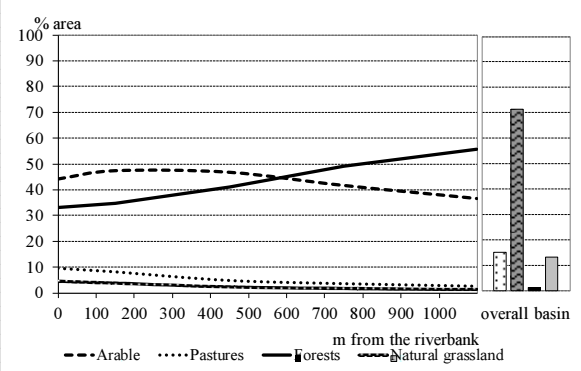

Fig. 6. Change of land use of the Šventoji basin on sand sediments, distance from the bank

Analysis of dispersion of land cover on loam sediments

Loamy soil is the richest soil for growth of plant. So, Arable and other agriculture areas cover almost 69% of loamy part of basin area. Almost 20% is covered by Forests, 6.4% is covered by Pastures and 3% is covered by Natural grassland. The Arable and other agriculture areas varies from more than 65% to more than 70% of the sections area. The Forests varies from more than 18% to almost 25% of the sections area. The Patures decreases from more than 9% of the section 0–50 m area to 2.7% of the section over 1000 m (Fig. 7).

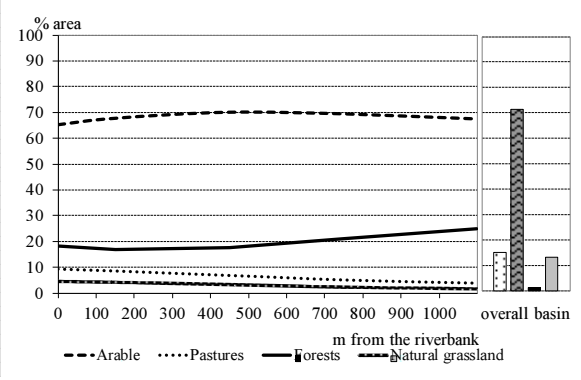

Fig. 7. Change of land use of the Šventoji basin on loam sediments, distance from the bank

Analysis of dispersion of land cover on clay sediments

Arable and other agriculture areas covers almost 47% of the basin area on the sand sediments. Almost 37% is covered by Forests. The percentage of Arable and other agriculture areas varies from almost 24% of the section over 1000 m area to almost 53% of the section 500–800 m area. The Forests varies from 30% of the section 50–200 m to almost 76% of the section over 1000 m.

Conclusions

Dissemination of sediments is uniform in basin of Šventoji river. The basin is covered by loam in average 57% and by sand in 33% of the overall and of the parts of the basin. Loam areas increase moving to the direction opposite the river bank from 40% to 64% of section area; sand areas are the largest near the river, in the section 0–50 m; clay areas are distributed unequally.

Šventoji basin is covered by Arable and other agriculture areas in almost 56% of the overall basin area within its territory and varies from more than 39% to 65% of section area. More than 28% is covered by Forest, increases moving to the direction opposite the river bank, varies from 17% to 45% of section area.

An area of sand sediments of Šventoji basin is covered by Arable and other agriculture areas in more than 32% and decreases from more than 47% to 29% of section area. Forest covers almost 32% of sand sediments, increases moving to the direction opposite the river bank from 33% to 66% of section area.

An area of loam sediments of Šventoji basin is covered by Arable and other agriculture areas in almost 67% and varies from more than 65% to 70% of section area. Forest covers almost 20% of sand sediments, increases moving to the direction opposite the river bank from 18% to 27% of section area.

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