ENVIRONMENTAL ENGINEERING

May 22-23, 2008
The 7th International Conference
Faculty of Environmental Engineering
Vilnius Gediminas Technical University
Saulėtekio ave 11, LT-10223 Vilnius, Lithuania
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INFLUENCE OF WOODY VEGETATION OF REGULATED STREAMS IN SOUTHEAST LITHUANIA FOR THE HYDRAULIC CONDUCTIVITY

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Abstract. The analysis of overgrowing of regulated stream slopes with woody vegetation shows that its distribution on ditch slopes is not uniform. The most favourable conditions for the majority of the species of woody vegetation are on the lower and middle thirds of a slope. At the existing density of woody vegetation (0.01 to 0.68 u.m^{-2}) the roughness coefficient ranged from 0.030 to 0.045. In all investigated stream sections, when spring flood discharge probability is with 10 %, water overflow indicator is positive; the water depth in the bed (z_V) of the natural reaches was lower than the depth of a regulated stream (h_G). The reserve of hydraulic conductivity in the investigated Nemėža stream section is lost when roughness coefficient reaches 0.080.

Keywords: regulated streams, overgrowing of slopes, woody vegetation, hydraulic conductivity

1. Introduction

Rivers and streams are used by people for different purposes. In order to adapt rivers to people's needs a reasonable number of different changes in watercourses have been made. Increasing productivity of agricultural plants resulted in installation of drainage systems in the majority of wetlands; streams (natural watercourses) were straightened, deepened, riverside vegetation and other perennial plants eradicated. Recently both in Europe and elsewhere it has become relevant to review maintenance technologies of the streams regulated for drainage purposes and the practice of their use. New ways are being looked for to harmonize the increase of agricultural productivity and at least partly renovate the ecological balance of the streams. After the reduction of traditional maintenance of the regulated streams in Lithuania spontaneous winding of the bed and other bed processes are taking place. The slopes and riversides of the regulated streams overgrow with grassy and woody vegetation and a bed starts to deform.

Analysing the botanical composition of grassy vegetation [1] and the regularities of its distribution on ditch slopes suggests that plant communities occupy a certain place here. On the upper part of a slope plants that can stand a longer period of humidity shortage during summer droughts prevail, i.e., bent-grass (*Agrostis*), herd's-grass (*Phleum*) and cock's-foot (*Dactylis*). The middle part of the slope is distinguished for the greatest variety of plants as there are the most favourable moisture conditions for the plants here (up to 12 species can be found per 1m^2 area). The plants which like moisture and are moisture-proof prevail in the lower part of the slope. They are sedge (*Carex*) and green reed-grass (*Typhoides arundinacea*). A major danger to hydraulic conductivity of ditches is caused by coarse-stem grass vegetation prevailing on slopes when ditch slopes are not mowed. Prevailing of coarse-stem grass vegetation on slopes is called impoverishment of natural diversity as well. With prevailing of bulrush (*Schoenoplectus*) and especially of common reed-grass (*Phragmites australis*) and great reedmace or lesser reedmace (*Typha latifolia, Typha angustifolia*) hydraulic conductivity of ditches decreases dramatically and the most important thing is that the slowed down flow is not able to bend plant stems and increase hydraulic conductivity of beds in such way during summer floods [2]. If mowing of ditch slopes is not carried out for a long time, woody plants start to grow on them. Most often they are deciduous trees and bushes. The research [3] established that woody vegetation was also distributed in a specific pattern over the ditch slope. The lower and middle thirds of the slope maintain the most favourable conditions for the majority of species, therefore, we can find the largest number of species and stem density is the highest here. A similar pattern is observed in the case of bush distribution as well; however, their abundance and stem density is reduced in a more uniform fashion by going up the slope. Tree distribution was established to be different. The most common and dense growth of trees was observed in the middle and the scarcest growth on the lower part. Therefore, uneven conditions of plant growing in different parts of the slope and unequal demand for moisture by species determined its specific distribution over the slope.

A lot of researchers have written about the resistance of trees and bushes to water flow, their shading impact on the development of grass vegetation and the influence on ditch hydraulic conductivity [4, 2, 5, 6, 7, 8, 9]. Without doubt, any additional obstacle (trees, bushes and grass vegetation) increases the resistance to the flow, decreases the hydraulic conductivity of a ditch and increases roughness coefficient up to 0.147. It was established [10], that in the regulated streams of a smaller basin, when bottom slope is not too low (0.5 ‰ and higher), overgrowing of main canals with course-stem grasses and young trees did not reduce their functions, therefore, there is no need to hurry and remove them. A better attention should be paid to the maintenance of the beds with low slope. Overgrowing of the drainage network of drainage systems with small trees reduces hydraulic conductivity of a ditch which is very important in maintaining its primary function; however, it has a positive impact on the environment. The process of overgrowing of drainage system network with small trees was assessed ambiguously: it reduces hydraulic conductivity but has a positive effect on the landscape structure, decreases deflation probability, accumulation of silt and pollution of water bodies.

Comprehensive investigation of ditch slope overgrowing with woody vegetation, its specific composition and distribution are carried out in the flat relief of the Nevėžis basin [11, 12], where the density of the drainage network (13–16 m. ha^{-1}) is nearly 2 times lower than that in a hilly (28–30 m. ha^{-1}) relief. There have been no similar investigations in Southwest Lithuania so far.

The work objective is the investigation of quantitative and qualitative regularities of regulated streams overgrown with woody vegetation, evaluation of functionality (hydraulic conductivity) changes and possibilities to plan naturalization of the regulated streams in the region of southeast highlands.

2. Research Object and Methods

Field measurements were carried out in the Neris river basin (Fig. 1), the Baltic upland in Lithuania's South and East, in the sections of the regulated streams Bezdonė, Dūkšta, Gnesvianka, G-1, Nemėža, Riešė, Rudamina, Vaišvilė and Vilnoja. In total the length of the observed stream sections amounts to 12.7 km and 110 slope sections. The average selected section length is 10 m. We identified an analysed profile in the most representative place of the section, in which we carried out morphometric measurements of the bed.

In each slope part of the regulated streams (place of dwelling) we identified distribution of the woody vegetation growing there according to the features of certain species, communities and their entirety in habitats:

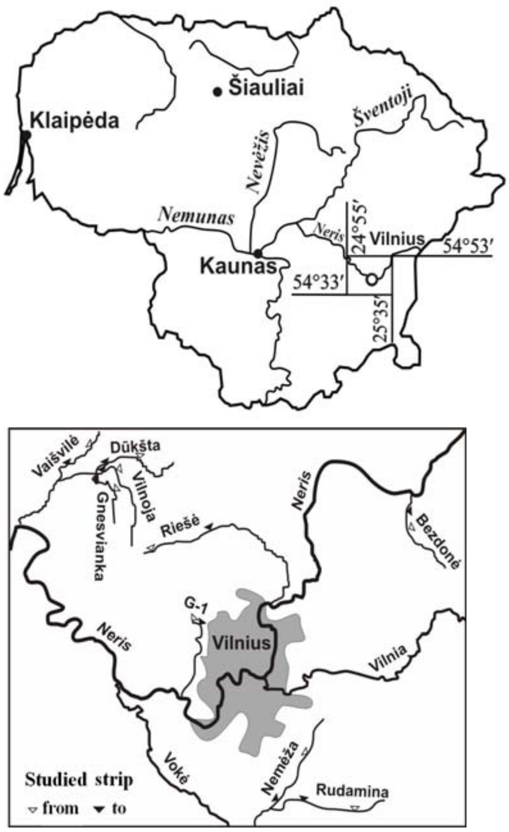

Fig.1. Research location

Number of species (R_{sk}), abundance of individual morphological forms of woody vegetation and individual species.

Incidence (D) – ratio of slope sections where a species was identified with the number of all investigated sections. Density (T) – quantity of stems per 1 m^2 of slope area. A stream bed profile, in which specimens or communities of species are found, is regarded as a habitat of woody vegetation [13].

The number of woody vegetation species (R_{sk}) in place of dwelling with distinction of the upper, middle and lower slope parts was established with reference to the Guide to recognize Lithuanian plants [14, 15]. The data was processed by the methods of mathematical statistics [16].

In establishing the suitability of regulated streams to perform the functions of main canals the main evaluation criterion of their condition is theirs hydraulic conductivity. It is reduced by vegetation – small trees, bushes and grasses growing on the slopes of regulated streams. In order to establish the impact of trees, dense low bushes (willows) and coarse-stem grasses growing on the slopes of regulated streams on hydraulic conditions a methodology of hydraulic calculations [10] was used allowing calculation of emerging hydraulic resistances, water flow speeds and coefficients of hydraulic roughness.

The methodology of hydraulic calculations was made using a formula of hydraulic resistance force of cylindrical stem:

$$T = \gamma C_f K_T H d \frac{\alpha v^2}{2} \quad (1)$$

when γ – liquid volumetric weight;

C_f – stem shape estimation coefficient;

K_T – stem density estimation coefficient;

H – height of submerged stem part;

d – stem diameter;

α – Corioli's coefficient;

v – flow velosity;

g – gravitational acceleration.

Having changed this force with an equivalent pressure flow pressure losses, hydraulic resistance coefficients and hydraulic gradient formed due to these resistances are achieved. Then, the average flow speed is calculated according to the following formula:

$$v = \sqrt{\frac{2gi}{\frac{\zeta}{l} + \frac{\lambda}{4R}}} \quad (2)$$

when i – hydraulic gradient;

g – gravitational acceleration;

ξ – coefficient of hydraulic resistance of tree stems;

l – average distance between small tree stems;

λ – coefficient of hydraulic friction at canal bottom and on slopes;

R – hydraulic radius.

Having calculated the hydraulic roughness coefficients of the regulated streams we used HEC–RAS (River Analysis System) programme to evaluate the influence of woody vegetation on a stream's hydraulic conductivity. Software HEC–RAS created by the Hydrology Engineering Centre (HEC) is designed to carry out one-dimensional calculations of settled and unsettled flow and silt movement. The calculations of a stream hydraulic conductivity is made from a cross profile of one section to another by energy equilibrium equation:

$$h_1 + \frac{\alpha v_1^2}{2g} = h_2 + \frac{\alpha v_2^2}{2g} + h_w \quad (3)$$

when h_1 and h_2 – water depths in the first and second sections;

v_1 and v_2 – average water flow velocity in sections;

α_1 and α_1 – Corioli's coefficients in sections;

g – gravitational acceleration;

h_w – energy losses.

The programme can cover the entire network of beds, either a complicated branched system or a single arm of a river.

While hydraulic conductivity of the regulated streams varied, water levels in the bed were calculated at spring flood discharge with 10 % probability (as it is required by standard documents of hydraulic calculations for systems).

He calculated the established water overflowing indicator in the investigated stream sections was positive ($z_V \leq h_G$), when water depth in the bed (z_V) was lower or equal to the factual (h_G); and it was negative, when water depth in the bed (z_V) was higher.

3. Results and Discussion

Different vegetation (woody vegetation – trees and bushes included) grows on the slopes of regulated stream beds. The research of the streams in the Neris river basin revealed the total number of 32 woody vegetation species, of which 14 tree and 18 brush species. 110 sections of the regulated stream slopes were investigated and 86 of them had woody vegetation. 74 slope sections had both bushes or their forms and 57 had trees. The total incidence of all woody vegetation species on the slopes of regulated streams in southeast Lithuania is 0.76. The incidence of bush outspread is 0.66 and that of trees is 0.45.

The greatest chance is to find common sallow (*Salix cinerea*), common willow (*Salix caprea*) and gray alder (*Alnus incana*) of all species growing on the regulated stream slopes (Table 1).

Table 1. Ten most common species of woody vegetation on regulated stream slopes in Southeast Lithuania ($D\ 10^{-2}$)

Species of trees, bushes	$D\ 10^{-2}$
Common sallow (*Salix cinerea*)	42.73
Common willow (*Salix caprea*)	22.73
Gray alder (*Alnus incana*)	20.00
Black alder (*Alnus glutinosa*)	14.55
Dark-leaved willow (*Salix myrsinifolia*)	13.64
Common birch (*Betula pendula*)	11.82
Brittle willow (*Salix fragilis*)	11.82
Eared sallow (*Salix aurita*)	9.09
European aspen (*Populus tremula*)	8.18
European hazel (*Corylus avellana*)	8.18

The incidence of species indicating the probability of finding a species in a specific location does not show its abundance. With a view to evaluating its abundance we calculated the density of all woody vegetation T and the density of individual stems T_1). The density of average of woody vegetation forms in the investigated 17 regulated stream slope sections T=0.123±0.014 u.m^{-2}, total stem density T_1= 0.351±0.044 u.m^{-2}, trees T_{1m}=0.070 ±0.013 u.m^{-2}, bushes T_{1k}=0.281 ±0.042 u.m^{-2}.

The analysis of overgrowing of regulated stream slopes with woody vegetation suggests that its distribution over the regulated stream slopes is uneven. The most favourable conditions of growing for the majority of woody vegetation species are on the lower and middle thirds of a slope. Here, their incidence and density are the highest. The incidence of woody vegetation on the middle slope part is 0.64 and it is 0.56 at the foot. The incidence on the top of the slope is smaller – 0.46. Similarly, the density of woody vegetation in different parts of the slope varies. The greatest density of woody vegetation is observed in the middle part of the slope – 0.73±0.139 and it is 0.34±0.089 u.m^{-2} at the foot. The smallest density of woody vegetation as well as incidence is observed in the upper part of the slope.

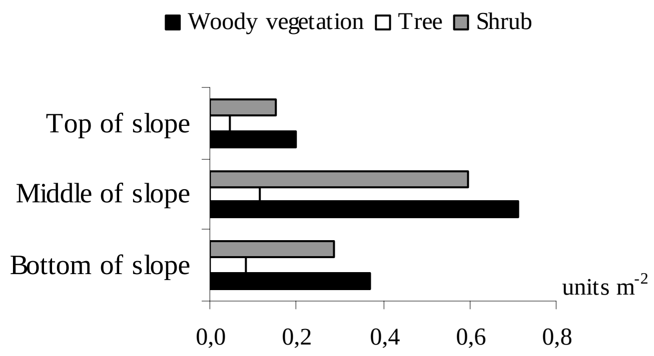

Fig. 2. Distribution of woody vegetation (tress and bushes) density in different parts of regulated stream slopes

Comparing of trees and bushes suggests that the number of trees is always smaller than the number of bushes (Fig. 2). Their greatest density is in the middle part of the slope.

The most favourable conditions for growing of certain species such as black alder (*Alnus glutinosa*) and brittle willow (*Salix fragilis*) are at the foot (Table 2). Their greatest incidence (9.09 %) and density, respectively 0.0079 and 0.0508 u.m^{-2}, were observed there.

More favourable conditions for growing of other species such as gray alder (*Alnus incana*), laurel willow (*Salix pentandra*) and common willow (*Salix caprea*) are in the middle part of the slope. Pedunculate oak (*Quercus robur*), common spruce (*Picea abies*), European spindle-tree (*Euonymus europaea*), smell-leaved linden (*Tilia cordata*), peartree *(Pyrus*) and apple-tree (*Malus*) were found only in the upper part of the slope or in a protective zone. Lamsodis [3] attributes European hazel (*Corylus avellana*) to this group of plants (outspreading of species increases going up the slope).

The majority of regulated streams have the reserve of conductivity and can pass floods under increased roughness (regulated stream slopes are overgrown with grassy and woody vegetation) without overflowing into the valley. However, under specific conditions (too small gradient, too high roughness coefficient) such reserve might be insufficient [12].

The Southeast Lithuanian stream Nemėža was chosen for research. The Nemėža is the Rudamina's tributary. The total length of the stream – 10.3 km – is regulated, basin area is 42.8 km^2 [17]. The nature of windingness is comparatively straight according to Baltrušaitienė [18] (I). The middle part of the stream from measurement point 22 to point 29 was chosen for research. The gradient in the upper part of the investigated section from point 29 to 27 is 4.5 ‰, in the lower part from point 27 to 22 – 0.6 ‰. According to the data of the National Water Management Planning Institute the average discharge with 10 % probability during vegetation period in the investigated section of this river was 0.333–0.365 m^3 s^{-1} and the discharge of spring flood with 10 % probability was 5.11–5.50 m^3 s^{-1}. In the summer of 2006–2007 field measurements of woody vegetation and hydraulic calculations in the Nemėža stream established that the hydraulic roughness coefficient *n* varied from 0.025 to 0.045.

Table 2. Distribution of woody vegetation in different parts of slope

Species	Incidence (*D*), 10^{-2}			Density (*T*) × 10^{-2} u./m^{-2}		
	top	middle	foot	top	middle	foot
Black alder (*Alnus glutinosa*)		1.82	9.09		0.11±0.11	0.79±0.40
Almond willow (*Salix triandra*)	1.82	3.64	7.27	1.09±1.09	1.04±0.88	1.40±0.79
Brittle willow (*Salix fragilis*)	3.64	7.27	9.09	1.02±0.84	3.27±1.78	5.08±2.66
Gray alder (*Alnus incana*)	3.64	20.00	18.18	0.18±0.13	4.00±1.48	3.84±1.58
Common willow (*Salix caprea*)	5.45	18.18	7.27	0.92±0.71	3.63±2.08	2.00±1.75
Laurel willow (*Salix pentandra*)		5.45	1.82		4.36±2.78	0.25±0.25
Smell-leaved linden(*Tilia cordata*)	1.82			0.11±0.11		
Pedunculate oak (*Quercus robur*)	3.64	1.82		0.46±0.41	0.08±0.08	
Norway maple (*Acer platanoides*)	7.27	5.45		1.07±0.82	0.64±0.42	

The carried out modelling established that under present stream roughness from 0.030 to 0.045 spring flood water contained itself in the Nemėža stream and did not overflow (Table 3) and water depth in the bed (z_V) was in all cases lower that the depth of the regulated stream (h_G) and still had reserve.

As the stream overgrows with woody vegetation, roughness coefficient *n* increases.

By modelling roughness was changed from 0.025 (Fig. 3), bed clean, straight, with no shoals or pits) to 0.290 (slopes overgrown with woody vegetation, bottom and slopes overgrown with reeds and other coarse-stem grasses).The carried out field measurements showed that the density of woody vegetation in the Nemėža stream varies from 0.01 to 0.68 u.m^{-2}. When the density of woody vegetation is 0.16 u.m^{-2}, roughness coefficient varies at about 0.034–0.036. The increased density of woody vegetation on the slopes up to 0.24–0.68 u.m^{-2} resulted in the roughness coefficient in the Nemėža stream up to 0.037–0.045. Besides, the regulated Nemėža stream is overgrown with coarse-stem grassy

Table 3. Values of roughness coefficient n and water overflowing indicator in the Nemėža stream, when spring flood discharge is of 10 % probability

Investigated stream sections	Quantity of sections	Roughness coefficient *n*	Water overflowing indicator
NE3, NE4, NE2, NE5,NZ1, NE1, NE7, NE6, NZ8	9	0.025–0.034	Positive, $z_V \leq h_G$
NZ14, NZ16, NZ12, NZ15, NZ13, NZ5, NZ3, NZ4, NZ10, NZ11, NZ7, NZ6, NZ9	13	0.035–0.044	Positive, $z_V \leq h_G$
NZ2	1	0.045–0.054	Positive, $z_V \leq h_G$

Note. z_V – water depth in bed; h_G – regulated stream depth.

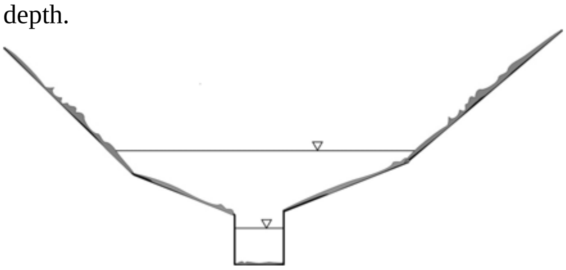

Fig. 3. Water levels in modelled profile, when spring flood discharge is with 10 % probability and the average discharge of vegetation period is with 10 % probability as well (roughness coefficient *n* = 0.030)

vegetation. Its impact on the roughness coefficient was measured as well. The roughness coefficient in other regulated streams of Southeast Lithuania was sometimes higher than in the Nemėža. e.g., when the density of woody vegetation in the Vilnoja stream was 1.66 u.m^{-2}, the roughness coefficient reached 0.057; in regulated Girija stream, when the density of woody vegetation was 2.29 u.m$^{-2)}$ – 0.053; and in regulated Ž–2 stream, when the density of woody vegetation was 5.42 u.m^{-2} (the section had several 1–2 cm thick spread out bushes), the roughness coefficient reached 0.050. In the Vaišvilė stream overgrown with reeds the roughness coefficient was 0.094.

The dynamics of water levels in the Nemėža stream, while modelling stream overgrowing with woody vegetation, i.e. changing roughness coefficient n, at the average discharge with 10 % probability spring and vegetation period flood is shown in Figure 4. When roughness coefficient *n* in a regulated stream is 0.025 and the average discharge of vegetation period with 10 % probability flows along, water level raises up to 156.17 m altitude; it reaches 157.01 m altitude when the discharge of spring flood with 10 % probability flows.

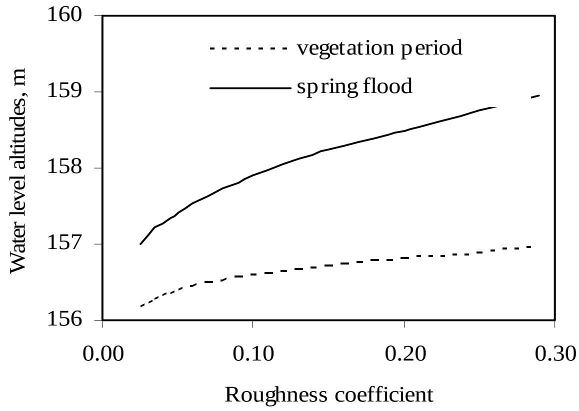

Fig. 4. Water level altitudes in the Nemėža stream, when the average spring flood and vegetation period discharge is with 10 % probability at varied roughness coefficient

Table 4. Water overflowing indicator in the Nemėža stream when spring flood discharge is with 10 % probability

Roughness coefficient *n*	Quantity of sections	Water overflowing indicator
0.025–0.080	23	Positive, $z_v \leq h_g$
0.081–0.135	15	Positive, $z_v \leq h_g$
	8	Negative, $z_v > h_g$
0.136–0.145	13	Positive, $z_v \leq h_g$
	10	Negative, $z_v > h_g$
0.146–0.155	6	Positive, $h_v \leq h_g$
	17	Negative, $z_v > h_g$
0.156–0.165	4	Positive, $z_v \leq h_g$
	19	Negative, $z_v > h_g$
> 0.166	23	Negative, $z_v > h_g$

Note. z_V – water depth in bed; h_G – regulated stream depth.

When roughness coefficient is 0.100, water levels go up to 156.59 and 157.90 m respectively, and when it increases up to 0.200 – to 156.81 and 158.50 m altitude. If roughness coefficient reaches 0.200–158.50 and 156.81 m altitude respectively. When roughness coefficient increased from 0.025 to 0.290 and the vegetation period discharge was with 10 % probability, water level increased by 0.78 and at spring flood discharge with the same 10 % probability – 1.93 m.

Water overflowing indicators while modelling water levels in the Nemėža stream and changing roughness coefficient are given in Table 4. Under present roughness coefficient measured by field measurements (0.025–0.045) all investigated stream sections had positive water overflowing indicators and water depth in the bed (z_V) was lower than the regulated stream depth (h_G) in all cases. Hydraulic conductivity reserve was lost in the investigated section of the Nemėža stream, when roughness coefficient reached 0.080 (Fig. 5).

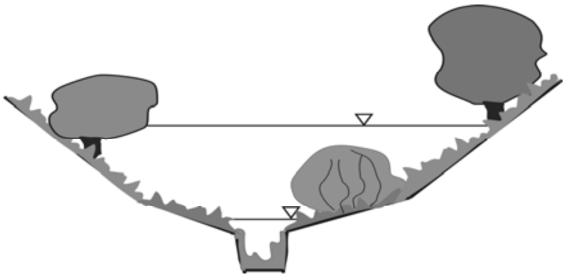

Fig. 5. Water levels in modelled profile, when spring flood discharge is with 10 % probability and the average discharge of vegetation period is with 10 % probability as well (roughness coefficient *n* = 0.080)

Having increased roughness coefficient in the stream sections (0.081–0.135), when spring flood discharge was with 10 % probability, overflowing indicator in 8 sectors out of 23 was negative and the discharge of the mentioned probability did not contain itself in the bed. Having increased roughness coefficient up to 0.140, water overflew in 10 sections, having increased it up to 0.160 – in 19 sections and when roughness coefficient was 0.170 water overflowing indicator was negative in all investigated sections of the stream. Modelling results show that, when roughness coefficient is nearly 0.170, the bed lacks about 0.40 m depth or roughness coefficient has to be reduced down to 0.070–0.080. At such roughness coefficient spring flood discharge with 10 % probability will not overflow the bed.

If the slopes of the Nemėža stream bed overgrew with woody and grassy vegetation and roughness coefficient was higher than 0.070–0.080, a strip clear from trees at the foot of the slope should be arranged; or trees should be thinned on the entire slope; or one slope should be cleared of all vegetation and thus bed roughness coefficient reduced to an accepted value according to the requirements of bed hydraulic conductivity. In the case when about 0.40 m depth is lacking in the bed, woody vegetation should be thinned from 10–11 u.m^{-2} to 6–7 u.m^{-2} (the values submitted are approximate as while carrying out thinning grassy vegetation, the width of the strip overgrown with woody vegetation and bed gradient should be taken into account). When cutting small trees and bushes it is recommended [3] to leave the overgrown southern slope because, as it was mentioned above, the woody vegetation growing on the southern slope will shade the bed, subdue overgrowing of the northern slope or the bottom with grassy and aquatic vegetation and reduce bed silting at the same time. The Nemėža stream runs from the North-East to the South-West, therefore, in future the woody vegetation should be left on the south-eastern slope of the regulated stream. At the moment the stream roughness coefficient has not reached the critical limit. Water overflowing indicator is positive in the entire section of the investigated stream; therefore, small trees and bushes should be removed with consideration. From the hydraulic point of view they should not be removed yet. The stream overgrown with course-stem grassy vegetation (roughness can reach 0.290), could be mowed to prevent spring flood discharge with 10 % probability overflowing the bed. Mowing should be done as periodically [1] as it precludes establishing course-stem grasses on the slopes (roughness coefficient does not exceed 0.080).When the average discharge of vegetation period is with 10 % probability, all attention should be paid to the overgrowing of the regulated stream bottom with aquatic vegetation and the amount of silt on it. The grassy vegetation growing at the foot and submerged in the stream increases roughness coefficient as well and the raised level of water can dam up the mouth of drainage. The experience of other countries, e.g. Holland, shows that certain affluent does not undermine drainage function and at an increased water level plants grow better [12]. When the regulated stream is overgrown with dense grassy vegetation (spring flood discharge) roughness coefficient might not reach the critical limit in the case, if spring flood discharge with 10 % probability would not contain itself in the bed of the regulated stream (water overflowing indicator would be negative) as the snow in winter flattens course-stem vegetation and thus its resistance to the flow is reduced. Moreover, the summertime water overflow into the floodplain in natural unregulated beds happens periodically and is very useful as the water purifies [19]. Therefore, it might be even useful and tolerated when restoring (renaturalizing) regulated streams. All this shows that the issues of bed hydraulic conductivity, their maintenance and restoring have to be solved in an integrated manner, evaluating both economic and environmental needs.

4. Conclusions

The research carried out on the regulated stream slopes of southeast Lithuania showed that among the most prevailing tree species were common willow (*Salix caprea*) – incidence – 22.7 %, gray alder (*Alnus incana*) and black alder (*Alnus glutinosa*) – incidence is 20.0 and 14,5 % respectively. The most prevailing bushes are dark-leaved willow (*Salix myrsinifolia*) – 14.3 and common sallow (*Salix cinerea*) – 42.7 %. It was established that the most favourable conditions to grow for the majority of the species of woody vegetation are in the middle (density and incidence respectively T – 0.73±0.139 u.m^{-2}; D – 0.64) part and at the foot of the slope (T – 0.34±0.0 u.m^{-2} 89; D – 0.56). The least indicators are in the upper part of the slope (T – 0.18±0.049 u.m^{-2}; D – 0.46).

According to growing distribution of different vegetation species on a regulated stream slope three identified types of stream woody vegetation proved the statement that different moisture regime and habitat were typical to the species. The most favourable growing conditions for such species as black alder (*Alnus glutinosa*) and brittle willow (*Salix fragilis*) were at the foot. Other species, such as gray alder (*Alnus incana*) and common willow (*Salix caprea*) prefer growing in the middle part of the slope. Pedunculate oak (*Quercus robur*) and smell-leaved linden (*Tilia cordata*), were found only in the upper part of the slope or in a protective zone. The research established that the density of woody vegetation in the investigated Nemėža stream varied from 0.01 to 0.68 u.m^{-2}. When the density of woody vegetation was 0.16 u.m^{-2}, roughness coefficient reached about 0.034–0.036. The increased density of woody vegetation on the slopes up to 0.68 u./m^{-2} resulted in the roughness coefficient in the Nemėža stream up to 0.045. Now field measurements have established roughness coefficient of 0.025–0.045. In all investigated stream sections, when spring flood discharge is with 10 % probability, water overflowing indicator is positive and water depth in the bed (z_V) is lower than the regulated stream depth (h_G) in all cases. Hydraulic conductivity reserve is lost in the investigated section of the Nemėža stream, when roughness coefficient reaches 0.080. If the slopes of the Nemėža stream bed overgrew with woody and grassy vegetation and roughness coefficient exceeded 0.070–0.080, according to the requirements of bed hydraulic conductivity calculations a strip devoid of trees at the bottom of the slope should be made or trees should be thinned out on the entire slope, or all vegetation should be removed on one slope and thus the bed roughness coefficient would be reduced to an acceptable value.

Thanks to the Lithuanian State Science and Studies Foundation for the financial support.

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