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INFLUENCE OF SMALL WATER RESERVOIRS ON GROUNDWATER LEVEL

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Summary. Construction of even the smallest artificial water reservoirs, both dug and dam reservoirs, always exerts some impact on the natural environment. This is a result of e.g. change of predestination of inundated area and changes of water relations in adjacent areas due to the elevation of ground water level. The extent of this impact depends mainly on geologic conditions and the height of water level lift. One might observe far reaching changes of ground water dynamics caused by lifting. The changes may transform vegetation cover and thus negatively (or positively) affect the natural environment. Therefore, the prognosis of reservoir impact on ground waters should become one of the basic elements in planning future directions of water management.

Key words: water reservoirs, ground waters, water balance, river catchment, valleys, weirs

INTRODUCTION

The term „water reservoir" includes various types of reservoirs which periodically or permanently collect surface waters. Usually, a reservoir is meant as a man made construction. But natural water bodies like lakes, puddles or beaver ponds are also water reservoirs.

In the present paper „reservoir" is meant as an artificial water body that permanently or periodically retains surface waters regardless of their further use. Natural ponds are also included if their reconstruction results in changes of water level.

Reservoirs constructed in the world are of various sizes, sometimes huge with a capacity of several billion cubic meters and heavily affecting various components of the natural environment. This paper pertains to dug reservoirs and small dam reservoirs of a capacity less than 0.5 million m^3 and water elevation up to 1.5 m.

Practically, every new or reconstructed reservoir alters the hydrologic regime of running water, water relations in soil [Kowalewski 2003], creates new conditions for the development of aquatic vegetation, etc. In most cases these are positive changes in view of natural and economic purposes. Small reservoirs form valuable enclaves in otherwise monotonous agricultural landscape [Bielecka *et al*. 2006].

Changes of ground water level in areas adjacent to reservoirs might transform terrestrial vegetation as a result of changing soil moisture. Therefore, understanding the effect of reservoirs on ground waters should be one of important issues considered in planning water management in catchments and in the development of small retention.

DAM RESERVOIRS

Dam reservoirs are made by damming up the channel and the river valley with a water-lifting construction. Water level is lifted and a part of the valley is inundated. Such reservoirs are also made by damming already existing ponds and lakes, by restoring puddles, etc. [Radczuk and Olearczyk 2002].

The level of surface water may also be changed due to the construction of damming installations across rivers and channels when water does not flow over the bank and does not flood the valley. Such water bodies are often called linear reservoirs.

Every dam reservoir, if its water level is kept higher than before damming, affects ground water table and soil moisture in the close surroundings of the reservoir. The extent of this impact depends of the relief, damming height, geological structure and hydro-geological conditions [Mioduszewski 1995]. When the reservoir is surrounded by poorly permeable grounds, the range of the impact is small – several to several dozen metres. In catchments dominated by sandy formations the effect of water lifting may reach several hundred metres.

Figure 1 shows the ground water table before and after the construction of a reservoir depending on the geological structure of the valley and upland. The impact is far reaching when the upland and valley are made of permeable and uniform formations (Fig. 1a). The effect of water lifting may manifest itself farther, resulting in the inundation of local depressions (Fig. 1a).

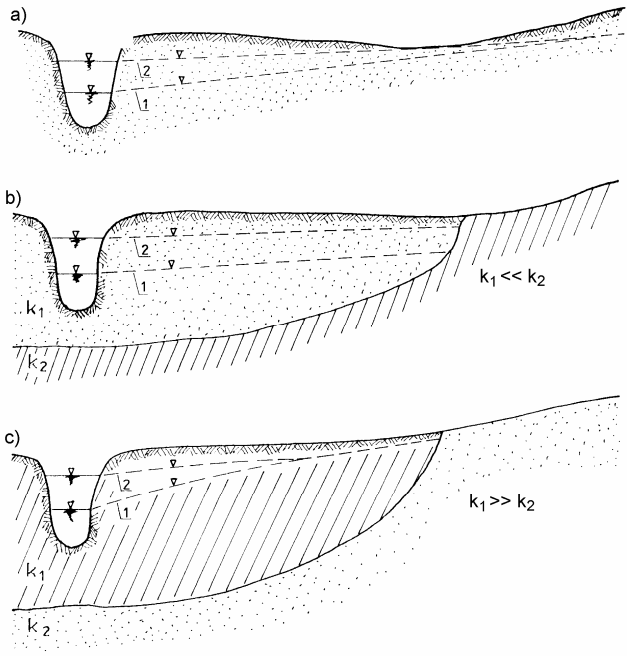

Fig. 1. Influence of the reservoir on groundwater level: a) uniform and permeable substratum, b) erosion valley in permeable soil, c) valley built of non permeable grounds underlined by permeable structures; 1 – phreatic line before reservoir construction, 2 – after water level lifting

Rys. 1. Wpływ zbiornika zaporowego na wody podziemne: a) jednorodne przepuszczalne podłoże, b) dolina erozyjna w gruntach przepuszczalnych, c) dolina zbudowana z gruntów słabo przepuszczalnych podścielona utworami przepuszczalnymi; 1 – krzywa depresji przed budową zbiornika, 2 – po spiętrzeniu wody

When an erosion valley runs in older poorly permeable formations (Fig. 1b), the range of reservoir impact is limited by the width of permeable channel. When, however, reservoirs are constructed in poorly permeable grounds, they affect ground water table in their close vicinity (Fig. 1c). It has been estimated that water lifting by 1 m in grounds of hydraulic conductivity of 10^{-6}-10^{-7} cm s^{-1} affected ground water not farther than several dozen metres.

The influence of dam reservoirs on soil moisture depends on the depth of ground water table before and after reservoir construction. At deep ground water level (a depth greater than the height of capillary rise), water lifting does not affect soil moisture (Fig. 2a). It may, however, cause inundation of terrain depressions as shown in Figure 1a.

When a reservoir is built in a relatively flat area, which is often the case with the localization of small reservoirs, the elevation of ground water table may assume the form of capillary irrigation, thus improving the moisture of once drained wetlands. This leads to an increase in biomass production and in evapotranspiration. At great evapotranspiration the stream (reservoir) changes its function from draining to recharge (Fig. 2b).

In many cases, ground water table elevated due to the installation of a lifting construction modifies the vegetation cover towards hygrophilous habitats. It may also contribute to the protection or renaturization of dried wetlands.

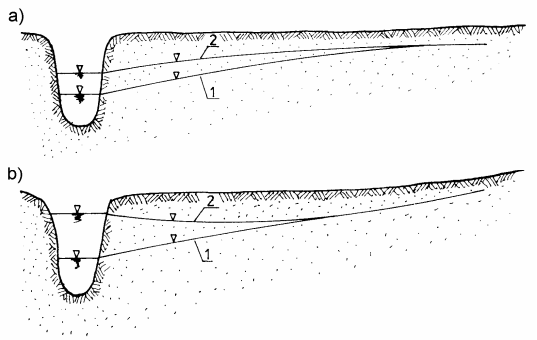

Fig. 2. Influence of reservoir on groundwater level: a) in the winter season, b) in the growing season; 1 – groundwater level before the reservoir construction, 2 – after water rising
Rys. 2. Wpływ zbiornika na położenie zwierciadła wód gruntowych: a) w półroczu zimowym, b) w okresie wegetacyjnym; 1 – zwierciadło wody przed budową zbiornika, 2 – po spiętrzeniu wody

DUG RESERVOIRS

Dug reservoirs exert a weaker impact on ground waters than dam reservoirs. In practice it might be assumed that in dug reservoirs water table is kept at the height of primary ground water level. At substantial water uptake from the pond and resulting decline of water table there, ground water level in adjacent areas decreases as well (Fig. 3b). Usually the changes are not important and do not bring about negative phenomena in the surroundings.

Ponds fed from an aquifer under pressure, situated in a geological structure as in Figure 3a, may exert a negative effect of ground waters. Construction of a shallow pond (Fig. 3b) would not significantly change the dynamics of ground waters. Drilling through poorly permeable layer may, however, result in the decline of ground waters on uplands, reaching sometimes the distance of several kilometres (Fig. 3c).

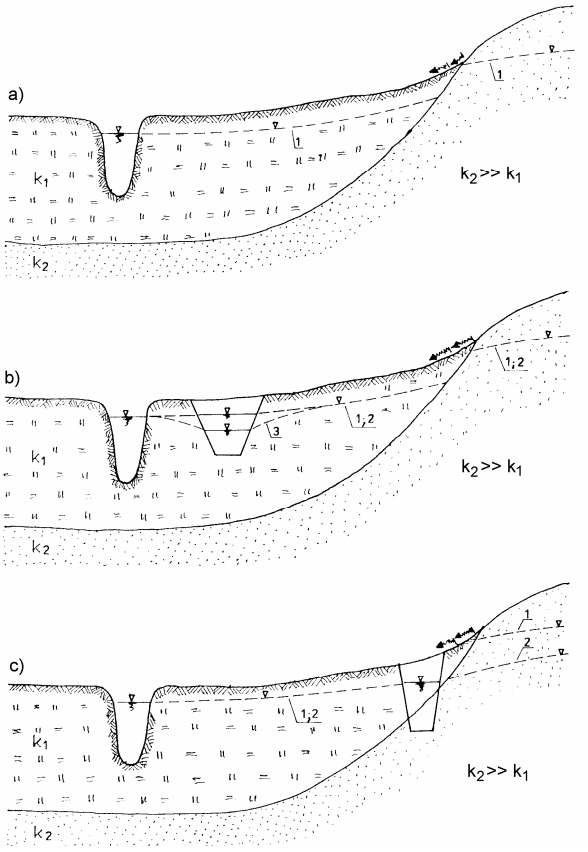

Fig. 3. Influence of dug reservoir on groundwater: a) primary groundwater level, b) after construction of a shallow pond, c) after construction of a deep pond in spring area; 1 – groundwater level before reservoir construction, 2 – after pond construction, 3 – after lowering water level in the pond
Rys. 3. Wpływ lokalizacji zbiornika kopanego na wody podziemne: a) pierwotne położenie wód gruntowych, b) po wykonaniu płytkiego zbiornika w dolinie rzeki, c) po wykonaniu głębokiego zbiornika w strefie źródliskowej; 1 – zwierciadło wody przed budową zbiornika, 2 – po wykonaniu zbiornika, 3 – przy poborze wody ze zbiornika

CONCLUSIONS

1. Practically all types of water reservoirs bring about changes in the ground water level in adjacent areas, which may have positive or negative consequences for the natural environment. In many cases water lifting is a fundamental step in wetland restoration. The impact and prospective biological and economic consequences of the construction of small dam reservoirs are of limited range because of small size of reservoirs and small water lifting. Particularly negligible impact is observed in valleys built of poorly permeable grounds.

2. In most cases dug reservoirs do not alter the dynamics of ground water table except for those fed with waters under pressure. The latter may unfavourably decline ground waters even at large distances.

3. Presented review shows that the construction of small water reservoirs should be preceded by analysis of the effects they may exert of ground waters and the natural environment. In more complex situations proper prognosis of the impact of a reservoir on ground waters requires detailed recognition of geological conditions and calculations based on numerical hydro-geological model.

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ODDZIAŁYWANIE MAŁYCH ZBIORNIKÓW WODNYCH NA WODY PODZIEMNE

Streszczenie. Budowa nawet tych najmniejszych sztucznych zbiorników wodnych, zarówno kopanych, jak i zaporowych, wywiera pewien wpływ na środowisko przyrodnicze. Wynika to m.in. ze zmiany przeznaczenia określonego obszaru w wyniku zalania wodą oraz zmian warunków wodnych w terenach przyległych na skutek podwyższenia poziomu wód gruntowych. Zasięg oddziaływania zbiornika zależy głównie od warunków geologicznych oraz wysokości piętrzenia. Obserwuje się zmiany dynamiki wód podziemnych, spowodowane piętrzeniem, sięgające niekiedy na znaczne odległości. Powodują one przekształcenia szaty roślinnej, a tym samym negatywnie (lub pozytywnie) oddziałują na środowisko przyrodnicze. Dlatego też prognoza oddziaływania zbiornika na wody podziemne powinna stanowić jeden z podstawowych elementów w procesie planowania kierunków rozwoju gospodarki wodnej.

Słowa kluczowe. zbiorniki wodne, wody podziemne, bilans wodny, zlewnia rzeczna, doliny, budowle piętrzące