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VEGETATION ON MSZANKA RIVER BANKS 28 YEARS AFTER RIVER ENGINEERING WORKS

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ABSTRACT

The presented research performed throughout 2001 and 2002 on 4 cross sections of the Mszanka river between its 5+039 km and 5+724 km was aimed at assessing the current state of plants covering the banks of the river (a right side stream of Raba river) whose watercourse underwent regulatory works in 1974, namely a combined bars and water steps engineering was applied. It was revealed that well developed plants lining the watercourse properly protected the river banks from being *washed out*, despite slightly inconsistent, with regard to varieties, introduction of trees and bushes. Suitability of several varieties of trees and bushes was found high enough for the purpose of biological development in watercourses of rivers with habitat conditions similar to Mszanka river catchment area.

Key words: mountain river, watercourse, biological development

INTRODUCTION

For the past few decades in Poland various systems of water steps and bars in watercourses of mountain rivers as well as planting plants at rivers banks have been implemented. It took several years for the papers that track the development of the implemented systems and their effectiveness to be published, among which the ones on rivers in Beskid Żywiecki [17], in the area of Orawa Watersheds placed at the foot of Beskid Żywiecki [11], in Beskid Sądecki [12], in the region between Orawsko-Podhalańska Depression and West Beskid [18], in Beskid Wyspowy [19] and many others can be found. A combination of water step - bar systems with system of embedding plants into the riverbanks have been applied to the watercourse of Mszanka river. The presented paper has been aimed at assessing the actual state of plant cover 28 years after regulatory works and 24 years since the biological embedding system was implemented.

METHODOLOGY

The presented research on plant communities and edaphic conditions was carried out in summer 2001 and in late spring 2002 on Mszanka river banks between its 5+039 and 5+724 km (see Fig.1, Photo 1), below the alluvial scree dam that closes systematic combined water bars and steps apllied in the middle and down part of the river course. Low level of waters in the watercourse was recorded during the studies. The state of both the river channel and all the regulatory structures has been reported in a separate paper [14].

Floristic and phytosociological research in the area restricted to four belts, each 5 metres wide, along the levelling cross sections taken at half the distance between the steps (cross sections I-III, Fig.1) and between the step and the alluvial debris fan dam (cross cestion IV, Fig.1) was carried out twice. The cross sections were determined with no reference to the general altitude network by means of tachimetry. A vertical profile of plants at the surface of the belts was assessed, and based on the growth and size (height) standard for overground parts, four layers were defined, namely tree, bush, herb, and moss-lichen layers, noted as layers *a,b,c* and *d*, respectively. Additionally, all varieties of vascular plants were identified, their quantitative characteristics and companionship, along with edaphic requirements were determined by means of Braun-Blanquet method and ecological index numbers proposed by Zarzycki [23], respectively. Moreover, projective land coverage, i.e. the horizontal projection of all the overground parts, with herbal plants along the profile/cross section line were determined with Kostuch method [4].

Fig. 1. Design for watercourse regulatory works on Mszanka river between 5+039 and 5+724 km

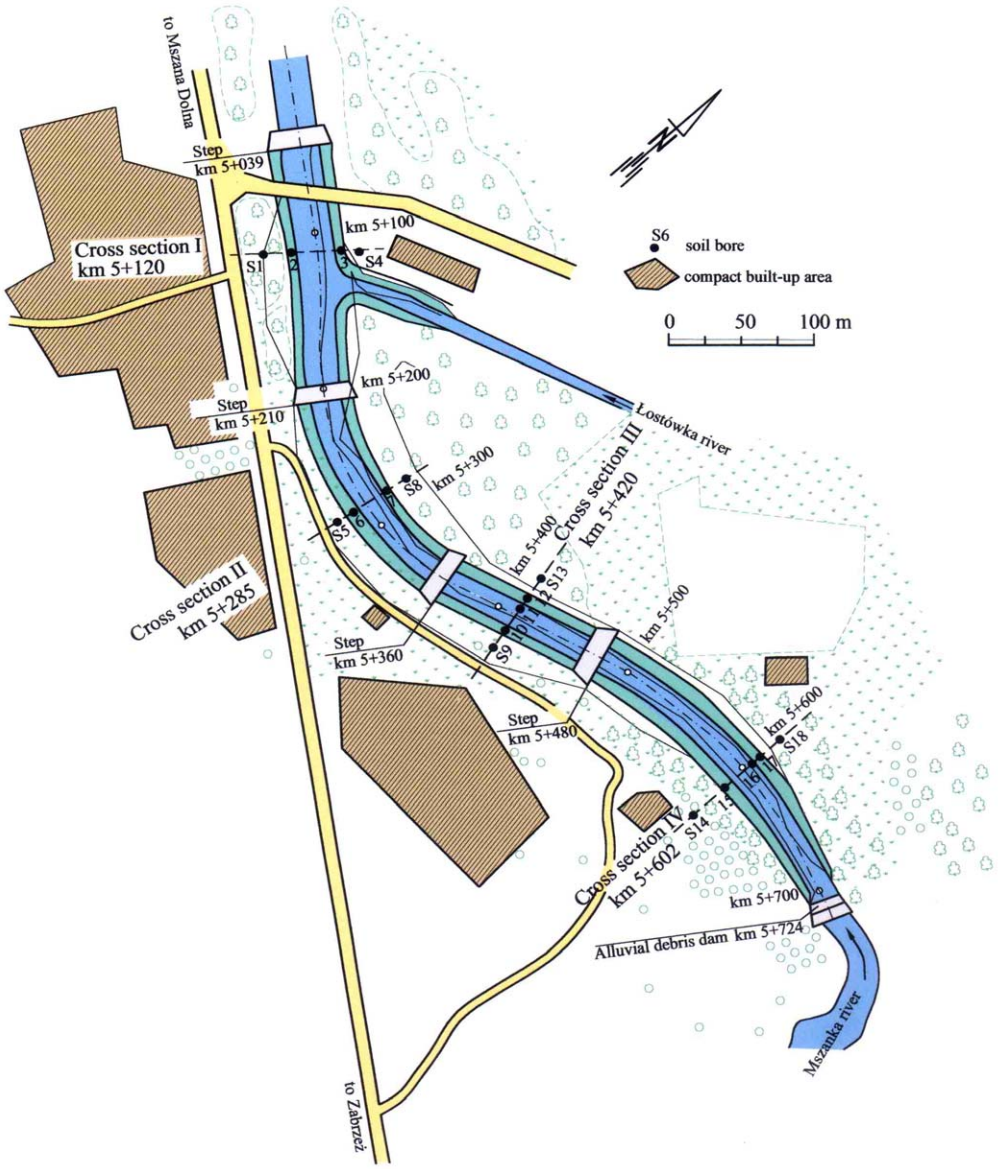


Photo 1. Ortophotomap of the research area

Studies of plant communities were preceded by finding physical and chemical properties of the soil, such as a mechanical composition, pH, and the content of organic matter, potassium, phosphorus and calcium. An analysis of 18 soil samples from shallow (30 cm) bores taken from the centre of the riverbed and from by-watercourse belts for all the cross sections and for alluvial debris for the cross section III and IV (Fig.1) was performed. The following standard laboratory methods were used to determine specific soil properties: a Prószyński modified aerometric Bouyoucos's method for grain size composition of soils, with grade and subgrades assignment according to Polish Standard PN-R-04033 [16]; a destilled water and 1 n KCl solution by a combined electrode pH-meter for pH, a weighted method for organic matter content after annealing at 550°C; an Egner-Riehm's method with a Spekol spectrometer, an atomic mass spectrometer (ASA) with wavelength of 766 nm and 422 nm for the content of available phosphorus, and potassium and calcium, respectively.

RESULTS AND DISCUSSION

According to physical geographical classification of Kondracki [3] Mszanka catchment area is located in the border area of 2 mesoregions - Beskid Wyspowy (513.49) and Gorce (513.52) in a Western Beskids macroregion (subprovince Outer West Carpats), and in J.M.Matuszkiewicz [7] classification it belongs to the West-beskidian Subland (West Carpats Land). With regards to administrative divisions, the catchment area of Mszanka river lies within Mszana Dolna commune area, Limanowa region, voivodship of Małopolska. Mszanka river is a right side stream of Raba river, into which it flows at its 94+300 km in Kasinka Wielka village, the altitude of which is 378 m above the sea level. The springs of the river are located at the altitude of 730 m. Its length equals to 18.2 km, and the area of its catchment area amounts to 174 km^2 [13]. The regulatory works of Mszanka watercourse helped to allow free flow of waters, stabilise the river bed, and to made the side-watercourses to cease, as well as to stop erosion of both the bed and banks of the river, and to limit the movements of alluvial debris. It was also intended to protect the adjacent farmlands, civil structures, such as roads and bridges, and to provide grounds for recreation facilities. The regulatory works have been performed in stages; first works were finished in between the world wars, while the recent ones in the section from 0+000 to 4+000 km were completed as late as 1978. Design and as-built documents for the works performed before 1975 are practically unavailable due to either dispersed archives or loss of the relevant documents in the process of administrative reorganisation, closures of various institutions and endeavours related to the regulatory works projects in the Southern Poland. Parts of documents accessible today that were the base for the presented study, due to their 'random' nature, shall be treated as a source of information that is inevitably incomplete and generalized in its meaning.

Alluvial debris dam at 5+724 km (Photo 2) was built in 1934. During the flood in 1964, both its stone after-basin and the lower part of the dam body were devastated. After 8 years the damage was repaired, both the number and size of spillway chutes for discharging low water were changed during the reparatory works. The bed of the river below the rebuilt dam was faced with a stony blanket. Next restoration works were carried out in 1997, subsequently to the flood. The watercourse of Mszanka at its section below the dam, which is the subject of the research, was regulated in 1974. Heavy machinery was used to shape a trapezoid-like watercourse of 20 to 26 m wide at the bottom, with a 1:5 scarp slope, and 1.6 m of depth, which with long bed slope of 5‰ allowed to carry the flow of water $Q_{5\%}$=109.0 $m^3 \cdot s^{-1}$ (below Łostówka confluence 134 $m^3 \cdot s^{-1}$). 1 m high steps and bars of 0.125 slope from prefabricated concrete elements were also built at that time. The tallest concrete step at the studied section of the river, 26 m wide in the outflow throat, was built at 5+039 km; at 5+210, 5+360, 5+480 km 20 m wide steps were built. Slopes of the after-basins of the steps were reinforced with prefabricated elements of “O”

end “½ O” type (so called Gall chains), whereas for the river bed and the slopes below the end gurts stone-net cylinders of 0.5 m in diameter and 5 m long were used. Places inbetween the steps were reinforced with standard prefabricated elements. Slopes at inside arc and in the region of Łostówka confluence were reinforced with Gall's chains up to the height t=0.8 m, which corresponds to Q50% water fill. In the other sections the footage of slopes inbetween the steps were faggotted with 30 cm in diameter elements. In order to concentrate small flows a 0.2 deep triangle-shaped lowerings in the middle part of the bed and at the cross sections at which bottom steps were positioned were profiled.

Photo 2. Alluvial debris dam at 5+724 km. As in 2001 (photographed by M.Zyguła)

During regulatory works a major part, or even entire system of plants, had to be devastated. Works resulted also in soil degradation which in turn blocked immediately the succession of plants. A new succession, leading to restitution of sets of mountain alder forests *Alnetum incanae* (LÜDI) [6], (AICH. & SIEGR.) [9, 20] that are sub-connected to *Alnenion glutinosao-incanae* (OBERD.) [8], (SEIBERT) [7], of the connection *Alno-Ulmion* (BR.-BL. & TX.) [1], order *Fagetalia sylvaticae* (PAWŁ.) [15], class *Querco-Fagetea* (BR.-BL. & VLIEG.) [8, 10] started in autumn 1974 when the regulatory works and construction of water steps were finished. According to Medwecka-Kornaś [9] or J.M.Matuszkiewicz [7] such sets are typical for carpatian rivers and river valleys.

In years 1978-79 an artificial biological development system was introduced on the banks in the studied section of Mszanka river. The originator of such an idea was Professor Piotr Prochal who at that time was the head of Institute Arable and Forest Land Reclamation at the Agricultural University in Cracow. Fragments of Professor's notes available today read that in the watercourse and in by-watercourse belts, located along the river section between 5+040 and 5+501 km, a total number of 6650 cuttings was planted to stabilise the banks and experiment on the recreation-oriented management of the area. Cuttings of the following species were planted: border forsythia(*Forsythia intermedia*), mountain ash (*Sorbus aucuparia*), mock orange (*Philadelphus coronarius*), Siberian pea (*Caragana arborescens*), bladder-senna (*Colutea arborescens*), basswood (*Tilia cordata*), black and grey alder (*Alnus glutinosa, Alnus incana*), Japanese quince (*Chaenomeles japonica*), wild and rugosa rose (*Rosa canina*, *Rosa rugosa*), blackthorn (*Prunus spinosa*), thin-leaved snowberry (*Symphoricarpus albus*), Van Houtte’s spirea and briodewort (*Spiraea Vanhouttei*, *Spiraea salicifolia*), Lombardy poplar (*Populus nigra*), and a variety of white and tristis willow (*Salix alba*, *Salix alba* “*Tristis*”) and Julianne’s jungle (*Deutzia rosea*). In the vicinity of the water steps also rhizome of butterbur (*Petasites albus*) were planted. Unfortunately, localisation plans of that planting made by Water Engineering Structures Enterprise in Cracow are not available.

Despite disturbances in regenerating the plant cover arising from a close vicinity of buildings and high traffic intensity interregional road linking popular summer resorts, both its floral composition and land coverage is found nearly optimal since at the top of vegetation season, apart from few exceptional turf- free places, no traces of significant surface erosion were detected.

While comparing the plants covering the right and left bank significant differences with regards to the structure of layers can be noted. Disrupted patches of herbal plants and bush stands in the watercourse belt on the left bank results most likely from prefabricated concrete elements applied to secure the slopes. The concrete elements

happen to be covered with mud and grown over at one location, or remain partly uncovered at another. Almost a complete lack of bushes and a scarce number of trees on this bank in wide areas of the by-watercourse belt (Photo 3) along the main and local road, result from the pasture and recreational character of the meadows. On the right bank, especially at its section between the water step at 5+039 km and the cross section IV at 5+602 km, in the space more distant from the buildings and the interregional road, less exposed to devastation plants managed to cover the land with a gąszcz of trees, bush, and herbs almost impossible to explore. They serve a protective and ostoja function, as well as provide a migration corridor for many species of land animals, insects and awifauna, whose importance was highlighted, among the others, by Kostuch and Lipski [5]. Figures 2-5 show schematically localisation of tree and bush stands in the cross sections I-IV, as well as herbal plant belts selected with regards to diversification in the land coverage degree.

Photo 3. Meadow on the left bank of Mszanka river at the cross section I (5+100 km). A concrete step at 5+210 km in the bacground (photographed by M.Zyguła)

Photo 4. Łostówka - Mszanka confluence. Concrete platforms from devastated basin of concrete step after-toe built in Łostówka watercourse (photographed by M.Zyguła)

Fig. 2. Levelling and phytosociological cross section I

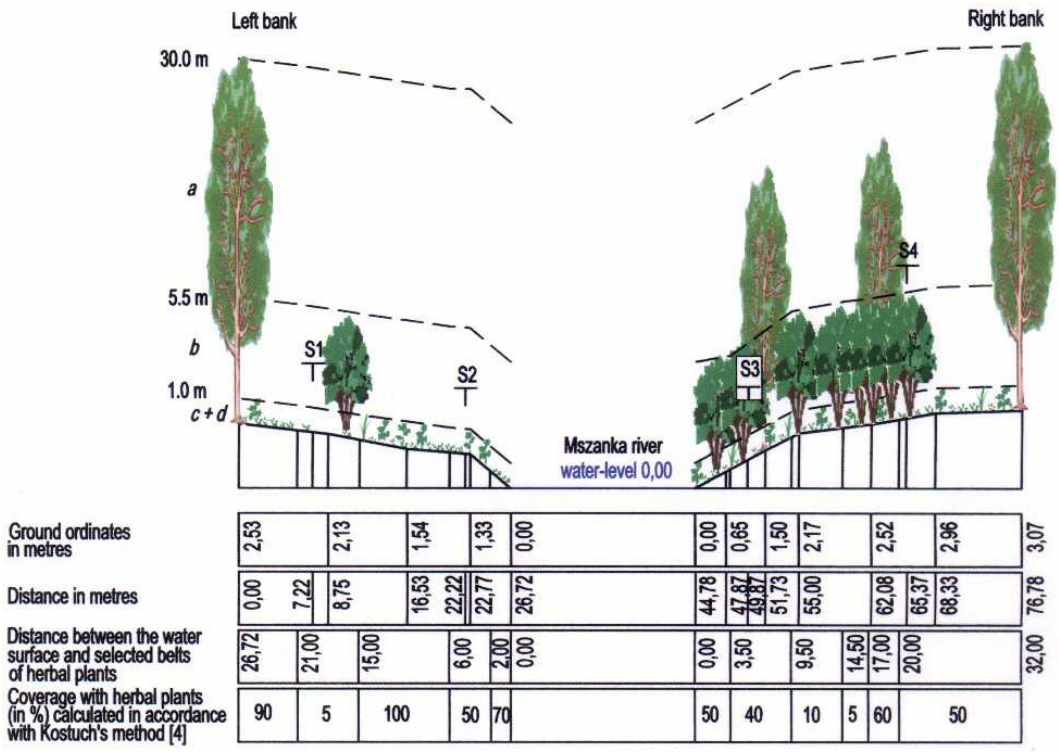


Fig. 3. Levelling and phytosociological cross section II

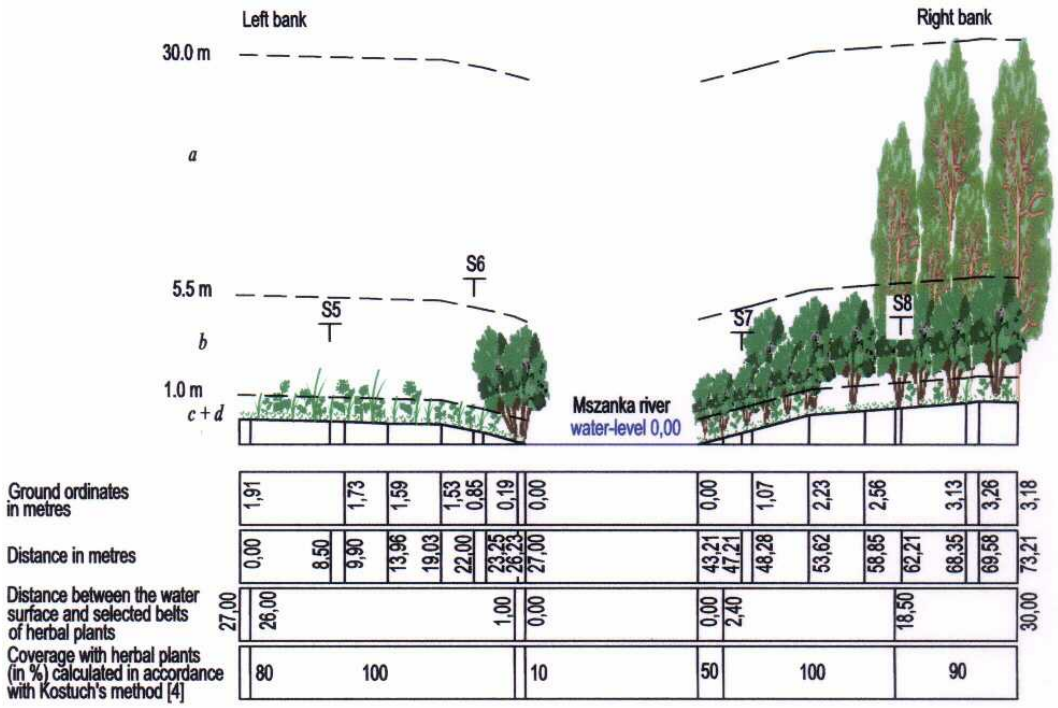


Fig. 4. Levelling and phytosociological cross section III

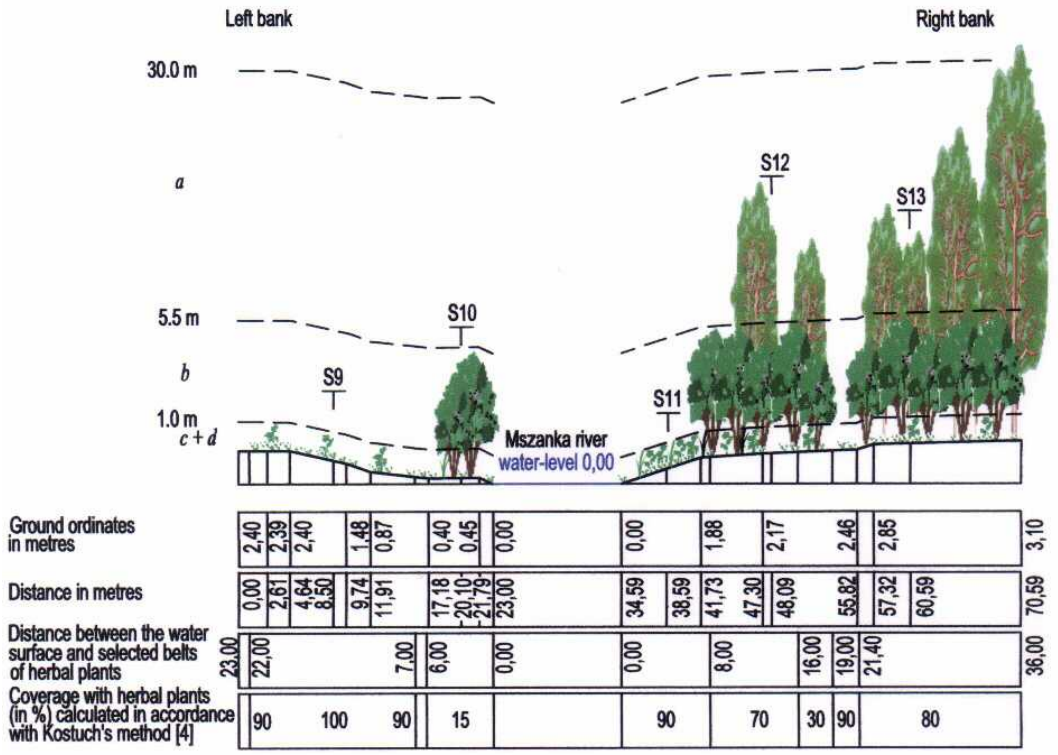
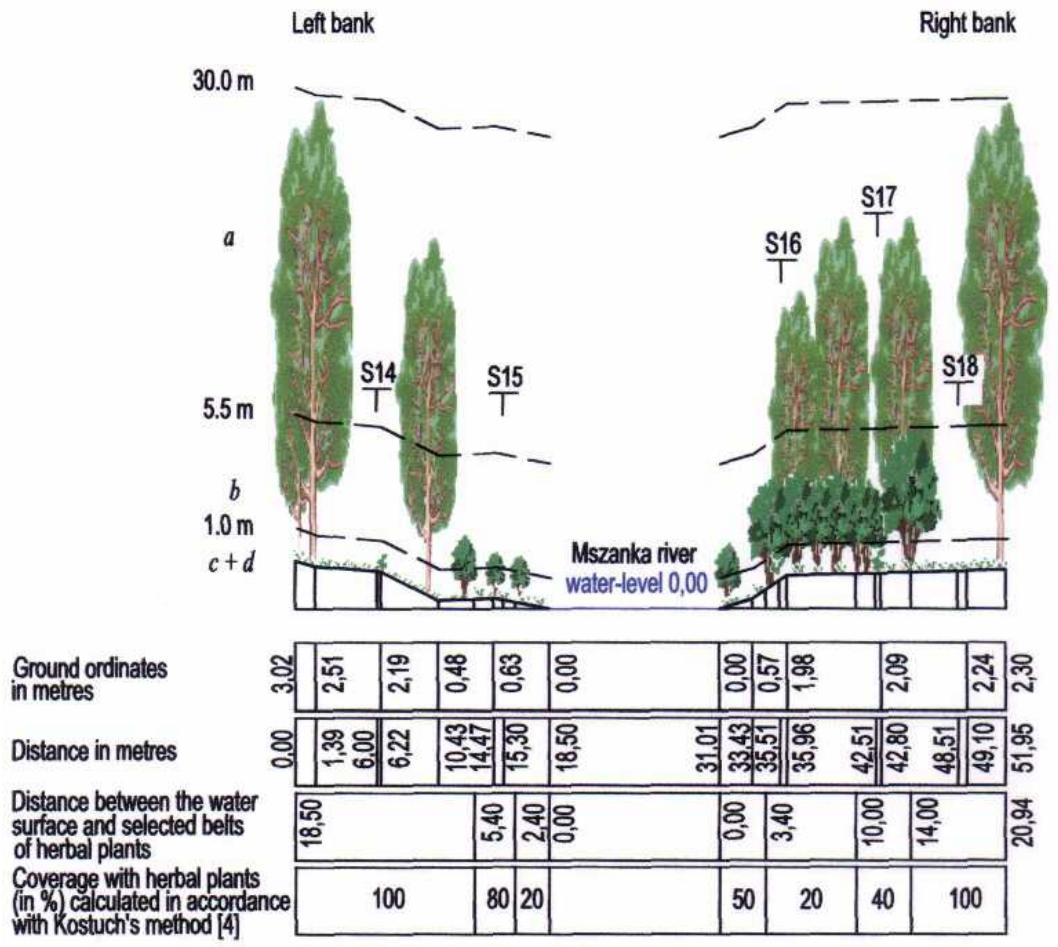


Fig. 5. Levelling and phytosociological cross section IV



The belts along the cross sections I-IV are covered by plants of 129 species as well as other unidentified plants from either the grass family (*Gramineae*) or subclass *Bryidae* (see Table 1). Off all the decorative bushes and trees planted in 1978-79 only mountain ash, mock orange, bladder-senna, wild and rugosa rose, blackthorn, thin-leaved snowberry, Van Houtte spirea and bridewort can be found today. However, their vegetation is poor and they grow at lone stands or in small groups, and mostly are dwarfed.

Table 1.Phytosociological samples collected at belts along cross sections I-IV and Zarzycki´s cological index numbers [23] for identified species

Species		Cross section number								Index marker				
		I	II	III	IV	I	II	III	IV					
		Left bank				Right bank				W	T_r	R	D	H
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
a	*Acer pseudoplatanus*				+					4	4	3-5	2	3
	Alnus incana					1.1	1.1	1.1	1.1	4	4	4	2-4	2-4
	Betula verrucosa						+			no index numbers				
	Fraxinus excelsior						+	+	+	4-3	4	4	4-5	3
	Larix decidua				+					3	2	3	2-4	3
	Padus racemosa					1.1	2.1	2.1	+	no index numbers				
	Populus alba							+		3-4	4	5	3-5	3
	Populus nigra	+				+	+	+	+	3-4	4	5	3-5	3
	Quercus sessilis						+			no index numbers				
	Robinia pseudacacia				+	+	+			2	3	3-5	2-4	2
	Salix alba					+	1.1	1.1	+	4	4	5	4	2
	Sorbus aucuparia							+		3-4	3	2-4	4-3	3
b	*Alnus glutinosa*						+	+		5	4-3	4	5	4
	Alnus incana				+	2.1	1.1	1.1	+	4	4	4	2-4	2-4
	Betula verrucosa						+	+		no index numbers				
	Cornus sanguinea					2.2	2.2	1.2	+	2-4	4	4-5	4	3
	Crataegus monogyna						+	+	+	3	3	4-5	4-5	3
	Frangula alnus						1.1	1.1	+	5-3	3	3	4-3	3-4
	Fraxinus excelsior				+	+		+	+	4-3	4	4	4-5	3
	Malus sylvestris				+					3	4	4	4	3
	Padus racemosa				+	+	1.1	1.1	1.1	no index numbers				
	Philadelphus coronarius					+				no index numbers				
	Pinus silvestris							+		2-4	1-3	1-5	3-4	2-4
	Prunus spinosa					+	2.1	2.1	1.1	2-3	4	4-5	4	3
	Robinia pseudacacia				+	+		+	+	2	3	3-5	2-4	2
	Rosa multiflora				+	+				no index numbers				
	Rubus caesius	+					1.1	2.2		2-4	3-4	4-5	2-4	3
	Salix alba					+	+	+	+	4	4	5	4	2
	Salix purpurea		1.4	3.5		1.2	2.2	2.3	3.2	4	4	4-5	2-4	2
	Salix viminalis					+	1.2	1.2	1.2	4	4	4-5	2-4	2
	Sambucus nigra					+	+	+	2.1	3	4-5	4	4	3
	Sorbus aucuparia							+	+	3-4	3	2-4	4-3	3
	Symphoricarpus albus					3.4				no index numbers				
c	*Achillea millefolium*	+	+.2	1.2					+	2-3	3-4	3-4	4	2-3
	Aegopodium podagraria	1.2	+.2	1.2	1.2	1.1		1.2	2.2	3/4	4	4	4	3
	Agrimonia eupatoria						+	+		2-3	4	5	2-5	3
	Agropyron repens		1.2	2.2	1.2		1.2		1.2	3	3-4	3-5	4	2-3
	Agrostis alba		2.3				3.3	2.2		no index numbers				
	Ajuga reptans	+								3	4/5	3	4	3
	Alchemilla pastoralis	1.1		1.2	1.2					no index numbers				
	Alectorolophus glaber		+							no index numbers				

Table 1 cont.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Alnus incana				+	+	1.2	1.2	+	4	4	4	2-4	2-4
	Arctium lappa	+	+							3	5	4	4	3
	Armoracia lapathifolia	+	+							no index numbers				
	Artemisia vulgaris						+			3	4	4-5	4	3
	Asperula odorata				+					no index numbers				
	Bellis perennis	+			1.1				+	3-4	4	3-4	5	2-3
	Betula verrucosa						+	+		no index numbers				
	Campanula trachelium					+	+			3	4	3-4	4-5	3
	Carduus acanthoides		2.2							3	4	4	3-5	2-3
	Carex fusca							1.2		no index numbers				
	Carex riparia	1.5	+.2	1.2	1.2					5	4	4	5	4
	Carlina acaulis						r			2-3	3	3-5	3-5	2-3
	Carlina vulgaris						r			2-3	3	3-5	2-4	1
	Centaurea jacea			1.1	1.1		+	1.1		3	4	3-4	5	3
	Chenopodium album			+						3	4-5	3-5	4-5	3
	Chrysanthemum leucanthemum			1.1			+			no index numbers				
	Cirsium lanceolatum		2.1	1.1				1.1		no index numbers				
	Colutea arborescens						+			no index numbers				
	Cynosurus cristatus	3.2		2.2	1.2		1.2	1.2	1.2	3	4	4	4	3
	Dactylis glomerata	1.2	2.3	2.2	1.2	+	2.2	1.2	2.2	3	4-5	4-5	4	3
	Echium vulgare						1.1	+		2	3-4	4-5	2-3	2
	Epilobium roseum				+	+		+	+	4-5	4	4	4	3
	Equisetum sylvaticum								+	4	4-3	4-3	4-5	3
	Erigeron canadensis			+						no index numbers				
	Euphorbia cyparissias			1.2		+	+	+		2	3	3-5	2-4	2-3
	Euphrasia rostkoviana	+					1.2			3	4	4	4	3
	Fragaria vesca			+	+	+	1.2	1.2	1.2	3	3	3-4	4	3
	Fraxinus excelsior	+					+	+		4-3	4	4	4-5	3
	Galeopsis tetrahit						+			3-4	3-4	4	4	3
	Galium aparine		+					+		4	4-5	3-5	4-5	3
	Galium verum		1.1				1.1	+	+	2	3	5-4	4-3	3
	Gentiana ciliata								r	no index numbers				
	Geranium pratense			+		+		+	1.1	3	4	4-5	4-5	3
	Geranium robertianum					+				3	4	4	4-2	3
	Geum urbanum					+	1.1	1.1		3-2	4-5	4-5	4	3
	Glechoma hederacea	+.2	+.2	+.2	1.2	1.2		1.2	1.2	3	4	4	4,2	3
	Helianthus tuberosus		+							2-3	3-4	4	2-4	3
	Heracleum sphondylium	+	3.2	1.1	+	+	2.1	1.1	2.1	3	4	4-5	4-2	3
	Hypericum perforatum	+	+	+		+	+		+	2-3	3-4	4	4	3
	Impatiens noli-tangere					+			+	4	4	4-5	4	3
	Juncus conglomeratus	+.2		+						4-5	3	4	4-5	3-4
	Juncus articulatus	+								4-5	3-4	5	4-5	4
	Juncus bufonius			2.2						4-5	3-4	3-5	4-5	3
	Juncus inflexus							1.2		4-5	3-4	4	4-5	2-3
	Lamium amplexicaule	+	+			+	+	+		3	4	5	4-5	3
	Lathyrus vernus						+	1.1		3	4	4-5	4	3
	Leontodon hispidus		+	+	1.1		+		1.2	3-4	4	4	4	3
	Lolium perenne	2.3	1.2	3.4	4.4	+	1.2	2.2	3.3	3	4	4	4	3
	Lotus corniculatus	+	+	1.2			+			3-4	4-3	3-5	4	3

Table 1. cont.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Lysimachia nummularia					1.2	1.2	1.2	1.2	4	4	4	4-5	3
	Medicago lupulina			2.2	1.1		1.1			2-3	3-4	5	4	2-3
	Medicago sativa		+.2	3.2						no index numbers				
	Melandrium album		+							3	4	4	3-4	3
	Melilotus albus		1.1	1.1			+			2-3	3	5	2-4	2
	Mentha aquatica	+		+.2						5	4-3		4	3-4
	Mentha longifolia	+	2.2	1.2	1.2	+	1.2	1.1	+	4-5	4	4-5	4-5	2-3
	Myosotis palustris	+			+				+	4	4	4	4-5	3-4
	Myricaria germanica								+.2	4	3	5	2-4	1-2
	Odontites rubra	1.2		1.2	1.1		1.2	1.2		no index numbers				
	Ononis arvensis			1.1						3	3-4	4-5	4-2	3
	Origanum vulgare						1.2	1.2		2-3	3-4	5	2-4	3
	Petasites albus		2.3	2.4		1.2	1.2	1.2	2.4	4	4	5-3	4-5	3
	Phleum pratense		1.2	1.2					3.5	2-3	3-4	4-5	3-1	3
	Pimpinella saxifraga	2.1	1.1	1.1	1.1	+	1.1			2	3	5-4	2-4	2-3
	Plantago lanceolata	+	+	+	2.2		1.2	+	1.2	2-4	3-4	4	4	3
	Plantago major	+.2	+	2.2	2.2	+.2		+	1.2	3	4	4	4-5	3
	Poa annua	+.2	+.2			+				3	4	4-5	4-5	3
	Polygonum minus	+								3-4	4	4	4	3
	Polygonum nodosum				+					no index numbers				
	Polypodium vulgare							+		2-3	2-3	3	1-3	2-3
	Potentilla anserina	1.2	+	2.2						3-4	3-4	5-4	4	3
	Potentilla reptans			1.2	+.2					3-4	3	5-4	2-4	2
	Prunella vulgaris	+		1.1	1.1					3-4	4	4	4	3
	Ranunculus acris				1.1					3-4	4	4-5	4	3
	Ranunculus arvensis		+	1.1	1.1	+	1.1		+	3	4	5	4-5	3
	Ranunculus repens	1.1	+	+	1.1	+	1.1	1.1		4-3	4	4-5	4-5	3
	Rosa multiflora		+						+	no index numbers				
	Rubus caesius						+	2.2	+	2-4	3-4	4-5	2-4	3
	Rubus idaeus						+	1.2		3	4-3	3-5	4	3
	Rumex acetosa					+			+	3-4	4	4	4	3-4
	Rumex obtusifolius		+		1.1				1.1	3-4	4-5	3-5	4-5	3
	Salix purpurea					+	1.2	1.2	1.2	4	4	4-5	2-4	2
	Salix viminalis								2.3	4	4	4-5	2-4	2
	Salvia glutinosa					+	1.2	1.2	1.2	3-4	4	4-5	4	3
	Sambucus ebulus		+							3	4-3	5-3	2-4	3
	Sanguisorba officinalis	+								4	4	4-5	4	3
	Spiraea Vanhouttei						1.2			no index numbers				
	Stellaria media	+	+		+					3-4	4-5	5-3	4-5	3
	Symphytum officinale	+	+				+			4-5	4	4	4	3
	Tanacetum vulgare	+	2.2	+						3	4		4-2	3
	Taraxacum officinale	1.1	+	2.2	2.2	1.1	+	1.2	1.2	no index numbers				
	Thymus vulgaris	+.2					2.2	1.2		no index numbers				
	Trifolium dubium	+		1.2						3	4	4	4	3
	Trifolium incarnatum	+								no index numbers				
	Trifolium pratense	+	+.2	2.3		+	+	1.2	+	3	4	4	4	3
	Trifolium repens	3.3		+.2	3.3	1.1			1.2	3-4	4	4	4	3
	Tussilago farfara	+.2	+.2	+.2	+.2	+	1.2	1.2		3-4	4	5-4	4-5	1-2
	Urtica dioica	2.2	1.2	+	+	+	1.1	1.2	1.2	3-4	4-5	4-5	4	3-4
	Veronica hederaefolia				+					3	4	5-4	4	3

Table 1 cont.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Vicia cracca	+	2.1				+			3	4	4-5	4	3
	Viola silvestris								+.2	no index numbers				
	Not recognised in grass family (*Gramineae*)	+	+	+	+	+	+	+	+	not assessed				
d	Not recognised in subclass *Bryidae*	+.2	+.2	+.2		+.2	+.2		+.2	not assessed				

Markers assignment:

W – soil moisture indicator
1 – very dry soils
2 – dry soils
3 – slightly dry soils
4 – wetter soils
5 – wet soils
6 – water

R–soil (water) acidity index (reaction)
1 – extremely acid soils (pH usually below 3.5)
2 – very strongly acid soils (pH from circa 3.5 to 4.5)
3 – acid soils (pH 4.5-5.5)
4 – moderately and slightly acid soils (pH 5.5-6.5)
5 – neutral and alkaline soils (pH >6.6)

H – organic matter and humus content index
1 – humus efficient soils (no organic matter)
2 – humus poor soils
3 – mineral-humorous soils
4 – peaty with significant fraction of mineral parts
5 – organogenic soils

T_r–Soil (water) trophic factor (nutrient content)
1 – soils (waters) extremely mineral salts deficient (extremely oligotrophic)
2 – poor)oligotrophic) soils (waters)
3 – moderately poor soils (waters) (mesotrophic)
4 – nutrient abundant (eutrophic) soils (waters)
5 – highly nutrient abundant soils (waters) (extremely fertile, often overfertilized)

D–soil dispersion index (mechanical composition)
1 – rocks and rocky slots
2 – rock waste (rubble), talus, gravel, etc.
3 – sand
4 – sandy-clay soil, clayey-sand soil and clayey with a significant skeleton fraction
5 – heavy clays and silts

Number 1-2 or 2-3 stands for species that grow in the right range (i.e. from 1 to 2), whereas 1/2 indicates that intermediate conditiones between 1 and 2 are adapted.

On the right bank the biggest number of identified species was found at cross sections II and III and reached 67 and 58 species, respectively, whereas at the cross sections IV on the left bank and I on the right bank the corresponding a number of 43 and 45 species were found. On both banks at the belts along all the cross sections grew cow parsnip (*Heracleum sphondylium*), orchardgrass (*Dactylis glomerata*), longleaf mint (*Mentha longifolia*), dandelion (*Taraxacum officinale*) and stinging nettle (*Urtica dioica*). Frequently (at 3 cross sections) ribgrass (*Plantago lanceolata*) and common plantain (*Plantago major*), as well as ground-ivy (*Glechoma hederacea*), creeping buttercup (*Ranunculus repens*), red clover (*Trifolium pratense*) and coltsfoot (*Tussilago farfara*). 41 species were registered to occur on one bank only at the cross sections I, II, III or IV; single occurences of silberdistel (*Carlina acaulis*) and carline thistle (*Carlina vulgaris*) at cross section II on the right bank. It was noted (see Table. 1) that bird cherry (*Padus racemosa*), mountain ash, black locust (*Robinia pseudacacia*) and white willow (*Salix alba*) occured both among trees (5.5-30 m tall) and bushes (1-5.5 m), while european birch (*Betula verrucosa*), dewberry (*Rubus caesius*), multiflora rose (*Rosa multiflora*), purple and basket willow (*Salix purpurea*, *Salix viminalis*) ocured among bushes and also as seedling in the herb layer (0-1 m), whereas common ash (*Fraxinus excelsior*) and grey alder forest (*Alnus incana*) - occured among trees and bushes and aditionaly as seedlings among herbs. Herbal plants grew over the total width of the watercourse and by-watercourse belts, but their communities were found to diversify much with regards to the degree of land coverage as they covered both compact and loose pieces. The highest degree of land coverage by herbal plants, namely 100 %, identified with Kostuch method [4], were found on the external parts of the by-watercourse belts at the cross sections III and IV, while the smallest one (a mere 5%) occurred in the middle part of the cross section I on both left and right bank of the river (see Fig. 2-5). No relation of high significance was found between the degree of land coverage by herbal plants and the distance to the water table, which can be explained in terms of greater influence of the land management in comparison to physical and chemical properties of the land or water conditions. Such influence was pronounced the most on the left bank at the cross section I, where on a 'wild' football pitch only few clumps of annual bluegrass (*Poa annua*) were registered.

The following values determined by means of the method for weighted means of the land coverage were found for the cross sections from I to IV: 55.9% (66.8% and 46.8%), 94.3% (95.9% and 92.7%), 76.6% (77.0% and 76.4%), and finally 75.9% (86.4% and 66.7%); in parenthesis values for the left and right bank, respectively.

Though the species identified on Mszanka banks can grow on stands whose characteristics cover a wide range of edaphic conditions, the major part of them, as determined by ecological index numbers [23], prefer at least fresh (W=3.29) eutrophic (Tr= 4.11) soils from the ones of moderate by poor/low acidity to neutral (R=4.53), sandy-clay, clay-sandy and clay soils with significant skeleton content (D=4.099), similar to mineral-humus with respect to organic matter and humus content (H=2.86); the values in parenthesis represent average value of each index.

Table 2.Selected physical and chemical properties of soils for cross sections I-IV

Cross section number	Bank	Sample bore number	Size classes	Size subclass	pH		Content			
							organic mater	P	K	Ca
					in KCl	in H_2O	weight percent (%)	mg		g
								in 100 of soil		
I (km 5+120)	left	S1	clay	sandy clay	7.65	8.00	0.56	0.06	7.03	2.81
		S2	clay	clay	7.17	7.58	1.74	0.60	10.51	1.64
	right	S3	clay	sandy clay	7.10	7.45	1.51	0.57	6.80	2.07
		S4	clay	sandy clay	7.36	7.80	1.33	0.62	9.81	2.72
II (km 5+285)	left	S5	clay	clay	7.25	7.69	1.28	0.44	15.05	2.14
		S6	clay	clay	6.47	6.87	2.12	0.56	15.63	0.47
	right	S7	clay	clay	7.08	7.60	2.04	3.91	17.18	3.33
		S8	clay	clay	6.83	6.80	2.26	3.61	48.03	2.01
III (km 5+420)	left	S9	clay	sandy clay	7.45	7.73	0.84	0.70	12.21	2.60
		S10	clay	sandy clay	7.37	7.80	0.99	0.32	15.13	2.29
	right	S11	silt	sandy silt	6.67	7.32	1.49	0.50	6.27	0.43
		S12	clay	silty clay	5.72	6.62	0.91	2.33	11.25	0.20
		S13	clay	sandy clay	7.56	7.98	0.56	2.58	12.02	1.48
IV (km 5+602)	left	S14	clay	sandy clay	7.40	7.88	0.57	1.38	7.91	0.60
		S15	clay	light clay	7.27	7.71	0.99	0.65	14.72	1.42
	right	S16	clay	sandy clay	7.51	8.10	0.50	0.75	5.61	2.48
		S17	silt	sandy silt	6.97	7.36	1.31	1.28	6.81	0.52
		S18	silt	sandy silt	7.46	7.80	0.81	0.25	9.13	2.44

Edaphic preferences of plants were confirmed by the chemical and physical analysis of soils properties. The plant induced development of soils at stony and gravel areas that Mszanka banks are built of, started in autumn 1974, with completion of watercourse regulatory works. Recurrent overflows of the river, during which water carried away not only earth but also the thick skeleton prevented a stable development of soil-creative processes, especially in years directly following the completion of works. Currently, as classified by Polish Pedology Association [24], the following soils can be found there: litogenic (Division), mineral carbonate deficient poorly developed (Order), initially loose (Type), in the process of transformation into better developed soils with a profile structure AC-C, of a fen soils type. Surface layers (0-30 cm) of the studied soils were classified with regard to their granulometric composition as sandy, light clay, clay, silty-clay, and silty-sand soils (see Table 2 for details), heavy gravel with 35-60% of skeletal parts. According to a forest soils classification [22], the reaction of the studied soils ranges from neutral to alcalic, which corresponds to water pH range from 6.62 to 8.1, their humus content ranges from deficiency through poor to moderate (0.50 to 2.26 weight % of organic matter), whereas with regards to phosphor and potassium content they were found richer than typical brown mountain fen soils such as the ones described by Uglla [21] after Dobrzański, i.e. moderate or heavy fen soils originating from Rymanów and Haczów area in which P_2O_5 and K_2O contents per 100 g of soil ranged from 1.7 to7.5 and 2.5 to 17.5, respectively.

CONCLUSIONS

The presented research allowed to draw the following conclusions:

1. Diverse and well developed plants lining the Mszanka river provide adequate protection for the banks both at low and high level waters.
2. Only part of experimentally planted species of decorative trees and bushes introduced in 1978-79 managed to survive which proves their rather poor suitability as watercourse protection aid. Planting border forsythia and Siberian pea proved wrong with regards to the site habitat conditions, since they require [2] dry and permeable soils. The same applies to Japanese quince due to its careful maintenance requirements such as regular shoots cutting and deweedeing of the cultivated field. Despite the extinction of basswood and Julianne's jungle species, their disappearance should be most likely attributed to factors of rather a mechanical and devastational nature since both soil and climatic conditions enabled their proper development and growth.
3. However, of all trees and bushes present in the studied section of Mszanka banks dwarf elder (*Sambucus ebulus*), bird cherry, dogwood (*Cornus sanguinea*), common ash, dewberry (*Rubus caesius*), grey alder, blackthorn, black locust, black poplar, white, purple and basket willow, found the most favourable developmental conditions. Therefore, the very species are recommendable for covering river banks at sites with similar habitat conditions. The conclusion is also supported by earlier studies performed at other mountainerous and submountainerous sites of Southern Poland [11, 12, 17-19].
4. Another effective mean of preventing fresh banks slopes from erosion can be accelerating the formation of new herbal plants succession series by planting rhizome of butterbur and sowing the grass or papilionaceous plants seeds, in particular orchardgrass and perennial ryegrass (*Lolium perenne*) and papilionaceae red and white clover (*Trifolium pratense, Trifolium repens*), respectively. All species developed abundantly on Mszanka banks.
5. Maintaining the biological development of the river watercourse in a good state will strongly depend on cultivation practice. It should cover cutting the bush offshoots in both by-watercourses belts, and partial cleaning of the high water cross section (especially in Łostówka confluence point, see Photo 4) from self-seeded-trees and bushes that cause the section to be overgrown and will facilitate even more exuberant growth of herbal plants.

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