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The Negative Phenomenon of Anthropogenically Induced Hydropeacs – Process and Damage

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Abstract

The dynamics of hydropeaks significantly deviates from the same processes in nature by the short time and the number of events. These hydropeaks do not exceed the range of natural floods however, their frequency impacts environment negatively. This creates entirely new conditions for the riverbed morphology. Banks nearly vertical mainly above 6 m height. Narrow river channel regularly less than 40 m wide. More frequent elevated flows lead to stronger erosion, changes in the riverbed structure, and negative impacts on the river's environment. During a flood, animals seek shelter and when the flow decreases they return to the main channel of the river. This process leads to biological losses of fish, larvae, and eggs and applies to all species inhabiting the river. Every high enough water event is therefore a natural risk. Increasing the frequency of the event increases the likelihood of losses. A series of such events were observed and analysed by numerical modelling. We were able to establish an unprecedented frequency and short event time of the phenomenon as compare to the natural conditions. During the disappearance of the flow, as well in river as in model we found variable, rapidly, repeatedly changing and misleading directions of the water outflow. The human-induced narrow eroded channel structure proved to be more susceptible to dynamic changes escalating the negative process and has demonstrated by examples of fish population losses.

1. INTRODUCTION

Very little research on hydropeacs has been done in Poland (Bipa et al. 2024). In 2024, were carried out an analysis of the impact conditions on the section of the The Vistula River bed below the Przewóz Barrage, measurements of water flow, longitudinal profile, water surface level and photogrammetric documentation. Our research consisted of numerical simulation of flow phenomena of the mid-channel forms at the downstream location of the Przewóz Barrage

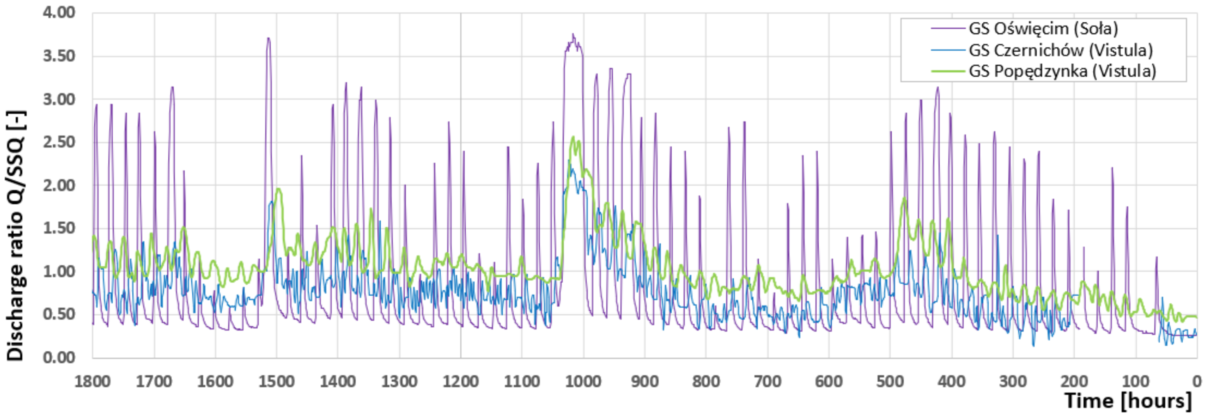

Fig. 1. Flow in relation to SSQ discharge at the Oświęcim (The Soła River), Czernichów, and Popędzynka (The Vistula River) water gauging stations.

and analysis of hydraulic conditions of water flow. The data obtained from the IMGW–PIB made it possible to determine the dynamics of the hydropeaks (Fig. 1).

2. CHANGES THE WATER SURFACE LEVEL AT THE PRZEWÓZ BARRAGE

The insufficient capacity of the regulated and narrowed Vistula riverbed below the Przewóz Barrage cannot effectively handle significant flow changes caused by the development of the Upper Vistula Waterway. As a result, water levels fluctuate dramatically in a short period. These fluctuations significantly exceed the near-natural hydromorphological and hydrological conditions of the Vistula River in the studied section. The recorded water level changes indicate that fluctuations upstream can occur in 15 minutes or less, ranging from 0.21 to 0.20 m. At the downstream position of the Przewóz Barrage, fluctuations can also occur within 15 minutes or less, reaching up to 30 cm and down to 106 cm (Fig. 2).

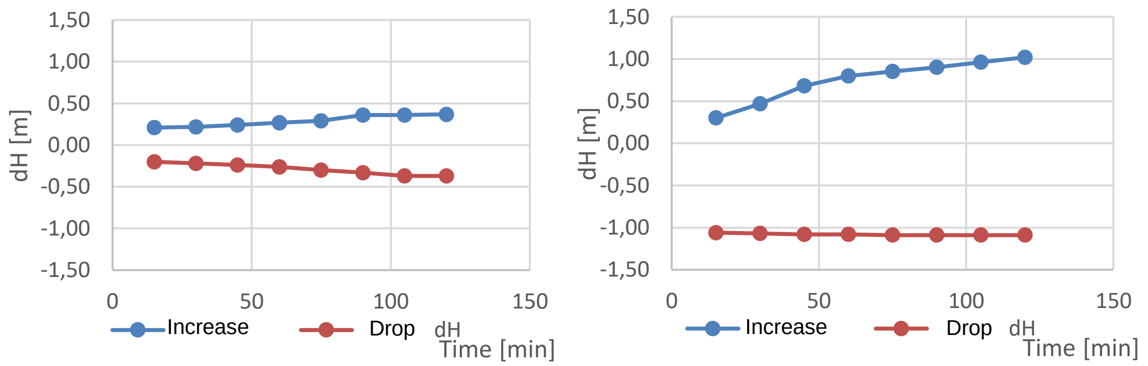

Fig. 2. Highest recorded fluctuation of water surface level in the period August–November 2023 from 15 to 120 minutes, The Vistula River, upstream (left) and downstream (right) of The Przewóz Barrage.

3. SPATIAL VELOCITY DISTRIBUTION

The riverbed features a deep cut with steep banks, and there is almost no fine sediment present, which poses challenges for the river's biological ecosystem. Using 2D numerical modelling, we intend to demonstrate the rapid, short-term nature of hydrodynamics and the transient currents that occur along the riverbed. While fluctuations in water levels are a natural occurrence, the significant number of human-made events can have destructive consequences (Hayes et al. 2021). Numerical simulation was carried out using depth averaged 2D model for unsteady flow

Table 1
Model parameters

Time [min]	Discharge [m^3s^{-1}]	WSL [m a.s.l.]	ΔH [cm]	Δt [min]	Δh [cm/min]
0	140.0	189.54	–	–	–
30	117.5	189.49	5	30	0.17
60	95.0	189.26	23	30	0.77
90	72.5	189.07	19	30	0.63
110	57.5	188.82	25	20	1.25
120	50.0	188.58	24	10	2.40

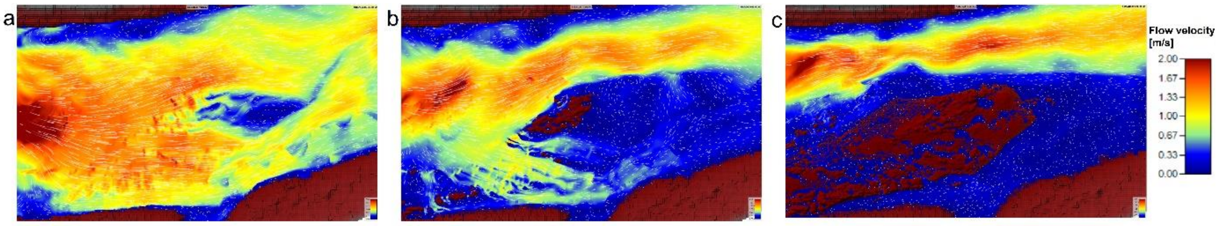

Fig. 3. Spatial velocity distribution around a gravel bar downstream the barrage: a) $Q = 140\ m^3s^{-1}$, $t = 0$ min; b) $Q = 72.50\ m^3s^{-1}$, $t = 90$ min; c) $Q = 50\ m^3s^{-1}$, $t = 120$ min.

conditions (Table 1 and Fig. 3). The results reveal the decay of the attracting current in the channel separating the mid-channel form from the banks. This site becomes as a trap for living aquatic organisms.

Acceptable flow rate changes are guided by changes in the water surface level. Assuming a maximum allowable water levels drop of 3 $cm \cdot min^{-1}$ (Greimel et al. 2018) an operating time of up to 2 hours was obtained for the water stage closure. This is 8 times longer than the recorded data. The operating principles of the control devices require significant adjustment.

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