Abstract

Assessment of the possibility of increasing retention in a selected area in the context of counteracting the effects of drought

Poland has relatively scarce water resources. Approximately 1,600 m³ of water per inhabitant is almost three times less than the European average, which is approximately 4,500 m³ per person per year. In recent years, these resources have fallen below 1,000 m³ per person, which means a potential threat of water deficit. The amount of water retained in Poland is also too small. It is estimated that the usable capacity of the existing reservoirs is just over 4.4 billion m³, constituting approximately 7% of the volume of the average annual outflow from the country. Therefore, it is necessary to increase water retention, which is necessary, among other things, to counteract the effects of drought.

The aim of the study is to assess the retention status and to propose actions to increase it in a selected area in the context of counteracting the effects of drought, as well as to prepare implementation recommendations in this regard. The possibility of increasing retention, defined as the ability of a given area (e.g. a river basin or catchment) to retain water, shaped by various factors, was analyzed. The focus was on the issue of reservoir retention. The main research was carried out in the catchment area of the Tresna reservoir on the Soła River, but many activities also covered a wider area. In order to present the possibilities of increasing retention in the context of counteracting the effects of drought, the following issues were considered:

- a) analysis of the current legal status in the field of retention a review of European and national regulations relating to the issue of retention,
- b) diagnosis of the state of reservoir retention in Poland which is the starting point for in-depth analyzes aimed at the selected research area,
- c) delimitation of the research area determining the territorial scope of work, taking into account, among others, the criterion of the risk of hydrological drought,
- d) characteristics of the study area including key hydrological elements,
- e) analysis of the possibility of increasing retention developing an original research methodology and assessing the possibility of increasing retention in a specific area,
- f) implementation recommendations proposing solutions in water retention and counteracting the effects of drought.

The study is a synthetic approach to the results and conclusions, presented as a series of thematically related scientific articles.

The main research methods used in the study were: a query of archival and current materials, calculations of the parameters of retention reservoirs and spatial analyzes in GIS software, including the proposal and implementation of original solutions.

The prepared analysis of the current legal status, the need to take actions related to the loss of capacity of retention reservoirs resulting from the diagnosis, research results on the possibilities of increasing water resources, as well as experience resulting from work at the State Water Holding Polish Waters allowed for the identification of elements requiring improvement. The developed implementation recommendations concern water retention in the context of counteracting the effects of drought.

During the analyses, it was found that it is crucial to maintain the appropriate parameters of retention reservoirs for their functions, including counteracting drought's effects. A study of 47 reservoirs located in various parts of Poland showed that in 2021, a total of 192.656 million m^3 less water was stored than after they were put into use (the average operating time of the analyzed reservoirs is 48 years): 27 reservoirs showed a reduction in storage capacity, 7 – an increase, and in 13 no changes were observed. In the next step, an original research methodology was developed allowing for a multi-criteria assessment of factors (land use, density of the river network, hydraulic development and terrain slopes) influencing the reduction of the capacity of retention reservoirs. The research has proven that it may be the right solution in works related to retention and counteracting the effects of drought.

Based on data analysis from the assumptions of the Water Resource Development Program implemented by the State Water Holding Polish Waters, it was calculated that activities carried out in 2020-2021 to counteract the effects of drought provided conditions for storing an additional 424 million m³ of water. As a result, the capacity of storage reservoirs in the country in 2022 was approximately 4.4 billion m³. The effect of the activities is the increase of retention in Poland to a level of over 7% of the average annual outflow. Implementing the proposed technical actions (construction of smaller and larger water stages, changes in land use) within the catchment area of the Tresna reservoir on the Soła would positively impact increasing retention. It was found that 11 reservoirs were planned to be built in the Soła catchment area with a total capacity of 180.9 million m³, and further works in the Leśnianka River catchment area would enable additional storage of nearly 0.1 million m³ of water. The implementation of this type of activities in the field of retention development is particularly important due to the threat of hydrological drought and the results of climate model analysis indicating that extreme natural phenomena will intensify in Poland by the year 2100, including long periods of drought.

All the proposed actions will allow for rational and optimal management and protection of water resources, as well as increasing the retention level in the context of counteracting the effects of drought. The presented activities were proposed for specific facilities and areas but can also be applied to other reservoirs and their catchment areas. Moreover, the obtained results allowed the preparation of implementation recommendations (including the implementation of some of them) for further work in the field of retention development and related counteracting the effects of drought.