

Influence of Melioration in Natural Ecological Processes of a Small River Valley (Poland)

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Abstract—On the basis of the topographic maps from 1933, 1951 and 1962 (sc 1:10 000, 1:25 000 and 1:100 000, respectively) and the satellite image from 2014 (sc 1:10 000), we determined changes in the channel of the small Brynica river (Southern Poland) as well as in the land-use pattern along this river valley after its melioration. Terrain regulation and drainage brought about an intensification of the overland runoff, and a decrease in irrigation of the territory. Due to soil overdrying, some tracts of the valley are experiencing a moisture deficiency. Peat drying can lead to negative consequences, because shallow peats mostly occur on the study territory. Disappearance of peaty soils acts to decrease the degree of suitability of the riverside territories for economic purposes as well as their capacity for recovery. The schematic map of vegetation distribution along the river valley prior to and after melioration as compiled from results of field observations displays differences between mosaic quasi-natural vegetation and areas of typical agrocenoses. The preservation of the natural values along the Brynica valley is possible through balanced economic management, while the differentiation of topography contributes to creating favorable conditions for the formation of biodiversity.

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Melioration of river valleys, including river channels, is a factor that transforms the landscape. This anthropogenic intervention in the natural environment has been and is taking place in significant spaces in Western Siberia [1, 2], along the valleys of medium-size rivers in Belarusian Paliessie and Ukrainian Polissia [3, 4] as well as along the valleys of small rivers. Melioration (including the operation of the melioration infrastructure) leads to multiple transformations within relevant territories, and to changes of land-use patterns causing a transformation of vegetation cover. This process can involve the disappearance of natural attractions of the river valleys [5–9].

The objective of this paper is to ascertain the influence of drainage operations and development of the territory on the natural ecological processes in the upstream stretch of a small river, Brynica (Southern Poland).

OBJECT AND METHODS

The Brynica river totaling 55 km in length flows on the territory adjacent on the north to the Upper Silesian Industrial Region, and then across this industrial

territory. The Brynica is the main right-bank tributary of the Black Przemsza river which, after the confluence with the White Przemsza, flows into the Vistula south of the city of Sosnowiec (Fig. 1).

During 1933–1939, the Kozłowa Góra dam reservoir with an area of 5.5 km² was created for military purposes in the upstream stretch of the Brynica valley, in the former Russian–Prussian border area. It became a part of the Fortified Area of Silesia, some elements of which have remained in the vicinities of this reservoir. Nowadays, Kozłowa Góra has water-economy and recreational-touristic functions [10, 11].

Since the 1950s, the Brynica valley has been undergoing continual transformations associated with melioration. The valley bottom was transformed to extensive territories occupied by meadows. The water management-caused modifications, disturbances to topographic features, and mechanized and intensive economic management gave rise to a peculiar kind of geosystem largely under human control. As a result of the transformation of the hydrographic network and of the morphology of the Brynica channel and all the

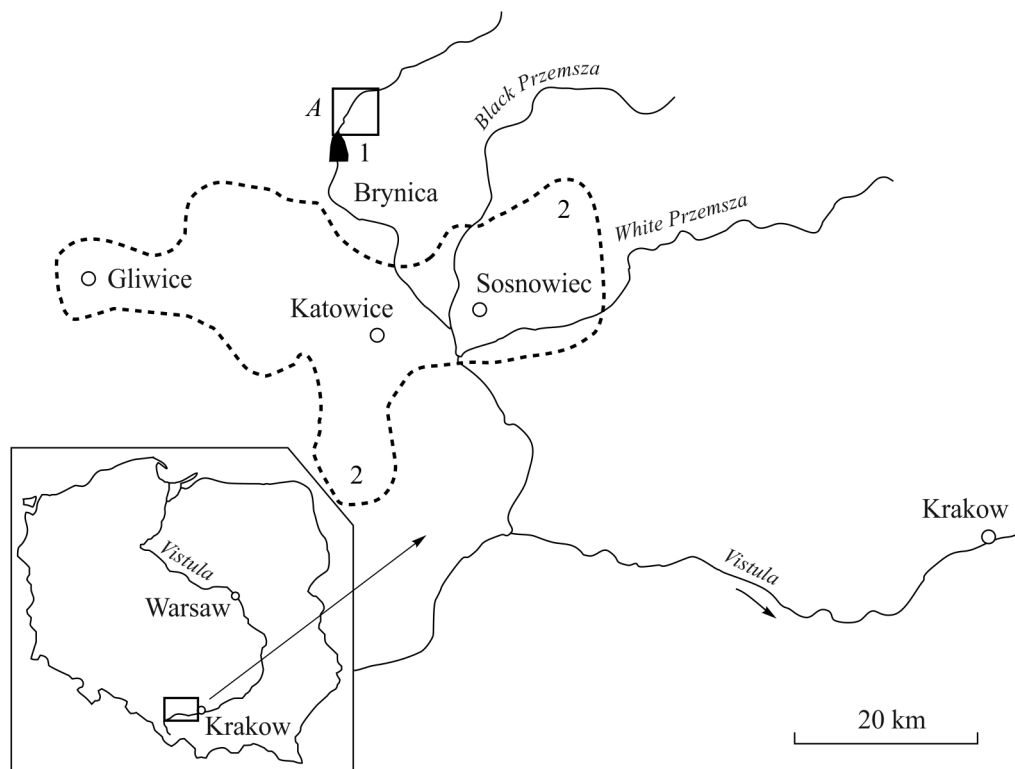


Fig. 1. Location map of the Brynica river.

A – stretch of the valley being analyzed. 1 – Kozłowa Góra dam reservoir; 2 – Upper Silesian Industrial Region.

other streams within the seminatural basin, changes began to be taking place also in other elements of the environment, including in vegetation cover and, in the associated landscape elements.

Environmental changes across the study territory were determined on the basis of the archival topographic maps from 1933, 1951 and 1962 (sc 1:10 000, 1:25 000 and 1:100 000, respectively) and data from a 2014 satellite image (sc 1:10 000). Cartographic material was all calibrated and recorded in Poland CS92 (EPSG: 2180). The rasters as recorded were digitized by means of MapInfo Professional GIS Software.

DEVELOPMENT OF THE BRYNICA VALLEY, AND CHANGES IN HYDROGRAPHIC ELEMENTS DUE TO REGULATION

The currently observed environmental changes along the Brynica valley are the result of its centuries-old evolution. This area was endowed with favorable conditions for agricultural pursuits; therefore, the original economic activities on this territory were associated with agriculture [12]. As a result of deforestation and drainage, the valley changed drastically: there emerged the ecosystem of intensive field and meadow cultures.

In the past centuries, the study territory was distinguished by large reserves of natural wealth.

Historical records testify that this area was home to beaver habitats which began to disappear in the 14th century, and the river abounded with fish (eel, pike, and others) [12]. The Prussian map from 1801 displays forest cover of the territory, numerous ponds, and the meandering channel of the river along its entire length. In the past, the riparian area was notable for inaccessibility, and a rich fauna and vegetation evolving according to the biotope conditions [13]. Such a state of the valley had persisted until the latter half of the 20th century. Before World War II, this area was still dominated by the agricultural-forest landscape with barren spaces in the form of undeveloped lands with herbaceous vegetation. The Brynica with all its tributaries had a broad valley [10, 12].

The first mentions of the human intervention in the natural environment of the Brynica valley go back to the early 19th century when the smeltery with an accompanying small canal were constructed in the vicinities of the village of Brynica, nearby the river. At the end of the 19th century there emerged a mine, whose operation was conducive to drainage of the adjacent territories [13]. In subsequent years, the Brynica valley was undergoing agricultural exploitation with a different intensity. The consequences of melioration are shown in Fig. 2.

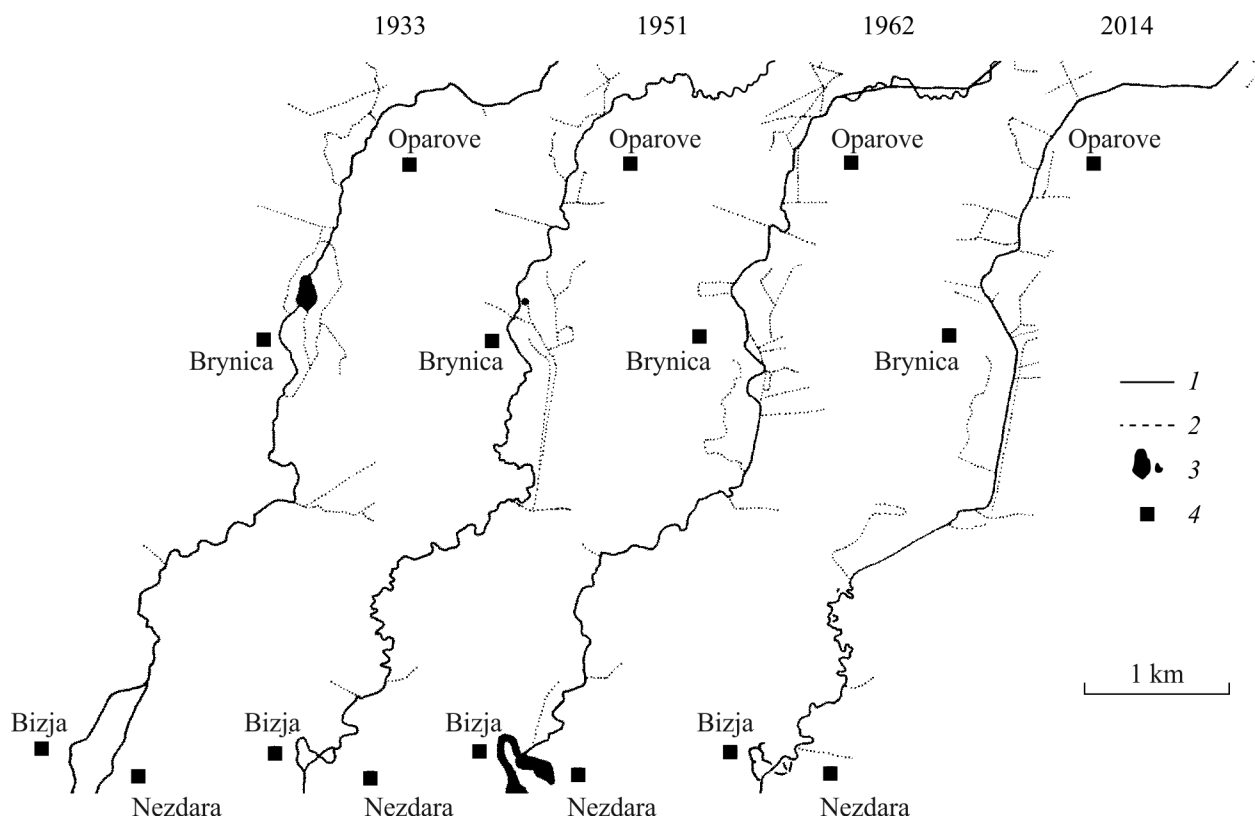


Fig. 2. Change in the course of the Brynica river channel along the stretch analyzed for particular periods.

1 – Brynica river; 2 – other streams; 3 – water bodies; 4 – settlements.

In 1933, the Kozłowa Góra reservoir did not exist yet. The Brynica and its tributaries were characterized by a sinuous course, and the valley bottom was waterlogged. In the southern part of the study territory (the vicinities of the settlements of Bizja and Nezdara), the Brynica channel was represented by two branches, which bears witness to a relatively high morphological activity of the river, and to its possible influence on the landscape of the valley. Nearby the village of Brynica, on the river, there was a pond (it was likely created previously to meet the needs of the smeltery) which had influence on the local natural environment and microclimatic conditions. Melioration ditches were also used at that period.

In 1951, the river still retained its natural, meandering character. The map displays no indication of artificial regulation of the channel, whereas melioration ditches appeared in the valley bottom. The aforementioned pond decreased dramatically in its area. The southern stretch of the river was somewhat complicated by the emergence of two islands; the left branch of the Brynica was eliminated. Since some stretches of the valley were waterlogged, its territory became accessible for agricultural exploitation. Meadows and pastures extended mainly as far as the

river itself. The belts along the channel were occupied by willows and riparian vegetation.

The end of the 1950s – beginning of the 1960s is a period associated with the overgrowing of the melioration ditches with vegetation. At that time there occurred the first regulation stage of the Brynica channel. Its consequences are observed in the northern part of the study territory where a straight reach of the channel was created, which usually bypassed the then existing meanders (not yet eliminated at that time). This contributed to an accelerated outflow of the flood waters. Nearby the village of Brynica, the river channel was connected with a parallel melioration ditch by transferring to it the main flow (and, hence, there appeared an artificial river channel). The reach of the Brynica near its mouth (Kozłowa Góra reservoir) remained unchanged at that period. The valley bottom was relatively waterlogged both along the river and on the meadows, which points to a high diversity of the landscape.

In the subsequent period, all the streams of the Brynica valley were undergoing a planned regulation. The next stages of regulation of the Brynica itself (including the cutting-down of the previously regulated channel and the elimination of the remaining

meanders) together with melioration of the valley were accomplished during 1986–1997.

At present (2014–2015) the Brynica river, except for its reach in the headwaters of the Kozłowa Góra reservoir (the southern portion of the study territory) and several stretches further to the north, is a regulated stream. In the aforementioned zone of the headwaters, the Brynica was never regulated and has retained its natural character. There occur numerous bends differing in size, and unevenly aged cutoff meanders. In the remaining part of the valley, the river (with its straight channel) flows via the hydrotechnical canal to a relatively large distance. A reduction in the total length of the melioration ditches is observed, which might be due to a retrogression of the water level in the river as a result of its cutting down. On the other hand, such a ‘sparsification’ of the network of the canals contributes to mechanical treatment of the soil [14].

The general picture of the melioration-caused changes that have occurred along the stretch of the Brynica river over the last 80 years is presented in Fig. 3, showing the position of the new channel relative to the former channel. The total length of the river here decreased by 1.5 km, i.e. by 20% of its length in the past (and the value of this indicator is still larger for the total length of the Brynica).

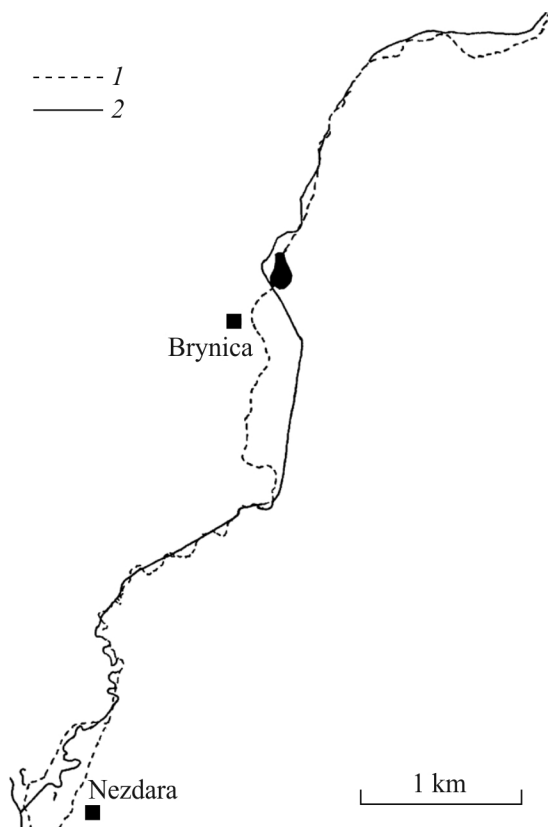


Fig. 3. Comparison of the course of the Brynica river channel in 1933 (1) and 2014 (2).

NATURAL WEALTH OF THE BRYNICA VALLEY AND MELIORATION

Comparison of maps from different periods and analysis of space-acquired images show that the landscape of the valley was characterized by a mosaic pattern prior to melioration. At that time, the riparian meadows were not occupied by monocultures of forage grasses and abounded with dicotyledonous plants of numerous species, which are considered rare to date. The extensive economic practices contributed to the formation of fodder resources for animals, with the preservation of the ecological and aesthetical functions of the landscape. The territories used for agricultural purposes were home to numerous areas of reed vegetation as well as willows.

After melioration, the typical vegetation of the wet meadows underwent a transformation: moisture-loving communities were replaced by communities of typical variably-wet meadows, and the originally paludic biotopes almost disappeared. The cutting down of the Brynica river and its tributaries led to a decrease in the role of fluvio-genic alimentation, owing to which the valley’s vegetation was characterized by a mosaic pattern in the past. The valley landscape became more homogeneous. Hydrotechnical and melioration structures appeared there. The adjustment of the territory of the valley to agricultural exploitation (deforestation and cutting down of the terrain, followed by the monoculture specialization of agriculture) led to the arrangement of the landscape elements in an orderly fashion. However, a landscape of this type is notable for low ecological qualities; it promotes biodiversity to a limited extent as well as having a low aesthetic significance [15].

The measures of regulation and drainage of the area caused an acceleration of the overland runoff and a decrease in irrigation of the territory. Due to overdrying of the soil, some stretches of the valley experience a periodic or constant moisture deficiency. There is a clear tendency toward drying of peats, which can lead to negative consequences, because largely shallow peats occur on the study territory. Mineralization and disappearance of peaty soils act to reduce the degree of suitability of the riparian territories for economic purposes as well as their self-recovery capacity.

The regulation of the Brynica has also had a negative influence on its fauna. The number of potential species is high here; however, the low water level, poor vegetation and a shortage of shelters do not contribute to their further development.

Our observations and field investigations were used in developing the pattern of vegetation distribution in the Brynica valley (Fig. 4). It illustrates the differences between the area of the ecosystem of a seminatural

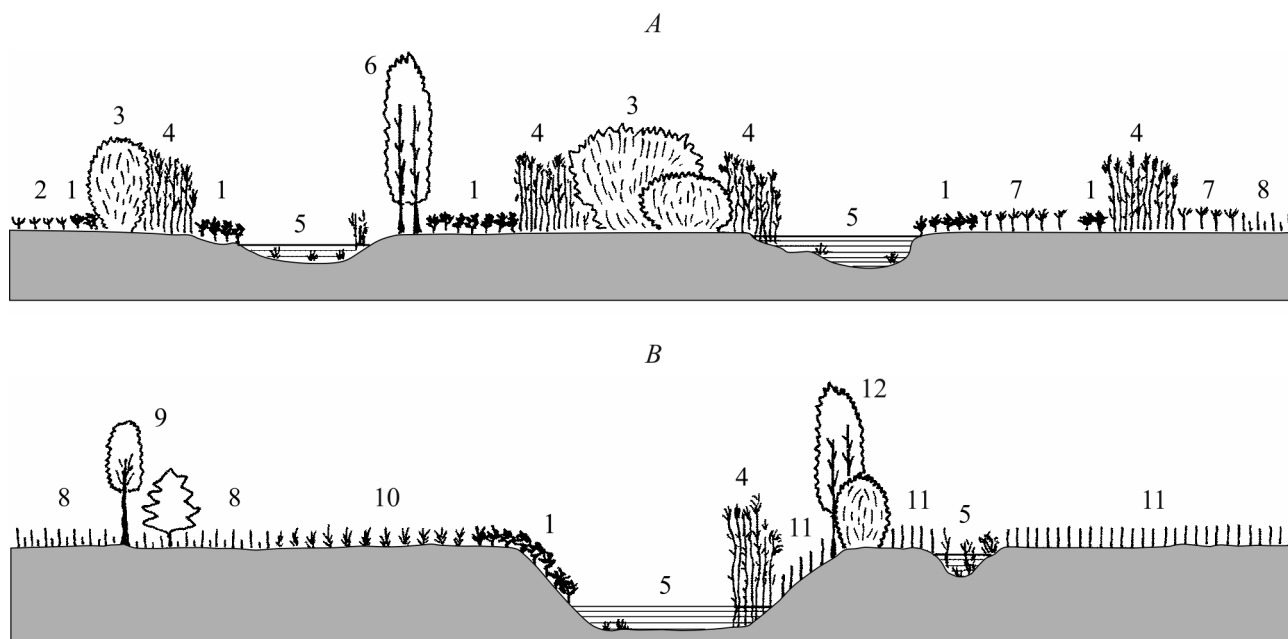


Fig. 4. Vegetation distribution pattern in the valley of the Brynica river along the unregulated stretch (A) and along the regulated stretch (B).

1 – stretches dominated by *P. arundinacea*; 2 – stretches dominated by *Juncus* sp.; 3 – willow vegetation; 4 – *Phragmites*; 5 – aquatic vegetation; 6 – group of *Alnus glutinosa*; 7 – *Carex* sp.; 8 – fallow meadows; 9 – willow and pine stands on fallow meadows; 10 – meadows dominated by *Deschampsia caespitosa*; 11 – seminatural and natural hayfields; 12 – riparian belts of *A. glutinosa* or irregular groups of other tree species.

character and the area functioning as a typical agroecosystem of an artificial origin, a part of which is currently out of crop (a fallow land).

The meadow vegetation in the Byrinica valley is represented largely by the ryegrass community of *Arrhenatheretum elatioris*. The area is dominated by anthropogenic meadows, and the area of the seminatural meadow is difficult to determine. There also occur numerous communities dominated by *Deschampsia caespitosa*, which are likely due to mismanagement of the fertile meadows with plant species of the Molinietalia order. Floristically, they are not very rich and, in some places, show a tendency toward swamping.

The plant communities covering the Brynica banks are relatively poor as is the bottom vegetation, especially in areas paved with chiseled plates and stones. Some of the areas have ecological and aesthetic functions (shrubs, scattered trees, and shallow ditches with stagnant water overgrowing with vegetation); in general, however, this area is dominated by a monotonous agricultural landscape.

Because of a decrease in intensity of land use within the areas that have long not been exploited, there occurs an initial stage of forest succession giving rise to emergence of birch or pine forests of a low ecological significance. Local vegetation differs

noticeably from potential vegetation associated with the biotope conditions.

The stretch of the Brynica valley in the zone of the upper pool of the Kozłowa Góra reservoir differs greatly from most territories of the quasi-natural basin. This stretch never underwent regulation and, hence, it has retained (like very few other territories) its original appearance thus preserving its potential and natural attractions. The river channel within this stretch has natural features and is accompanied by numerous water-filled cutoff meanders, and by flooded areas. All this creates favorable conditions for self-recovery of the territory in spite of the fact that it was used for agricultural purposes in the recent past. The plant communities also show some differentiation accompanied by a rich fauna. Upon cessation of land use, the study territory developed a typical bog vegetation. Of universal occurrence are *Phragmites* and *Carex* sp. There occur areas with *Glyceria maxima*, *Juncus conglomeratus*, *Typha latifolia*, and large groups of *Iris pseudacorus*. Typically, the areas overgrown with *Phalaris arundinacea* are extended along the river. This locality is diversified by willow vegetation, and by groups of alder. The bottom of the streams are home to phytocenoses of freshwater macrophytes of the classes Charetea, Lemneta, Littorelletea and Potamogetoneta.

The floristically rich river bends are home to the fauna of invertebrates as well as to numerous amphibian species. The belt of riparian vegetation provides nesting places and shelter for various species of the avifauna: aquatic, aquatic-paludal and reed vegetation. The banks create a good migration corridor.

The stretch of the Brynica valley being analyzed was recently colonized by beavers (*Fiber castor*). Water flooding of the locality as a result of beaver activity acts to accelerate the development of vegetation and increase the activity of the fauna. The areas at some distance from agricultural lands are experiencing a steady increase in biodiversity [16].

The stretch of the Brynica valley which is examined in this paper and is rich in attractions also undesirable phenomena, such as the widespread emergence of *Urtica dioica*. This is due to dramatic pollution of the surface waters as a result of intensive application of artificial fertilizers in the recent past as well as to mismanagement of waste water at present.

In spite of a significant degree of melioration transformation, the Brynica valley still remains endowed with natural assets, the bioresource potential and the self-recovery capacity. An increase in the area overgrown with woody vegetation and undergoing paludification due to beaver activity dictates a need for a further improvement of the natural value of this territory.

Nowadays, in the Brynica valley there is no way of totally eliminating the economic activities which have been pursued for hundreds of centuries. The preservation of natural assets is possible only through balanced economic management, and the differentiation of landforms on this territory creates favorable conditions for the formation of biodiversity.

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