

Ice is an important structural component of streams and rivers, affecting many biological, hydraulic, geomorphic and chemical processes, directly or indirectly through the hydrological effects of ice formation. The process of icing (occurring of ice phenomena) includes all ice forms appear on the flowing waters in the winter. The basic condition for initiating the ice process of the river is that the water is supercooled and that it reaches a temperature below the freezing point. Depending on the size of the river, such a situation usually takes place after a few or a dozen frosty days with persistently negative air temperature values. The rate of ice formation and the period of occurrence of ice on surface waters depends on the hydrometeorological conditions, in particular, on the time of negative air temperature. The most common form of river icing is ice cover, which occurs in the form of partial or complete coverage of the water surface.

Scientific research on river icing in various regions of the world proves that the climate changes that have been taking place in the last few decades, showing an increase in air temperature in global, regional and local terms, result in a shorter period of ice occurrence on rivers. This problem also applies to mountain areas with a much cooler climate than, for example, lowland areas. An additional factor disturbing the ice regime of rivers is human activity, which is mainly the construction of dam reservoirs. Winter thermodynamics of the water masses accumulated in the reservoir increases the water temperature (in relation to undisturbed conditions) in rivers below their location, which directly limits or even prevents the formation of ice on the rivers over a long distance. Climate change and dam reservoirs should be treated as the two most important factors influencing river ice changes.

In Poland, a comprehensive assessment of the icing of rivers (including the larger Carpathian tributaries of the Vistula) was last carried out in the 1960s. Since then, changes in the icing of Carpathian rivers in a regional terms have not been subject of detailed analyzes. The publications based on case studies (one river or data from one water gauge station) appearing from time to time do not exhaust the issues, but only indicate the need for more comprehensive research on the issue under consideration.

The aim of the proposed project is to conduct research on the impact of climate change and the construction of dam reservoirs on the occurrence of ice on rivers in the form of ice cover in relation to the area of the Polish Carpathians, which constitute a significant part of the upper Vistula basin. The Polish Carpathians is a geographical region with an area of 19,600 km² (approx. 250 km wide, approx. 100 km long), which plays an important role in shaping water relations (especially outflow) in the entire Vistula basin, which covers 54% of Poland's territory. The Carpathians are characterized by the highest dynamics of hydrological processes in the country, which results from the relationship between the climate, hypsometry and relief. The rivers of the upper Vistula basin have an extensive database of archival ice cover, which allows for the analysis of the formation of the ice cover in the last 100-120 years. There are over a dozen large dam reservoirs in the selected area with different ages, functions and parameters, which allows for the spatial and temporal assessment of the impact of hydrotechnical structures on the formation of river icing, both in the regional and local terms. The main research hypothesis tested under the planned project assumes that the functioning of dam reservoirs has a greater impact on disturbances in the icing of mountain rivers (ice cover formation) in a regional and local terms than climate changes.

In the proposed project, apart from the archival data from water gauges located on the rivers of the Polish Carpathians with different flow rates and the results of field observations of ice cover on selected rivers (carried out as part of the project), satellite radar images will be used. The analysis of radar data (Synthetic Aperture Radar systems) is a modern technique that allows to accurately determine the spatial and temporal course of ice cover formation on rivers. SAR has the ability to image ice cover day and night in all weather conditions with high spatial resolution and to record images from the same location even every few days.

The result of the research conducted as part of the proposed project will be the publication of 4 articles in renowned international scientific journals. These publications, supplemented with an article containing a review of the world literature on river ice research, will be the basis for applying for a doctorate by a person carrying out the research project.