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Original Research Article

DIRECTIONS OF POLDERIZATION IN THE MIDDLE BASIN OF THE ODRA RIVER

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A b s t r a c t

As an effective way of flood prevention it is widely accepted to construct flood embankments. These structures are getting bigger as the river changes from meandring to successive development of floodplain and narrowing the embankment. Meanwhile, it is worth returning old solutions and reactivating old floodplain polders. There are currently three polders on the central Odra River: Kiełcz-Tarnów-Bycki – with a capacity of approximately 15 million m^3, Połupin – with a capacity of 70 million m^3 and Krzesin-Bytomiec – with a capacity of 20 million m^3. Three further reservoirs are designed in: Urad – 30 million ha, Słubice Górzyca – 60 million ha and Ługi Górzyckie – 30 million ha. The authors propose additionally a reactivation of seven archival polders, with total capacity of approximately 4.9 million m^3.

Keywords: polder, flood, retention

1. INTRODUCTION

Odra River is the second river in Poland in terms of length (854.3 km), flowing through the territory of Czech Republic, Poland and Germany.

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The length of the river as well as the large area of the basin (118 861 km^2), cause that there are numerous urbanized areas (Opole, Wrocław, Zielona Góra, Szczecin and others) and protected natural areas.

Civilization development forced adaptation of the natural environment of the Odra basin for economic purposes. Water in both deficits (droughts) and in excess (floods) has always been a significant barrier.

The largest droughts in the Odra basin were recorded in 2003 – there were ferries in Milsko and Połęcko at that time, the shipyard in Nowa Sól could not launch ships, the navigation on the Odra River was closed, the water level in Połęcko fell to 54 cm. The situation repeated itself in 2017 and 2018.

Floods in Poland have long been the cause of severe disasters. Only in the last 20 years, there have been at least 4 large floods on the Odra River with a probability of occurrence of the order of p = 1% (100-year flood). Despite the impressive technical achievements, a continuous increase in flood risks can be observer here. This is due to economic and social pressure, which forced successive development of flood plains. In the Odra basin the floodwater of July 1997 is still an infamous example, which has exceed all the „big waters" and the most pessimistic visions in size (the state of water in Nowa Sól was 557 cm). Its effects did not give any chance of an effective maneuver preventing the creation of huge losses and proved that there is an urgent need to rebuild the neglected flood protection systems for years. In the central Odra River region, 3.57 km of embankments were then blurred, and the other two were strongly deformed [7,8]. As a result of these processes on the central Odra River (Zielona Góra), for a dozen or so years the groundwater table has been lowered by about 1.3 m.

A common protection against floods is active protection. It consists in securing an adequate reserve for flood waters, both in existing and designed water reservoirs. Another type of protection is passive protection. Its tasks is to maintain in proper technical condition of flood embankments and facilities that permanently build up water, which are not retention reservoirs, and to ensure patency of riverbeds [1,2]. Effective flood protection is also the undertaking of organizational measures, for example implementation of national and local flood protection programs and its consequences, as well as intensive operation of anti-crisis staffs.

Long term observations and analyses contribute to a better understanding of hydrological processes, prediction of water levels at various sections of rivers and forecasting of extreme events, including floods [6, 9, 12-14,16].

Apparently, it seems that water is an easily controllable environmental element, as hydrotechnical and drainage works can change the hydrological conditions of the basin in a short time. It is currently difficult to find elements of the hydrographic network that are not transformed by man [6, 4]. However, the situation, that has been observed for many years, indicates a permanent drop in

the level of water (surface and underground waters). This is an extremely unfavourable process for the functioning of the entire ecosystem and closely related elements of the natural environment.
Therefore, it is necessary to undertake actions aimed at improving the state of water resources, among others – by increasing the natural retention of the catchment [8, 11-14].
The increase in the retention capacity of the area is very important for the effectiveness of flood protection. Too small number of tanks is not able to accommodate large rain or meltwater during floods. The increase in the retention of the Middle Odra Region can be achieved both by increasing small retention and the construction of new retention reservoirs and polders. The current hydrotechnical development in the Odra basin is not sufficient to conduct optimal water management, and unfortunately this is not a problem related only to the Odra River, but also many other rivers in Poland [2,10].

2. MATERIALS AND TEST METHODS

The work uses a cartographic method for studying environmental changes [15], which involves incorporating a map into the research process. The map then has a dual role: as a research tool and as an object in the form of a model replacing the real phenomenon, whose direct examination is not possible. This situation applies to old polders, for which the determination of morphometric parameters based only on field works is not feasible.

3. RESULTS AND DISCUSSION

Flood polders are very common in Western Europe. They constitute a passive form of flood protection. They are usually located in close proximity of flood embankments as additional protection embankments and areas adjacent to rivers. Flood polders are used to collect excess water located in the riverbed. In the event of a flood hazard, or during a flood, the polder can accumulate a specific volume of water, thereby lowering the height of the flood wave. After the flood ceases, the excess water from the polder can be led back to the river, gravitationally or by means of pumping station. In the unpredictable period, polders can be used freely, usually in agriculture.
Before the First World War, there were 12 polders in the Odra River area which allowed for the collection of 104.6 million m^3 of water on the area of 12.7 thousand ha. Currently there are 10 polders on the Polish side of the Odra River with a total flood area of 6.4 thousand ha and a retention capacity of 75 million m^3 (71.7 % of the condition before the First World War). Three of them are located on the Middle Odra River area (and within the area of The Lubuskie

Voivodship) (Tab. 1): Kiełcz-Tarnów Bycki polder - with a capacity of approximately 15 million m^3, Połupin polder - with a capacity of 70 million m^3 and Krzesin-Bytomiec polder - with a capacity of 20 million m^3. Three further polders are designed in: Urad – 30 million ha, Słubice Górzyca – 60 million ha and Ługi Górzyckie – 30 million ha [3].

Table 1. Polders functioning along the Middle Odra Region

Polder name	Surface [ha]	Capacity [mln m^3]	River kilometrage [km]
Kiełcz-Tarnów Bycki	815	15	471.00 – 424.00
Połupin-Szczawno	3125	70	491.00 – 517.00
Krzesin-Bytomiec	1200	20	534.00 – 543.00

The analysis of archival data made by the authors of the study shows that in the years 1940 – 1950, other polders also functioned in the Middle Odra River area: Milsko, Tarnawa, Pomorsko, Brody-Bródki, Nietkowice, Będów and Połupin-Szczawno-Laski (Fig. 1). They used natural depressing of the area, as well as oxbow lakes and backwaters. Today, these are agricultural or wasteland areas. Restoring them to periodic retention of flood waters would allow the collection of an additional 41.9 million m^3 of excess water (Tab. 2).

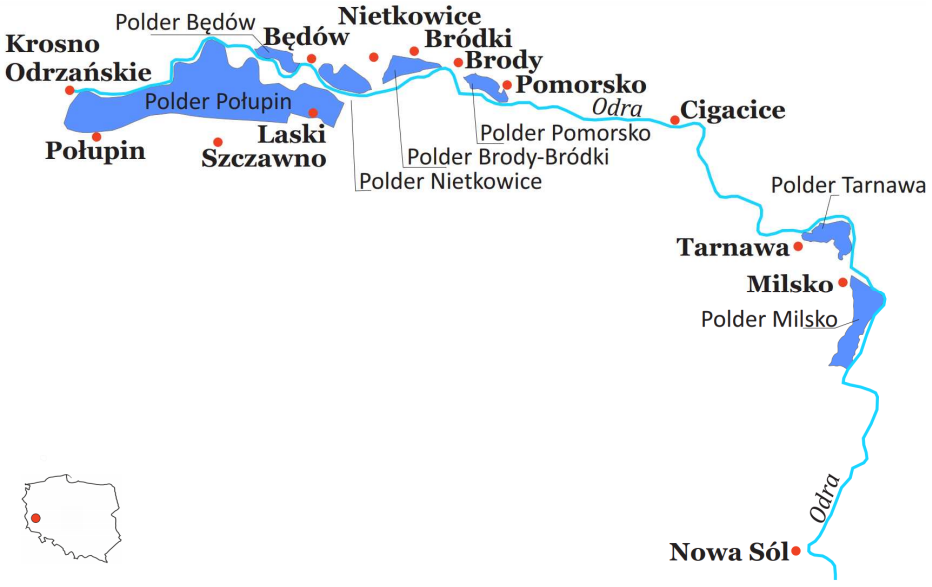

Fig. 1. Location of archival polders in the region of Middle Odra River

Table 2. Capacity of archival flood polders, assuming an average dam height of 1.0 m

Polder name	Surface	Capacity
	[ha]	[m^3]
Milsko	300	3,000 000
Tarnawa	220	2,200 000
Pomorsko	200	2,000 000
Nietkowice	310	3,100 000
Brody-Bródki	180	1,800 000
Będów	180	1,800 000
Połupin-Szczawno-Laski	2,800	28,000 000
Total:	**4,190**	**41,900 000**

Relatively easy to reactivate is the Milsko polder [3]. It is planned to be a dry, steady reservoir, with an area of approximately 300 ha and an estimated capacity of 5 to 10 million m^3 (Tab. 3). In the polders area, according to archival German maps and maps of GUGiK, one can see an existing drainage system, which unfortunately has been partially or even completely destroyed at the moment.
The location of the polder, between the natural escarpment (the frontal moraine of the North Polish glaciation) and the Odra River flood embankment, makes it easy to control the amount of water collected.

Table 3. Characteristics of the archival Milsko polder

Polder location	approximately 20 km East from Zielona Góra, South-East of Milsko
Length of the reservoir	approximately 4.5 km
Tank width	0.48 km – minimum 1.33 km – maximum
Surface of polder	approximately 300 ha
Maximum depth	from 1 m to 3 m
Polder capacity at maximum accumulation	approximately 10 millions m^3
Elevation of the crown of the dam	60.5 – 61.0 meters above sea level
Elevation of the polder bottom	from 56.5 to 59.0 meters above sea level
Length of the embankment	approximately 5.75 km
The Odra River is located along the eastern border of the polder, behind the flood embankment	

Each polderization gives a positive aspects towards improving the flood protection of people living in the lower part of the river. The increase of water retention is also invaluable. The area of the Middle Odra Region belongs to zones with an urgent need to develop small retention. This results both from

variable, unfavourable climatic conditions, as well as from the water deficit observed in this region during the growing seasons.
Reactivation of polders can have negative effects. In the polder, various types of pollution may occur due to floods, which at the same time may disqualify further functioning of this area in its present form (agricultural use). The decline in biodiversity will also be inevitable. One must always take into account the fact that the introduction of any hydrological regime is an unnatural process.

4. CONCLUSION

Flood protection should always be a superior objective due to its priority task, which is to protect people's lives. Its reconciliation with the requirements posed by hydrology and the natural environmental means that uncompromising compliance with the applicable design and construction rules is necessary.
The occurrence of a flood event and its extreme event which flood is, may mean that permitting flooding of flood polders, despite the resulting economic or social losses, may be necessary to protect human health and life.
Due to many years of human activity aiming at the growing development of the catchment, one should strive to create new or reactivate archival polders. This is an opportunity to recreate a specific ecosystem of the river valley and reconcile the problems of flood protection with nature protection.

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KIERUNKI POLDERYZACJI DORZECZA ŚRODKOWEJ ODRY

S t r e s z c z e n i e

Za skuteczny sposób walki z żywiołem powodzi przyjmuje się powszechnie budowę wałów przeciwpowodziowych. Konstrukcje te są coraz większe, w miarę przekształcania się rzeki z meandrującej w roztokową i sukcesywnego zagospodarowywania terenów zalewowych oraz zawężania międzywala. Tymczasem warto wrócić do starych rozwiązań i reaktywować dawne poldery zalewowe.

Na środkowej Odrze aktualnie funkcjonują trzy poldery: Kiełcz-Tarnów Bycki – o pojemności około 15 mln m^3, Połupin – o pojemności 70 mln m^3 i Krzesin-Bytomiec – o pojemności 20 mln m^3. Projektowane są tutaj trzy kolejne zbiorniki: Urad – 30 mln ha, Słubice Górzyca – 60 mln ha i Ługi Górzyckie – 30 mln ha. Autorzy proponują dodatkowo reaktywację siedmiu polderów archiwalnych, o sumarycznej pojemności około 4,9 mln m^3.

Słowa kluczowe: polder, powódź, retencja

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