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Międzyodrze: an example of diverse economic and nature-related activities in the part of the Lower Odra Valley

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Abstract

Międzyodrze is an area in Lower Odra Valley, from the fork of the riverbed to Szczecin, with the islands between the Odra River and Lake Dąbie. In the past, it has served primarily as a waterway route and now serves a variety of economic and nature-related functions. This paper presents the historical and present role of Międzyodrze, taking into account the specific natural values of the Lower Odra Valley, hydrography, hydrology and soil conditions.

In the area of Międzyodrze, there are basically three types of organic matter and the nature's point of view, the area is rich in flora and fauna.

The current stimulation to activity of Międzyodrze is to take account of the needs of the natural environment, tourism and recreation, while improving the hydrological and retention potential of the area. Exceptional natural values, complicated hydraulic system of canals, the complexity of hydrological phenomena and the specificity of soils make the selection of activities aimed at achieving the objectives of area revitalization requires comprehensive environmental and hydrological analyses as well as economic analyses. The paper outlined the range of difficulties encountered by this assessment.

Key words: *activity, hydrography, hydrological conditions, Lower Odra Valley, Międzyodrze, natural conditions*

GENERAL GEOGRAPHIC AND HISTORICAL OUTLINE OF THE AREA

Międzyodrze is a geographical name of the area located in Lower Odra Valley, between its two arms: the Western Odra and the Eastern Odra, also called Regalica [JASNOWSKI 2002]. The area extends from the Odra fork north of Widuchowa village to the Iński Nurt Canal (Fig. 1). The Międzyodrze area also includes the islands situated between the Odra River and Lake Dąbie and often includes areas of similar character east of the Regalica River and west of the Odra River, although they are not located between the arms of the river.

The area in question extends 1.5–3.0 km wide and 30 km in length, beginning from Widuchowa through Gryfino to Szczecin. It occupies an area of 5.72 thousand ha, including grassland (4.27 thousand ha), closed waters (lakes, old river beds) – 800 ha, dense forests (380 ha) and protective embankments (270 ha),

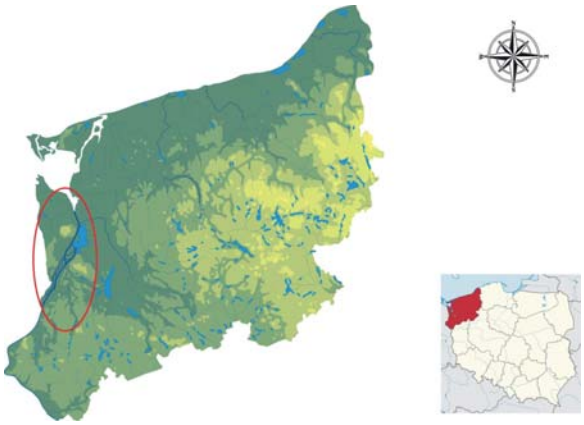

Fig. 1. Location of the Międzyodrze district; source: own elaboration

formerly used as flood embankments (at present they are registered as excluded from use) more than 70 km in length. It is a floodplain of the Odra River, part of the Szczecin Lowland, located relatively low, since its elevations range from 0.3 to 0.5 m a.m.s.l. [JASNOWSKI 2002].

Lower Odra Valley along this stretch has clear edges of the diluvial upland with steep slopes, composed of moraine clay with a mixture of sand, gravel and pebbles [DOBRACKI, PIOTROWSKI 2002]. The bottom of the valley is filled with Holocene sediments in the form of alluvial deposits of water origin and deposits of organic origin. The valley is a landmark section of the river, whose waters flowing from the Toruń-Eberswalder proglacial stream valley to the Odra Lagoon through the moraine hills of the youngest stage of the last glaciations have eroded, after the glacier has receded, a deeply indented and wide valley. As the amount of runoff was decreasing, the river disintegrated into a number of interconnected arms and river basin erosion products settled in the valley. In the first phase they were gravel and sands, often mixed with loam. At the rising valley floor, the configuration and location of the troughs, through which the water was flowing down, were changing as a result of declining accumulation. In proglacial lakes and old riverbeds, the organic deposits began to accumulate.

At present, the thickness of organic matter in the bottom of Międzyodrze reaches 20–30 m. The generalized geologic profile is as follows: under a 5–9 m thick layer of hydrogenic matter there is a layer of loam, clays or sand with some loamy fraction, and further down to the diluvial deposits – a layer of fine sand 15–20 m thick, with gravel underneath [KRZYWONOS *et al.* 1979].

The area of present Międzyodrze was included in the plans of the city as a warehouse already in medieval times, partly fortified with hard-to-reach marshy areas [PASZKOWSKI 2009]. There was navigation in the waters which was significantly impeded by shoals, trees, numerous dams and weirs. At the turn of the thirteenth and fourteenth centuries trade was conducted, while the rulers granted cities the right to form a settlement network. In addition to the physical impediments, there were also legal obstacles prohibiting the export of goods outside urban areas. It was possible to sell goods or leave them in city warehouse. Gartz, Szczecin or Gryfino competed for commercial influence. In 1283 inhabitants of Szczecin built the Long Bridge and the levee across Międzyodrze to Lake Dąbie. These buildings made it possible to stop Gryfino and Gartz vessels traveling to Szczecin Lagoon in order to collect fees and enforce the composition law. This forced the inhabitants of Gryfino and Gartz to build their own dykes and bridges with the possibility of collecting the same fees as by the bridges on the Szczecin dyke. These clashes lasted until the 15th century, when Szczecin's domination forced other cities to transform into merely river ports [URBAŃSKI 2004].

Up to the 18th century, in the area of the Odra River marshes outside Szczecin no new investments were made, although the levees by Międzyodrze still functioned in communication. The defensive structures were exceptions. In 1631, after Gryfino was conquered by the Swedes, defensive forts (Cłowy and Wielki Gryfiński) were erected in Międzyodrze, forming a defensive barrier for the city on the western side. Almost half a century later, the Swedes destroyed all bridges and fortifications on the side of the river before retreating from the city [URBAŃSKI 2004].

In 1717 the Inspectorate for Melioration of Łęgi Odrzańskie area was established. By the end of the 18th century, a number of hydrotechnical works were carried out. On the stretch from Hohenwutzen to Szczecin, aiming to capture the river in one trough after the side arms have been developed and slightly shortened. In 1899 in the Odra Regulatory Board of the Szczecin Construction Authority a project was developed under the slogan "To improve the drainage on the Lower Odra River". The construction work was carried out from 1906 to 1932, and the finishing work was continued until 1937. The investments were designed and executed with great vigor. A total of 33 km of excavations, 177 km of embankments and 129 hydrotechnical buildings were made [URBAŃSKI 2005].

The construction of the region lasted for 20 years and contributed to the significant stimulation to economic activity of the region. Essential works, including the construction of embankments, canals, pump stations and sluices were completed by 1930. As a result of the Odra River training, 17 polders were created, of which 7 were located within Poland after World War II (3 polders of Międzyodrze and four outer polders on the right bank of the Odra River [DUDA, BORÓWKA 2007].

After World War II the area was located within Poland, in the present West Pomeranian Voivodeship with its capital in nearby Szczecin. The Polish-German border runs along the Odra River up to the river fork in Widuchowa, and from the fork to the Gryfino

area – to the Western Odra, diverging from the river towards the northwest [URBAŃSKI 2005]. At present, the area of Międzyodrze serves various functions: communication and transport, fishing, agriculture, commercial, settlement, industrial, recreational and ecological.

The paper attempts to characterize Międzyodrze, taking into account the natural values of the Lower Odra Valley and an assessment of its anthropogenic impact on the environment in the light of the planned hydrotechnical activities and the development of tourism.

HYDRO- AND PHYSIOGRAPHIC CHARACTERISTICS OF MIĘDZYODRZE

HYDROGRAPHY AND HYDROLOGICAL CONDITIONS OF THE LOWER ODRA AREA

Both the Lower Odra and the entire Odra estuary have been intensively changed by humans [CHALFEN *et al*. 2014; OLSZEWSKA *et al*. 2014]. At the end of the 19th century and at the beginning of the 20th century, the Eastern Odra River bed was dug over and formed in its current setting. It is the main navigation riverbed with a depth of 4.0 to 9.0 m and a width at the average water level of 140–180 m. A weir was built at Widuchowa on the branch of the Western Odra; the Klucz-Ustowo ditch and the Parnicki ditch were made as well as the Mieleński ditch, the largest and deepest (up to 11 m). A number of canals and port basins were also constructed and Międzyodrze polders were made. These undertakings have completely transformed the estuary of the Odra River and significantly extended the reach of the sea to the upstream of the Odra River.

The Odra is a border river from Gozdowice to Widuchowa (Fig. 2). Its average depths range from 1.5 to 3.5 m. Eastern Odra River stretches from Widuchowa junction to Lake Dąbie has a width of 160 to 200 m. The Western Odra beyond the Widuchowa weir has diversified depths of 3.0 to 10.5 m and a width of 160 to 200 m. Both arms of the Odra River, the Eastern and Western, have a number of unmanageable connections, the most important of which are, beginning from the north, Mieleński ditch, Parnica, Kandy Odyniec, Klucz-Ustowo ditch (Skośnica), Gryfiński Canal.

In the estuary part of the Odra River, its waters, before reaching the Baltic Sea, flow through a very complex, dense network of basins that consist of: Międzyodrze river network (Fig. 2), Lake Dąbie (the Eastern Odra River) and Roztoka Odrzańska, then the Szczecin Lagoon and three straits, through which the Odra waters flow into the Baltic: Piana in the west, Świna carrying about 85% of the Odra waters [BUCHHOLZ 2007] and Dziwna in the east.

The estuary of the Odra is a type of estuary in which sea water rises upstream as a result of so-called backwater caused by the wind energy, which simultaneously changes both the water level in the mouth of the river and the waves that push the seawater inland, and where there is mutual interaction between the sea water and freshwater. So, there are a whole range of impacts there, such as water quality, water level, water flows, velocities, currents, and flow directions. They are caused by various factors such as: the condition of sea under the influence of winds and atmospheric pressure fluctuations (seiches) and the inflow of the Odra waters, i.e. the flows and levels of water in the Oder River. Having analyzed various factors and phenomena BUCHHOLZ [2007] has concluded that the range of the estuary part consists of the whole area of Międzyodrze described above stretching from the river fork at Widuchowa to the sea.

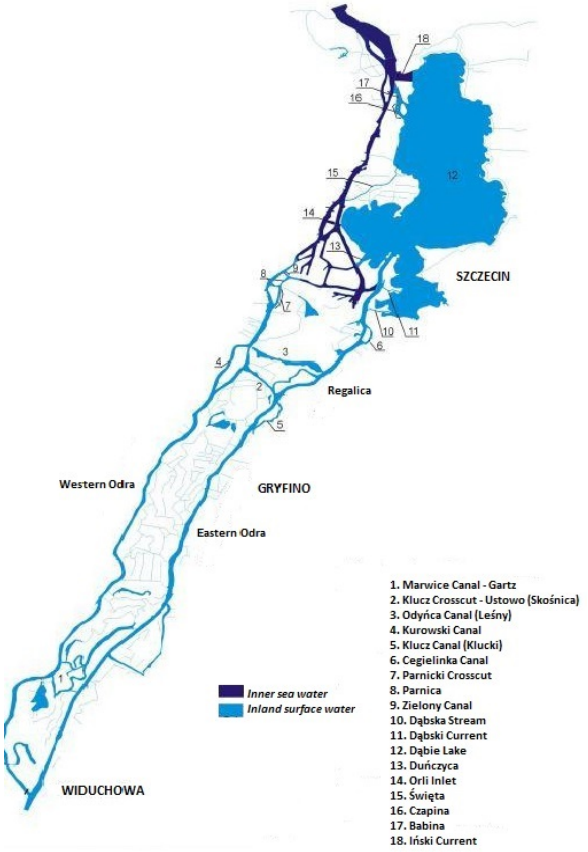

Fig. 2. The hydrography of Międzyodrze and the Szczecin water junction; source: The Regional Water Management Authority, Szczecin, modified

The specific hydrographic conditions resulting from the complex network of river beds and canals, combined with Lake Dąbie, Szczecin Lagoon and the straits that link with the Baltic Sea to "bring" seawater into the area in certain weather periods, have created a hydrological and hydrodynamic regime in Międzyodrze. BUCHHOLZ [1991; 2007] correctly described it as "a unified and combined fluvial-marine organism that can be compared to a system of connected vessels...". An additional factor shaping the hydrology and hydrodynamics of the river network are: the operation of the weir at Widuchowa and the flow of water through the uncontrolled polders of Międzyodrze and

Lake Dąbie along with the retention of these water bodies. Approximately 60% of the area of Międzyodrze is between 0.3 m and +0.5 m a.m.s.l. NN and when the water level in Szczecin Lagoon (sea) is higher than the average, they are flooded [BUCHHOLZ 1991]. In the present condition of Międzyodrze, the process of exchange of water between the canals and the arms of the Odra River (Eastern and Western) in the described hydraulic system is severely disturbed for many reasons. This area, first subjected to strong human control (desludging, water level control, etc.), and then left alone to become considerably slimed, which seriously diminished the hydraulic declines in particular canals and led to a situation in which there is almost no water outflow from large areas of Międzyodrze, and therefore there is no influx of fresh water. For these reasons, despite the dense network of canals – which may seem to indicate water conditions favorable to hydrological exchange – the exchange is very difficult and limited. The main cause of unfavorable changes is the blocking of flow on the existing water facilities (sluices, weirs) and in canals. Failure to use the area has led to the devastation of nature and vandalization of devices. As a result of thefts of the mechanisms and bars of the existing sluices and gates, and the leaving many elements in the bottom of the inlets or outlets in the structures, there was a severe disturbance in the movement of rubble between the area in Międzyodrze and the riverbeds of the Eastern and the Western Odra. This makes the exchange of water and fluvial rubble movement in many places impossible. This has led to considerable canal sludging, reduced speed and disappearance of water flow, important for the growth of rush plants and floating aquatic plants (Statiotes aloides type), which prevents even the touristic use of the canals. The processes described by BUCHHOLZ [2007], characteristic of such estuaries, favorable for natural regeneration and beneficial for flood protection of the Międzyodrze areas, are disappearing. The phenomena mentioned cause the disappearance of the natural retention of the area, which is changing as a result of water movement to and from the sea. The river estuary, typical of such estuaries, is characterized by the processes described by Buchholz, which are beneficial for the natural regeneration of natural values and are favorable for protection against floods in the Międzyodrze area.

These interactions between the sea waters and the Odra River, mentioned above, cause that the relation the water level – flow (flow curve) for the estuary part of the Odra River is only maintained for the Odra River section from the Gozdowice water gauge station up the river. Gozdowice is the last water gauge station on the Odra River, on the basis of which it conclusions can be made regarding the Lower Odra flows into its estuary. The total inflow of water to the river from its catchment area beyond Gozdowice can only be estimated. The water gauges located in the lower Odra area beyond Gozdowice allow for the analysis of water levels only.

Characteristic water levels from many years for the analyzed gauges are presented in Table 1, and the characteristic flows for Gozdowice are shown in Table 2.

Table 1. The ordinates of the water table (m a.m.s.l. Kr.) corresponding to the characteristics of the waters of the Odra River (as defined by BUCHHOLZ [2007])

Water gauge cross section	The ordinate corresponding to the characteristic water level					Period of observation
	highest	medium high	medium	medium low	lowest	
Gozdowice	9.61	7.94	6.24	5.10	4.46	1952–2002
Bielinek	6.44	4.22	1.38	0.98	0.34	1954–2002
Widuchowa	2.55	1.35	0.27	–0.37	–0.76	1949–2002
Gryfino	1.69	0.90	0.12	–0.45	–0.71	1952–2002
Szczecin – Long Bridge	1.10	0.75	0.00	–0.54	–0.79	1959–2002

Source: own elaboration.

Table 2. Characteristic flows ($m^3 \cdot s^{-1}$) of the Odra River in Gozdowice in 1952–2002

Maximum	Medium high	Medium	Average low	Minimum
3 180	1 257	535	252	134

Source: own elaboration acc. to BUCHHOLZ [2007].

BUCHHOLZ [2007], analyzing water flows on the analyzed gauges concluded that even the largest flood waves on the Odra River (August 1997) do not affect the level of the water table in the estuary. The influence is different and it comes from the backwater phenomena mentioned above which cannot be described with simple "water level – flow" relationships. Hydrological and hydrodynamic problems of the Odra estuary should therefore be examined by: identifying the phenomena generating the hydrological and hydraulic conditions in the Odra estuary, in-depth field studies for the quantitative identification of hydrodynamic and hydrological determinants and conditions as the basis for the construction of "multi-layered" mathematical models taking into account all factors, including anthropogenic factors.

The movement of water in the estuary of the Odra River is a non-uniform motion, practically forced by external factors (backwater) because the water level and the waves of the Szczecin Lagoon are dependent on sea level, which is also forced by the winds. As already mentioned, it also depends on other factors, such as unnatural canal silting and partial blocking of flow in structures, resulting in a decrease of hydraulic gradients and the slowing of water discharge at lower

water levels in the Odra River and water inflows at higher water levels. The levels of water table in the river network which carry the risk floods do not come from water rise but rather are a result of atmospheric phenomena. Even the great flood wave in 1997 caused the water level in Szczecin to rise by only 20 cm, not exceeding the flood alert and flood warning levels, and no change of the water table at all was recorded at Trzebieża [BUCHHOLZ 2007]. Other characteristic features of surface water movement in the area of Międzyodrze are: very small natural hydraulic gradients on a stretch of 70 km (from Widuchowa to Trzebieża) amounting to $5 \cdot 10^{-7}$ (0.35 m). With such small declines the speed of water flow is very small, especially in the Western Odra River, where the weir at Widuchowa lowers the water level and the gradients are many times smaller. According to BUCHHOLZ [2007] the shortest reach of backwater goes to Bielinek and the longest to Gozdowice, which means that it periodically appears on a distance of about 27 km.

In hydrotechnical activities, it should be remembered that the estuary of the Odra River, being a specific system of "connected vessels", is sensitive to changes in hydraulic conditions; the action in one place may have adverse consequences in a completely different place. Winds and sea conditions also significantly affect the movement of pollutants. They must therefore be taken into account primarily in the activities related to: the protection of the aquatic environment, the colocation of surface water intakes, discharge of water, flood protection, port navigation and flow control by hydraulic structures. The selected actions should support the use of the functioning of this specific hydraulic system in the form of multi-connected vessels and strengthen its effect at least in the context self-purification of the waters flowing through Międzyodrze. The duration of the water flow in the area of Międzyodrze should be relatively long, while at the same time an appropriate speed of water is ensured, and – in the absence of management – a possibility of water overflow from the canals without the negative effects of flood and the use of natural habitats, many of which require precisely that kind of hydrological regime, that is, to provide local and temporary flooding.

The use and development of the area in question requires the ability to anticipate opportunities and barriers to development and the mutual influence of various activities. Therefore, the basis of the development plans must be the results of research and the accumulation of knowledge about the phenomena and their mutual relations.

THE CHARACTERISTICS OF SOIL AND HYDRO-SOIL CONDITIONS IN MIĘDZYODRZE

The characteristic feature of the area is vast, flat plains of marshy and riparian character, which fill surface of the Odra Valley with organic matter. The area is carved with canals, ravines and broadly spilled old river beds.

According to the study by the Institute of Land Reclamation and Grassland Farming (now Institute of Technology and Life Sciences) [JURCZUK 1977; KRZYWONOS *et al.* 1978; 1979] there are three distinct groups of soil in the area of Międzyodrze (Fig. 3).

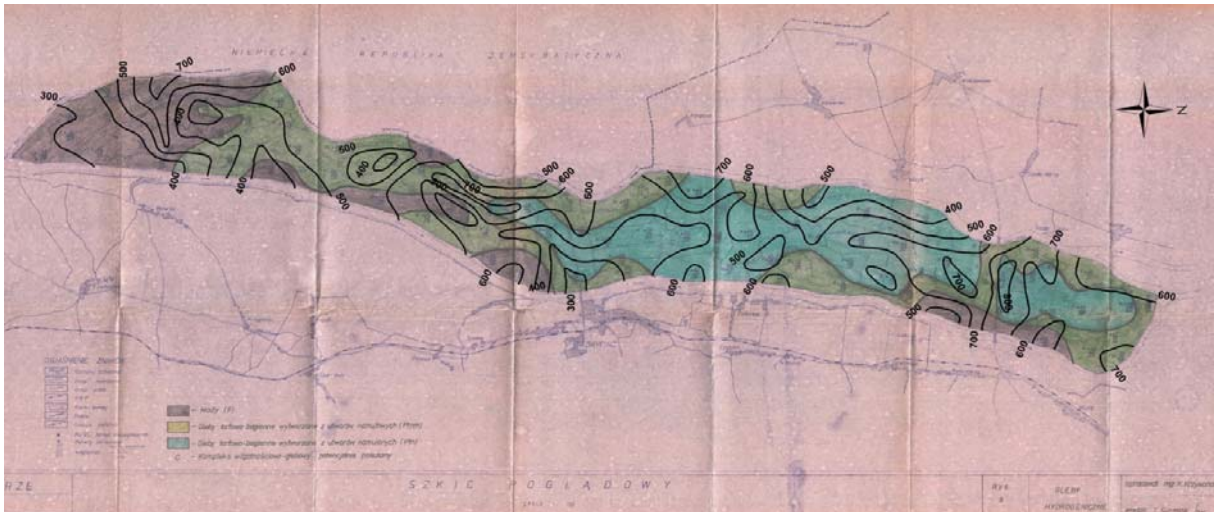

Fig. 3. Map of soils and isobaths of organic deposits in Międzyodrze; own compilation according to two maps with research from KRZYWONOS *et al.* 1979, reduced scale

In the soil classification used for the research [OKRUSZKO 1976] they were described as hydrogenic soil: alluvial soils (F) on peat (located mainly in the southern part of the Widuchowa polder), peat-bog mud soil (acc. to PTG 2011 – and peat fabric soils, limnic fabric soils, peat hemic soils, limnic hemic soils) (on the Gryfino polder) and peat-bog soils made from peat-mud sediments (acc. to PTG 2011 – Organic limnic soils, typical and organic limnic, hemi-limnic soils) (located along the Odra riverbed around the entire Międzyodrze) [PTG 2011]. The thickness of these deposits is considerable and quite diverse, be-

cause it ranges from 2.4 to 8.6 m, according to KRZYWONOS *et al.* [1978]. Large thicknesses occur in the upper, middle and lower part of Międzyodrze. Three basic organic sediments have been found: gyttja, peat and mud. The thickness of these layers vary (Fig. 4).

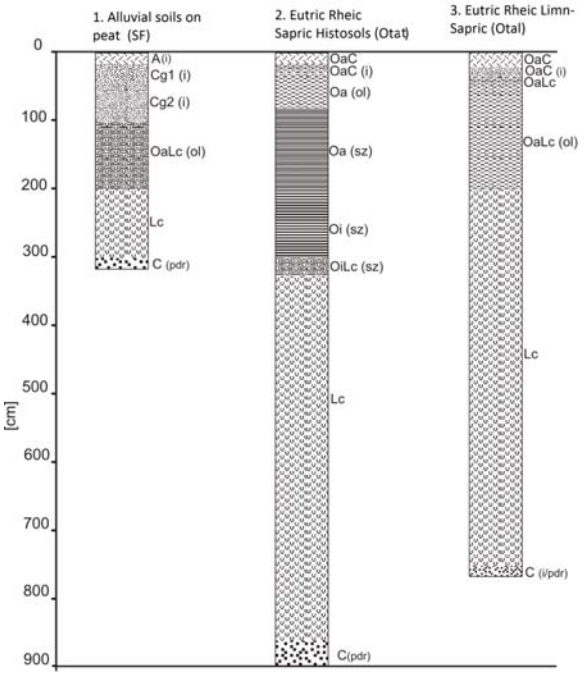

Fig. 4. Characteristic types of soils acc. to PTG [2011] occurring within Międzyodrze and their general profiles; Oa = sapric peat, Oi = peat fiber, Lc = gyttja, mud, C = mineral mud, A = humus level, sz = peat low rush, ol = peat low olesite, i = loam, pdr = fine sand, g = glueing; source: own elaboration

Mineral substrates are sands or loam. Above them lies the detritus gyttja, with a layer thickness of 0.3 to 5.5 m, generally larger in places with a higher thickness of the organic deposits. The gyttja deposits are covered by low peat with predominant alder peat, strongly decayed, amorphous especially in the floor parts, beneath the layer of mud. The particular levels of the deposits are characterized by high lability of physico-mechanical properties. Alder peats contain a lot of minerals and have been classified [KRZYWONOS *et al*. 1978] as weak and strongly muddy or sandy (25–80% of ash) in the floor layer or mixed with gyttja in the thill layer. The alder peat layers are deposited at different depths and reach a thickness of 1.0 to 4.5 m. For these reasons, the bulk density of these peats is strongly diversified (0.10–0.50 g·cm^{-3}).

The second type of peat having a significant share in the deposits is the reed peat, and in top layers – the sedge peat as an admixture of the alder peat. The reed peat deposits can be found over a large area of Międzyodrze and cover the middle part of the Widuchowa polder and almost the entire area of the remaining two: the Gryfino and Szczecin polders. Their thickness is considerable, ranging from 0.5 to 4.2 m (the floors lie between 0.6 and 1.5 m and the thills between 1.4–2.5 m, occasionally 4.0–5.0 m). In the botanical composition of the reed peat reed is predominant. These are poorly distributed or fibrous peats (apart from the layers with a mix of gyttja) with low content of ash (8.8–27%) and low bulk density (0.067–0.15 g·cm^{-3}). In the thill layers the ash content increases to 90% and the density to 0.5–0.8 g·cm^{-3}. Gyttja has an ash content of 40–80% and a bulk density of 0.12–0.77 8 g·cm^{-3}; in the thill layers these values increase to 90% and 0.5–0.8 g·cm^{-3}, respectively.

Layered construction of organic sediments with different properties is the reason for the high variability of the bed filtration coefficient. The value of this coefficient, determined in the paper of KRZYWONOS *et al.* [1978] with the Ernst method at high water levels in the bed (5–25 cm below the surface), ranged from 1.43 to 6.12 m·(24 h)$^{-1}$; at the reduced water levels, the filtration rate decreased (during experiments by more than 1 m·(24 h)$^{-1}$).

Silty material occurs on nearly the entire area of Międzyodrze peat bogs. Their thickness decreases from the southern polder, almost completely covered with silts up to 1.05 m thick, to the Szczecin polder, where of the thickness of the layer in the middle part decreases to 0.10–0.15 m.

The content of macro- and microelements in soils and the abundance of mineral components in soils are related both to the properties of geological bed on which they were formed and to the processes of soil formation, which in this case include: peat-forming process still ongoing, siltation process associated with floods involving the Odra River waters (outside waters bringing both mineral materials in the form of wash load as well as various pollution of these waters, and changing soil moisture associated with the hydrological regime of the area.

The current state of the said components in Międzyodrze soils has not been researched. We have, however, the results of research, now historical, carried out by the former Institute for Land Reclamation and Grassland Farming (IMUZ, now Institute of Technology and Life Sciences – ITP) between 1978 and 1979. They could serve as a background for research into the soil properties of this area. Soil samples for chemical analysis were taken from three layers of soil profile: 0–30 cm, 30–50 cm and 50–70 cm. The results of these studies, published in WESOŁOWSKI and CHURSKI [1981; 1983], indicate that:

– irrespective of the type, the soils were moderately acidic, suitable for the development of meadow plants,
– soil types differ in terms of content of organic matter and mineral content, the nitrogen content was decreasing, and the content of calcium, magnesium and zinc were also diversified,
– soils contained moderate quantities of macro- and microelements except for potassium available to plants which was scarce.

THE NATURAL CONDITIONS OF MIĘDZYODRZE

VEGETATION

In the course of many years of natural succession in the area of Międzyodrze and as a result of changing hydrological conditions the diversified vegetation was subject to constant and rapid changes. This was largely due to changes after the exceptionally high waters, including the great flood in 1997, which resulted in shallowing and accelerated growth of the vegetation, and the slowing down of and expansion of riparian shrubs and trees [KUPIEC, PIEŃKOWSKI 2010]. This unique natural area is also characterized by rich mosaic of vascular plants with numerous endangered and protected species and diverse plant habitats.

According to studies by WESOŁOWSKI and CHURSKI [1981], in the 80s of the pevious century, among the vegetation in the area of Międzyodrze prevailing were widespread communities of great manna grass (*Glyceria maxima* L.), acuta sedge (*Carex gracilis* Curt.) and common reed (*Phragmites australis* L.), with a diversifying element of single or larger clusters of gray willow and strips of reed. Great manna communities were found mainly in the most hydrated parts of the valley, mainly on the alluvial soils of the Widuchowa polder and the Gryfino polder. The communities of high sedge, dominated by acute sedge and upright sedge, were found on the Gryfino polder and partly on the Widuchowa polder. On the northern polders and partly on the central (Gryfino) there were also small forest groups (ash-alder swamp forest OIJ). The communities of acute sedge formed compact clusters of up to 35–50 cm. On the Szczecin polder there were mainly reed communities and forest groups (grey alder – *Alnus incana* (L.) Moench). The type of vegetation was related to habitat moisture.

At present, the area of Międzyodrze is in more than 80% covered with treeless swamp vegetation: sedges, herbs and rush vegetation. A few percent is occupied by alder forests, extensive meadows and pastures and embankments, dirt roads and sandy terrain. The open waters cover in total 11.6% of the area [JASNOWSKI 2002]. The Międzyodrze peat bog is an important and valuable area which acts as a specific filter, stopping harmful substances flowing along with flood waters of the Odra River. The reed vegetation, which occupies almost 1/3 of the peatbog surface, is dominated by phytocoenoses of great manna grass (*Glyceria maxima*), broadleaf cattail (*Typha latifolia*), reed canary grass (*Phalaris arundinacea* L.) and the common reed (*Phragmites australis* (Cav.) Trin. ex Steud) [JASNOWSKI 2002]. There is also a new location for this part of West Pomerania, and also for Poland, the position of the longleaf pondweed (*Potamogeton nodosus* Poir.) [KOWALSKI, WRÓBEL 2011].

The vegetation submerged in Międzyodrze waters is dominated by the rigid hornwort (*Ceratophyllum demersum* L.). These communities are mainly formed in very fertile waters, where the bottom areas are covered by significant layers of silt. In the waters of Międzyodrze, the vegetation is characterized by a very high biomass production and it affects to the greatest extent the growth of old river beds and canals. Besides the rigid hornwort in Międzyodrze canals the most common are the curled pondweed (*Potamogeton crispus* L.) and the blunt-leaved pondweed (*Potamogeton obtusifolius* Mert. & Koch). The second plant is considered as an endangered species, it grows in the waters of Międzyodrze in the vicinity of lush underwater vegetation of the rigid hornwort [ZIARNEK, ZIARNEK 2002].

In the eutrophic zones with low water levels, there are protected white water lilies (*Nymphaea alba* L.) and yellow water lilies (*Nuphar lutea* Sm.) as the increasingly dominant species. In addition, less frequent are also the watermilfoil (*Myriophyllum spicatum* L.) and the precious water soldiers (*Striatiotes aloides* L.), which is a rare gathering of vegetation occurring in Pomerania [KOWALSKI, WRÓBEL 2011]. In the places with increased flow speed in the canals of Międzyodrze there are communities of the waterstarwort (*Callitriche sp.* L.), with its underwater form arrowhead (*Sagittaria sagittifolia* L.).

In the blind canals and bays of Międzyodrze, among the small Pleuston plants predominant are the common duckmeat (*Spirodela polyrhiza* L.) and less frequently – the common duckweed (*Lemna minor* L.). In the shallow habitats, the frogbit (*Hydrocharis morsusranae* L.) is also found, mainly in strongly sunlit areas [ZIARNEK, ZIARNEK 2002].

ICHTHYOFAUNA

The ichthyofunistic study of the waters of Międzyodrze is based on the results of commercial fishing and fishing for the purposes of research, as well as on the literature, fisheries analyses (by professional fishermen and anglers), data from the results of amateur fishing [LEOPOLD, BNIŃSKA 1987] and the results of surveys conducted among Polish anglers [CZERNIEJEWSKI 2002].

There are several dozen species of fish in the waters of Międzyodrze. A review of the literature and business books indicates differences in species composition. Fishing records kept by the Fisheries Cooperative "Regalica" (Pol. Rybacka Spółdzielnia "Regalica") in the years 1952–1991 included such valuable salmon species as salmon (*Salmo salar* L.) and rainbow trout (*Oncorhynchus mykiss* Walbaum), as well as vimba bream (*Vimba vimba* L.) from the *Cyprinidae* family and – ruffe (*Gymnocephalus cernua* L.) from the family of the *Percidae*. Subsequent data from the years 1992–2002 did not include the above mentioned species. The highest numbers (52 species) are reported by ZYSKA and ZYSKA [2002], including the protected ones – sichel (*Pelecus cultratus* L.) and twait shad (*Alosa fallax* Lacepède).

According to the latest research, the ichthyofauna of Międzyodrze are represented by the following species: the European eel (*Anguilla anguilla* L.), carp (*Cyprinus carpio* L.), the crucian carp (*Carassius carassius* L.), the grass carp (*Ctenopharyngodon idella* L.), the gudgeon (*Gobio gobio* L.), the tench (*Tinca tinca* L.), the common bream (*Abramis brama* L.), the white bream (*Blicca bjoerkna* L.), the zope (*Ballerus ballerus* L.), the roach (*Rutilus rutilus* L.), the common rudd (*Scardinius erythrophthalmus* L.), the silver carp (*Hypophthalmichthys molitrix* Valenciennes), the asp (*Aspius aspius* L.), the ide (*Leuciscius idus* L.), the chub (*Squalius cephalus* L.), the bleak pike (*Alburnus alburnus* L.), the wels catfish (*Silurus glanis* L.), the northern pike (*Esox lucius* L.), the smelt (*Osmerus eperlanus* L.), the sea trout (*Salmo trutta* m. *trutta* L.), the burbot (*Lota lota* L.), perch (*Perca fluviatilis* L.), the ruffe (*Gymnocephalus cernua* L.) and zander (*Sander lucioperca* L.) [NEJA 2011]. Rare or very rare occurrences of the sunbleak (*Leucaspius delineates* Heckel), the three-spined stickleback (*Gasterosteus aculeatus* L.), the Romanian barbel (*Barbus petenyi* Heckel), the amur bitterling (*Rhodeus rhodeus* Pallas), the spined loach (*Cobitis taenia* L.) and the river lamprey (*Lampetra fluviatilis* L.) were confirmed among the caught fish [NEJA 2011].

The vast majority of Międzyodrze fish are indigenous species, typical for the region of the common bream and the smelt. Some of the species are out-of-the area populations, reaching the waters in question as a result of migrations from other waters during high water levels and targeted restocking of fish by RS "Regalica". Among them are distinctive the bighead carp (*Hypophthalmichthys nobilis* Richardson) and – the pumpkinseed (*Lepomis gibbosus* L.), introduced to European waters and artificially populated in the Odra River [NEJA 2011]. According to historical data taken from fishermen, the Siberian sturgeon and the bastard sturgeon (*Acipenser nudiventris* Lovetsky) also could be found in the waters of Międzyodrze. The pumpkinseed and the bastard sturgeon were not listed until 1999–2001.

The average economic catches between 1992 and 2002 were in the range of 927–4725 kg and the fish caught was characterized by the average growth rate. The fishing conducted for the purposes of research in the same period showed significant differences in the species composition of fish compared to commercial catches that turned out to be very selective at the time. The fish that is of low economic value was left out while new and rare species were recorded in fishing conducted for the purposes of research [KOMPOWSKI, NEJA 1999; TRZEBIATOWSKI 1999].

There are several fishing entities in the Lower Odra Valley. The area of Międzyodrze is covered by the activity of RS "Regalica" based in Gryfino. In accordance with operational documentation fish stocks are restocked and spawners are caught in order to produce stocking material.

WATER AVIFAUNA

The Międzyodrze area is also a very valuable migratory area of birds with a concentration of water and marsh avifauna [WESOŁOWSKI, WINIECKI 1988]. Lower Odra Valley is a bird sanctuary of a European importance. There are at least 34 species from Annex I of the Birds Directive and 14 species from the Polish Red Book. The riparian species include the white-tailed eagle (*Haliaeetus albicilla* L.), the black kite (*Milvus migrans* Boddaert,), the great bittern (*Botaurus stellaris* L.), the common crane (*Grus grus* L.), the garganey (*Spatula querquedula* L.), the common redshank (*Tringa tetanus* L.), the western marsh harrier (*Circus aeruginosus* L.), the grey heron (*Ardea cinerea* L.), the water rail (*Rallus aquaticus* L.), the common snipe (*Gallinago gallinago* L.), the bluethroat (*Luscinia svecica* L.) and the Savi's warbler (*Locustella luscinioides* Savi) [SAROSIEK 1993].

The ornithological research conducted in the years 1994–2006 in the area of Międzyodrze showed the occurrence of 210 species of birds, which is approximately half of all species registered in Poland [SAROSIEK 1993]. The riparian avifauna was represented by 124 species, which means that more than half of the breeding bird species in Poland were introduced to reproduction [TOMIAŁOJĆ, STAWARCZYK 2003]. During the study, ten species listed in the "Polish Red Book of Animals" were recorded: the great bittern, the little bittern (*Ixobrychus minutus* L.), the red kite (*Milvus milvus* L.), the white-tailed eagle, the little crake (*Zapornia parva* Scopoli), the Eurasian curlew (*Numenius arquata* L.), the short-eared owl (*Asio flammeus* Pontoppidan), the bluethroat, the aquatic warbler (*Acrocephalus paludicola* Vieillot) and the bearded reedling (*Panurus biarmicus* L.) [ŁAWICKI *et al.* 2007].

On the scale of West Pomerania, Międzyodrze is the most important refuge for the great bittern, the grey heron, the black tern (*Chlidonias niger* L.), the thrush nightingale (*Luscinia luscinia* L.), the bluethroat and the Savi's warbler. The main resting place for marsh birds is the widest canals of Międzyodrze and the Odra River stretch between Widuchowa and Szczecin. The areas under study are characterized by high ornithological values and are an important part of Lower Odra Valley – the birds' refuge of the European importance [ŁAWICKI *et al.* 2007].

THE ECONOMIC AND NATURE-RELATED ROLE OF MIĘDZYODRZE

FEATURES OF THE AREA AND SPATIAL STRUCTURE

For economic agricultural use, the area of Międzyodrze required protection against flooding by embankments. Basic drainage and construction work was performed in the area of Międzyodrze in the period

1906–1932. By the World War II the area, having been developed with the reclamation work completed, was used as hay-growing meadows and pastures.

The riverbeds were embanked and the whole area was divided into 3 polders by transverse flood embankments serving at the same time as road banks. These polders are called:

– Widuchowa polder, which is the southern part of the area extending from the weir at Widuchowa to the embankment of the road to Gryfino;
– a central polder called Gryfino polder located north of the embankment of the road to Gryfino,
– Szczecin polder in the northern part of the area, to the railway embankment of the Szczecin – Szczecin Dąbie railway route.

Each of the polders of Międzyodrze has a separate hydrographic network and drainage facilities. The largest area of water is found on the southern Widuchowski polder. The surface of this polder is carved with canals and old river beds and forms a complex network of over-flow arms and marginal lakes. Larger channels are of a shipping nature and are connected to the Eastern and Western Odra with sluices. The largest waterway is the Stara Regalica, a canal running in parallel to the Regalica River (the Eastern Odra), at the level of the Odra River, with its connections to the Marwicki Canal, the Długi Canal and the Gryfiński Canal.

The old River Bed of Gryfino polder (the middle one) covers considerably smaller area. However, it is carved with a network of artificial canals and a network of detailed ditches. The major canals are: the Płytki Canal, the Moczydłowski Czarny Canal, the Żeglicki and Kanał Drzewny Canals.

Szczecin polder is the most submerged in water. This is due to its lowest location in relation to the other two polders, slight outflow and backwater from the Szczecin Lagoon during northern winds. There are two canals on the polder – the lower canal and the Powiatowy Canal which jointly form the polder's bypass. There are two lakes on the polder, called: Wielkie and Małe. The weir on the Western Odra, located beyond a fork where this river divides into two arms, has caused a decline of the water levels in the Western Odra, as a result of which the waters on Widuchowa and Gryfino polders flow down towards the Western Odra.

Thus, a quite large volume of water from the entire water system of the Odra River flows through the Eastern Odra.

The hydrographic network of Międzyodrze is basically composed of canals and detailed drain ditches.

In the post-war period the agricultural use of this area was discontinued or very much reduced. By of lack of maintenance of facilities during the war and in the post-war years the hydrographic network of Międzyodrze was severely slimed and overgrown by rush vegetation and the water soldiers (*Stratiotes*). During the war, basic drainage devices, such as sluices, culverts, bridges and pumping stations were destroyed or damaged. This contributed to the land becoming marshy and the unnatural limitation of the flow of water through this area.

POST-WAR ATTEMPTS TO RESTORE THE AGRICULTURAL USE OF MIĘDZYODRZE

After the war destruction of the water and economic infrastructure of Międzyodrze the possibility of restoring the agricultural use of the area was considered as early as in the fifties of the last century. However, on account of the financial difficulties associated with reconstruction the area practically ceased to be agriculturally used for a long time. In 1958 "Studies and assumptions of the stimulation to economic activaty of Międzyodrze" [BPWM… 1958] were prepared. In the mid-1980s, the idea of restoring the opportunities for agricultural use and redevelopment of the area was born. As part of these plans, a study was commissioned on the nature-related and soil and water conditions to obtain an opinion on the possibility and economic viability of the concept of re-melioration of this area. The results of the expert assessments made by the former Institute of Land Reclamation and Grassland Farming, the Szczecin Branch and the Headquarters in Falenty were taken as the basis for a possible decision to implement the general melioration study [JURCZUK 1977; KRZYWONOS *et al.* 1978; 1979]. However, the conclusions were negative and in the aforementioned period no decision was made to restore the agricultural use of the area. Currently planned activities in this area are also not aimed at launching a farming industry but only improving the retention and flood management potential and improving conditions for the development of flora and fauna that exist or may exist in this area. The state of natural environment in Międzyodrze in its essential elements has not changed. The basic recommendations then formulated, referring to the rules of maintenance and recommended water levels below the terrain surface on designated soil compounds should be taken into account in the planned principles for shaping the moisture of protected areas. This is essential for the protection of organic soils on which Natura 2000 sites and other protected areas extend. To maintain and improve biodiversity the need for systematic mowing is envisaged only.

THE CHARACTERISTICS OF MIĘDZYODRZE AS A PROTECTED AREA

Extending from Widuchowa to Szczecin, Międzyodrze is an artificial creation made on the basis of parts of natural canals. The area is still marshy, characteristic of this section of the Odra River from mid-Holocene [BORÓWKA *et al.* 2005]. The whole was created in the 1920s and 30s of the twentieth century. The Germans wanted to adapt the wetlands for grazing animals. Sluices, drainage canals, weirs and pumping stations were created. The venture proved too costly to operate. The regulatory work conducted

has caused that most of the old troughs gradually became muddy and filled with mineral-organic deposits. After the war and now these areas were not used in agriculture. Since 1993 Międzyodrze on the Polish side has the status of a Landscape Park. On the German side this area is protected as Unteres Odertal National Park. Both Parks were created on the initiative of a joint Polish-German team of naturalists [DUDA, BORÓWKA 2007].

Międzyodrze is a part of the Lower Odra Valley, which belongs to Natura 2000 (PLB320003). The area between the main branches of the Odra River is a flat plain with numerous old river beds and smaller canals, it is marshy, the meadows and parts of the riparian meadows are periodically flooded. This area largely coincides with the Natura 2000 habitat site, Lower Odra (PLH320037, with a total area of 30 458.10 ha) and includes fragments of the Ujście Warty Landscape Park, Cedyński Landscape Park and the Lower Odra Valley Landscape Park, as well as 8 nature reserves: "Siegniewskie Lakes" (23.08 ha), "Wrzosowiska Cedyńskie" (72.02 ha), "Świergotki Valley" (11.00 ha), "Olszyna źródliskowa pod Lubiechowem Dolnym" (1.00 ha), Bielinek (76.42 ha), "Kanał Kwiatowy" (3.00 ha), "Kurowskie Błota" (30.63 ha) and "Wzgórze Widokowe nad Międzyodrzem" (4.43 ha).

CURRENT INTENTIONS REGARDING THE STIMULATION TO ACTIVITY OF MIĘDZYODRZE

The stimulation to activity of the Międzyodrze area is an element of extensive actions taken in cooperation between the government and self-government authorities within the framework of the "Flood Protection Project in the Odra and Vistula River Basin" (POPDOW), which covers a number of flood control activities in the Vistula and Odra river basins. The project "Restoring the natural values of the Lower Odra Valley by improving the retention and flood protection capacity of Międzyodrze" consists in revitalizing the area by preserving and improving its hydraulic and retention potential, while taking into account the needs of the natural environment, tourism and recreation. This is another attempt to reorganize the role of Międzyodrze in the new political and economic environment and to adopt a new approach to sustainable development and sustainable use of water, taking into account the needs of all elements of nature. The project is complementary and the adopted requirements are: positive impact on nature, economic justification of action, scope of activities open to discussion and analysis based on the results and conclusions from the activities of a team of experts in many fields.

The project implementation is planned for 2017–2022, in two investment phases: design- analytical and realization [ZZMiUW 2016].

To achieve the objectives of the project, the following is needed, inter alia:

– development of hydrological and natural models of various processes and phenomena occurring in this area as tools for various analyses needed to decide on the type and scope of activities in the existing environment of Międzyodrze; to perform this task, the following is needed: an inventory of and an assessment on the technical condition of equipment and canals, identification of directions and quantities describing water flows in canals and between canals and the Eastern Odra and Western Odra, as well as an assessment on the status and potential improvement of groundwater, peat bogs, the quantity of and presence (or possibility to populate) valuable species of aquatic and water-loving fauna and flora;
– the restoration of patency of canals inside Międzyodrze within the scope defined in the expert's assessments, to ensure the hydraulic gradients that guarantee free drainage and water inflow; it is planned to reconstruct 32 hydrotechnical structures, however, without restoring the functions from the times of farming in Międzyodrze to all constructions;
– improvement of the technical condition of about 60 km of the former flood embankments surrounding Międzyodrze, including the making footbridges over hydrotechnical constructions located in the dykes which will enable the technical maintenance and preservation of the condition of the structure and the organization of tourist routes in the area, restoring order to currently uncontrolled tourist traffic, which disturbs the nature's balance.

Exceptional natural values Międzyodrze, complicated hydraulic system of canals, flood hazards and the complexity of the course of hydrological phenomena make the successful implementation of the project tasks being not only limited to raising the level of flood safety in the Lower Odra Valley but it is also conditioned by the needs of the natural environment, defined, inter alia, in Natura 2000 Protected Area Action Plans. It is the analysis of these determinants and the accompanying extensive consultations of the project design that have shown the need for a specific approach to solving the task. It requires the creation of the aforementioned model, which will take into account not only the flow levels and volumes but also the flow paths of water, the assessment of its purity in terms of the presence of nitrates and phosphates (due to the assessment of the self-purification potential of the Odra waters flowing through this area) as well as correlation of water levels with the demand for water in areas dependent on these canals. Based on up-to-date data from the monitoring of water levels, flows and development of water quality, the need for water in areas of natural value and other phenomena, the model will make it possible to assess the possibilities and means for improvement, along with an indication of the treatments necessary to achieve the goal and where they should be applied (quantitatively, area-related), and where the interference should be com-

pletely eliminated, to fully preserve the current natural values of Międzyodrze, including the soils and peats described above. In order to protect these last elements of the natural environment, the canals, ditches and hydrotechnical facilities need to function in such a way as to ensure proper adjustment of water relations in areas of natural value in dry periods (too low water levels) and wet periods (high water levels remaining for too long), preventing further degradation of natural resources where it occurs and increasing the retention potential of Międzyodrze. Increasing the retention potential will allow for taking over some of the Odra River water during elevated levels, caused by backwater lasting up to approximately 24 hours, especially when they temporarily occur at the time of descend of flood waters from the south of Poland. The restoration of hydrotechnical infrastructure is aimed at developing free gravitational outflow and inflow of water from the Międzyodrze area, not forced by pumping or by damming on structures.

The function of Międzyodrze, which is invaluable in terms of the benefits to the human environment, is the potential for self-purification of water that flows through this area. The presence of peat bogs, reeds and other vegetation with similar properties causes that the water flowing out of the Międzyodrze area has a quality much better than the water flowing into the area [DYBKOWSKA-SENEK 1996]. The effectiveness of action in this regard depends on the duration of the flow of water through a given area; the longer it is, the more efficient this process is, provided that the water flows and does not stagnate. The planned activities in the project will make a significant improvement in this regard by providing additional kilometers of canals for the water self-purification process.

The need to implement the described project stems from the environmental conditions and the development strategy of municipality situated within the scope of impact of the region of Międzyodrze. The willingness to use Międzyodrze touristically (canoeing, bicycle riding, walking, historical tours, ornithological use, etc.) is confirmed by a series of declarations of support and opinions expressed by both local self-governments, the Management Board of the Association of Landscape Parks of West Pomeranian Region, NGOs, in "The Development Strategy of the Local Action Group of the Dolnoodrzańska Rural Development Initiative" for 2009–2015, in the "Spatial Development Plan of the West Pomeranian Voivodeship – Environmental Impact Forecast" as well as in many other documents of self-governments.

CONCLUSIONS

The area of Międzyodrze, which is a part of the valley of the Lower Odra, is subjected to the influence of the sea and the waters of the Odra River. It has been shaped by this influence and it constitutes the floodplain of the Odra. The specific hydrographic conditions resulting from the complex network of river beds and canals combined with the said Baltic influence through the straits, the Szczecin Lagoon and the Lake Dąbie have created a hydrological and hydrodynamic regime in the Międzyodrze area, especially during windy weather, when the masses of sea water are pushed inland through the aforementioned basins.

Before World War II, in the years 1906–1932, during the period of belonging to the German Reich the area of Międzyodrze was adapted for the economic agricultural use by building embankments for the protection against flooding and for melioration. The drained and developed areas were used as hay-growing meadows and pastures. Following the destruction of the water and economic infrastructure of Międzyodrze during wartime, the agricultural use was practically abandoned after the post-war period. After the war agricultural revitalization plans were abandoned for lack of profitability and a risk of destruction of organic soils in the area. At present, Międzyodrze is an area of nature, but with distorted hydrodynamic balance, subjected to natural and economic degradation.

Economic and pro-environmental activities require restoration of the natural retention of the area, to protect against the floods of the areas adjacent to the Odra River, including Szczecin, and to activate river flows in the canals through the Międzyodrze area.

Exceptional natural values Międzyodrze, complicated hydraulic system of canals and the complexity of the course of hydrological phenomena as well as the specific nature of soils cause that the selection of activities aimed at achieving the objectives of revitalization of the area requires the comprehensive natural – hydraulic and hydrological analysis and the economic analysis. The selection of activities must be preceded by: an inventory and assessment of the technical condition of canals and other structures and water facilities along with the determination of the directions and volumes that characterize water flows in the canals and between the canals and the Eastern and Western Odra, an assessment of the quality of water and the potential for improvement, including the retention of groundwater in the peat bogs, the assessment of the presence, the number or the possibility of introducing valuable aquatic and water-loving fauna and flora species, the development of hydrological and natural models of various processes and phenomena that occur in this area as tools of various analyses needed to decide on the type and scope of activities in the existing environment of Międzyodrze.

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REFERENCES

BORÓWKA R.K., OSADCZUK A., WITKOWSKI A., WAWRZYNIAK-WYDROWSKA B., DUDA T. 2005. Late Glacial and Holocene depositional history in the eastern part of the Szczecin Lagoon (Great Lagoon) basin – NW Poland. Quaternary International. Vol. 130. Iss. 1 p. 87–96.

BPWM Oddział Poznań 1958. Studia i założenia projektowe aktywizacji gospodarczej Międzyodrza [Studies and assumptions of the economic activation of Międzyodrze]. Typescript.

BUCHHOLZ W. 1991. Monografia Dolnej Odry. Hydrologia i hydrodynamika [Lower Odra monograph. Hydrology and hydrodynamics]. Gdańsk. PAN. Prace Instytutu Budownictwa Wodnego PAN. No. 25. ISSN 0860-3413 pp. 103.

BUCHHOLZ W. 2007. Warunki hydrologiczne estuarium Odry [Hydrological conditions of the Odra estuary] [online]. [Conference papers: Regional problems of water management and hydrotechnics] Available at: http://kbw.zut.edu.pl/Publikacje/Publikacje_Konferencja_2007/Buchholz2.pdf

CHALFEN M., ŁYCZKO W., PŁYWACZYK L. 2014. The prognosis of influence of the Oder River waters dammed by Malczyce barrage on left bank areas. Journal of Water and Land Development. No. 21 (IV–VI) p. 19–27. DOI 102478/jwld-2014-0010.

CZERNIEJEWSKI P. 2002. Analiza i ocena presji połowów wędkarskich na pogłowie ryb w wodach Międzyodrza [Analysis and assessment of fishing pressures on fish stocks in the waters of Międzyodrze]. Magazyn Przemysłu Rybnego. Nr 3 (27) p. 20–22.

DOBRACKI R., PIOTROWSKI A. 2002. Geomorfologia i geologia doliny Dolnej Odry. W: Dolina Dolnej Odry – Monografia przyrodnicza Parku Krajobrazowego [Geomorphology and geology of the Lower Odra Valley. In: Lower Odra Valley – Nature monograph of the Landscape Park]. Ed. J. Jasnowska. Szczecin. STN p. 33–52.

DUDA T., BORÓWKA R.K. 2007. Zmiany w krajobrazie Doliny Dolnej Odry na tle rozwoju paleogeograficznego regionu [Changes in the landscape of the Lower Oder Valley against the background of the paleogeographical development of the region]. Doliny Rzeczne, Przyroda-Krajobraz-Człowiek. Prace Komisji Krajobrazu Kulturowego. T. 7 p. 210–218.

DYBKOWSKA-SENEK D. 1996. Możliwości wykorzystania rejonu Międzyodrza dla poprawy jakości wód Odry Etap III [Possibilities of using the Międzyodrze region for the improvement of the quality of the Odra waters Stage III]. Oprac. dla Instytutu Morskiego w Gdańsku, Oddział w Szczecinie. Typescript.

JASNOWSKI M. 2002. Studium projektowe utworzenia Polsko-Niemieckiego Parku Narodowego Doliny Dolnej Odry. W: Dolina Dolnej Odry – Monografia przyrodnicza Parku Krajobrazowego [Study design of the creation of the Polish-German National Park of the Lower Oder Valley. In: Lower Odra Valley – Nature monograph of the Landscape Park]. Polska część projektu. Ed. J. Jasnowska. Szczecin. STN p. 15–31.

JURCZUK S. 1977. Ekspertyza w zakresie osiadania powierzchni terenu, dopuszczalnych stanów wody gruntowej oraz dawek nawodnienia podsiąkowego gleb Międzyodrza [Expertise on land subsidence, permissible groundwater conditions and inoculum doses of soil Międzyodrze]. Typescript. Falenty. IMUZ.

KOMPOWSKI A., NEJA Z. 1999. The Międzyodrze ichthyofauna as caught by various gear. Balic Coastal Zone. Vol. 3 p. 103–112.

KOWALSKI W.W.A., WRÓBEL M. 2011. *Potamogeton nodosus* Poir. (=*P. fluitans* Roth p.p.) i zbiorowiska pleustofitów w wodach przybrzeżnych Odry zachodniej pod Szczecinem [*Potamogeton nodosus* Poir. (= *P. fluitans* Roth p.p.) and the pestilent communities in the coastal waters of the Western Oder near Szczecin]. Folia Pomeranae Universitatis Technologiae Stetinensis. Agricultura, Alimentaria, Piscaria et Zootechnica. Vol. 289. Iss. 19 p. 75–82.

KRZYWONOS K., DURKOWSKI T., WESOŁOWSKI P. 1978. Badania glebowo-wodne do projektu melioracji Międzyodrza. Etap drugi: Określenie współczynników filtracji i parametrów do ustalenia wielkości osiadania torfów na terenie Międzyodrza [Soil and water studies for the melioration project of Międzyodrze. Stage two: Determination of filtration coefficients and parameters to determine the size of settling of peat in the area of Międzyodrze]. Typescript. Falenty. IMUZ pp. 101.

KRZYWONOS K., DURKOWSKI T., WESOŁOWSKI P. 1979. Badania glebowo-wodne do projektu melioracji Międzyodrza [Soil and water studies for the melioration project of Międzyodrze]. Typescript. Falenty. IMUZ.

KUPIEC M., PIEŃKOWSKI P. 2010. Sukcesja zadrzewień i zakrzewień w obrębie parku krajobrazowego i parku narodowego Doliny Dolnej Odry [Succession of trees and bushes within the landscape park and the Lower Oder Valley National Park]. Problemy Ekologii Krajobrazu. Vol. 26 p. 223–229.

LEOPOLD M., BNIŃSKA M. 1987. Ocena presji połowów wędkarskich na pogłowie poszczególnych gatunków ryb w wodach Polski – konsekwencje gospodarcze [Evaluation of fishing pressure on the fish species in Polish waters – economic consequences]. Roczniki Nauk Rolniczych. Vol. 2 p. 43–69.

ŁAWICKI Ł., MARCHOWSKI D., MRUGOWSKI W., NIEDŹWIECKI S., KALICIUK J., ŚMIETANA P., WYSOCKI D. 2007. Awifauna Międzyodrza w latach 1994–2006 [Avifauna Międzyodrze in the years 1994–2006]. Notatki Ornitologiczne. Vol. 48. Iss. 1 p. 38–54.

NEJA Z. 2011. Charakterystyka ichtiofauny i rybactwa w wodach Międzyodrza [Characteristics of ichthiofauna and fisheries in the waters of Międzyodrze]. Szczecin. ZUT. Wydaw. Uczel. ISBN 9788376630724 pp. 193.

OKRUSZKO H. 1976. Zasady rozpoznania i podziału gleb hydrogenicznych z punktu widzenia potrzeb melioracji. W: Materiały pomocnicze do badań gleboznawczych przy projektowaniu melioracji [Principles of recognition and division of hydrogenic soils from the point of view of melioration needs. In: Auxiliary materials for soil research in melioration design]. Ed. H. Okruszko. Biblioteczka Wiadomości IMUZ. Nr 52 p. 7–54.

OLSZEWSKA B., PŁYWACZYK L., ŁYCZKO W. 2014. The functioning of drainage canal near barrage "Brzeg Dolny" on the Odra River in 1971–2009. Journal of Water and Land Development. No. 22 p. 61–66. DOI 102478/jwld-2014-0023.

PASZKOWSKI Z. 2009. Planowanie transformacji szczecińskich wysp Międzyodrza [Planning the transformation of Szczecin's islands of the Odra River]. Przestrzeń i Forma. T. 12 p. 355–374.

PTG 2011. Systematyka gleb Polski [Soil classification of Poland]. Roczniki Gleboznawcze. Soil Science Annual. Warszawa. Wydaw. „Wieś Jutra". T. 62. Nr 3. ISSN 2300-4975 pp. 193.

SAROSIEK L. 1993. Zagrożenia Parku Krajobrazowego Międzyodrze [Threats of Międzyodrze Landscape Park]. Aura Ochrona Środowiska. Nr 4 p. 12–13.
TOMIAŁOJĆ L., STAWARCZYK T. 2003. Awifauna Polski. Rozmieszczenie, liczebność i zmiany [Avifauna of Poland. Arrangement, abundance and change]. Wrocław. PTPP „pro Natura". ISBN 839196261X pp. 870.
TRZEBIATOWSKI R. 1999. Occurrence, catches and protection policies of ichthyofauna in Lower Oder Valley Landscape Park waters in relations to environmental conditions on 1982–1996, a review. Limnologie Aktuell. Vol. 9 p. 387–406.
URBAŃSKI M. 2004. Międzyodrze ziemia pozyskana [Międzyodrze land reclaimed]. Gryfiński Kwartalnik Historyczny. Nr 7 p. 47–64.
URBAŃSKI M. 2005. Międzyodrze – ziemia pozyskana. Zagospodarowanie Dolnej Odry między Widuchową a Szczecinem, ze szczególnym uwzględnieniem budowli hydrotechnicznych. W: Plejstoceńskie i holoceńskie przemiany środowiska przyrodniczego Polski [Międzyodrze land reclaimed. Development of Lower Oder between Widuchowa and Szczecin, with particular emphasis on hydrotechnical structures. In: Pleistocene and holocene transformations of the Polish natural environment]. Ed. R.K. Borówka. Szczecin. Oficyna IN PLUS pp. 82.
WESOŁOWSKI P., CHURSKI T. 1981. Zawartość makro- i mikroelementów glebach hydrogenicznych na terenie Międzyodrza [The content of macro- and micronutrients of hydrogenic soils in Międzyodrze]. Opracowanie dla Woj. Zarządu Inwestycji Rolniczych w Szczecinie. Typescript pp. 26.
WESOŁOWSKI P., CHURSKI T. 1983. Mikroskładniki w glebach „Międzyodrza" [Microspheres in soils "Międzyodrze"]. Aura. Ochrona środowiska człowieka. Nr 6 p. 22–23.
WESOŁOWSKI T., WINIECKI A. 1988. Tereny o szczególnym znaczeniu dla ptaków wodnych i błotnych w Polsce [Areas of particular importance for water and marsh birds in Poland]. Notatki Ornitologiczne. Nr 29 p. 3–27.
ZIARNEK K., ZIARNEK M. 2002. Szata roślinna wód Parku Krajobrazowego Doliny Dolnej Odry. W: Dolina Dolnej Odry – Monografia przyrodnicza Parku Krajobrazowego [Vegetation of the Lower Odra Valley Landscape Park. In: Nature monograph of the Landscape Park]. Ed. J. Jasnowska. Szczecin. STN p. 263–266.
ZYSKA P., ZYSKA W. 2002. Park Krajobrazowy Doliny Dolnej Odry jako środowisko życia zwierząt kręgowych. W: Dolina Dolnej Odry – Monografia przyrodnicza Parku Krajobrazowego [Lower Odra Valley Landscape Park as a living environment of vertebrate animals. In: Nature monograph of the Landscape Park]. Ed. J. Jasnowska. Szczecin. STN p. 267–277.
ZZMiUW 2016. Przywrócenie walorów przyrodniczych Doliny Dolnej Odry poprzez poprawę zdolności retencyjnych i przeciwpowodziowych Międzyodrza [Restoring the natural values of the Lower Odra Valley by improving the retention and flood retention capacity of Międzyodrze]. Materiały udostępnione. Szczecin. Zachodniopomorski Zarząd Melioracji i Urządzeń Wodnych w Szczecinie.

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Międzyodrze jako przykład zmienności wykorzystania gospodarczego i przyrodniczego części Doliny Dolnej Odry

STRESZCZENIE

Międzyodrze to obszar w Dolinie Dolnej Odry, od rozwidlenia koryta do Szczecina, wraz z wyspami pomiędzy Odrą i jeziorem Dąbie. W przeszłości służyło głównie jako szlak transportu wodnego, a obecnie pełni różnorodne funkcje gospodarcze i przyrodnicze. W pracy scharakteryzowano historyczną oraz obecną rolę Międzyodrza z uwzględnieniem specyficznych walorów przyrodniczych Doliny Dolnej Odry, hydrografii, hydrologii i warunków glebowych.

Na obszarze Międzyodrza występują zasadniczo trzy rodzaje utworów organicznych (mada właściwa na torfie, gleba torfowa saprowa typowa, gleba torfowa limnowo-saprowa), a z przyrodniczego punktu widzenia obszar charakteryzuje się bogactwem flory i fauny.

Prowadzona obecnie aktywizacja Międzyodrza ma uwzględniać potrzeby środowiska przyrodniczego, turystki i rekreacji, a jednocześnie poprawić potencjał hydrologiczny i retencyjny obszaru. Wyjątkowe walory przyrodnicze, skomplikowany system hydrauliczny kanałów, złożoność przebiegu zjawisk hydrologicznych oraz specyfika gleb sprawiają, że wybór działań zmierzających do osiągnięcia celów rewitalizacji obszaru wymaga wszechstronnych analiz przyrodniczo-hydrologicznych, a także analiz ekonomicznych. W pracy zarysowano zakres trudności w przeprowadzeniu takich analiz.

Słowa kluczowe: *aktywizacja*, *Dolina Dolnej Odry, hydrografia, Międzyodrze, warunki hydrologiczne, warunki naturalne*