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Small (natural) water retention in rural areas

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Abstract

Since 1960`s in Poland a phrase „small retention" has been used although it has been unknown in other countries. "Small retention" means various forms of human activity aiming towards limiting the fast water runoff after snow melting and heavy rains. It is believed that water that has been retained in periods of its excess can supply water courses during summer. It can also be used for agricultural purposes as it increases water availability for crops and improves biodiversity of rural areas.

Many different methods of water retention have been defined. Among others, increase of potential retention of surface waters can be achieved by construction of reservoirs or damming on rivers and lakes. Ground water retention capacity can be improved by increasing recharge of aquifers and improvement of soil structure in the aeration zone. Due to the form and way of implementation of small retention measures they can be divided into technical and non-technical measures. In other words, small retention can be defined as a set of measures aiming towards reconstruction of natural retention in the catchment that has been modified or destroyed by human activity.

In this paper, it has been stressed that activities and tasks undertaken in Europe in recent years under phrase "increase of natural retention" can be covered by the definition of small retention.

Key words: *agriculture, hydrology, river basin, rural areas, water management, water resources*

INTRODUCTION

Water resources can be characterized by a significant seasonal and spatial diversity [KOWALCZAK *et al.* 1997; ŁOŚ 1997; PALCZYŃSKI *et al.* 2002]. The extreme natural phenomena like floods and droughts can cause significant loss in economy (especially agriculture) and natural environment.

Our climatic zone can be characterized by small amount of precipitation that is relatively favourable distributed during a year. The most of the precipitation occur during summer (a growing season) which is the period with the highest demand for water. Despite this fact, in most of the country (except the seaside and the highest mountains) a significant deficit of water can be observed (Fig. 1). The monthly sum of

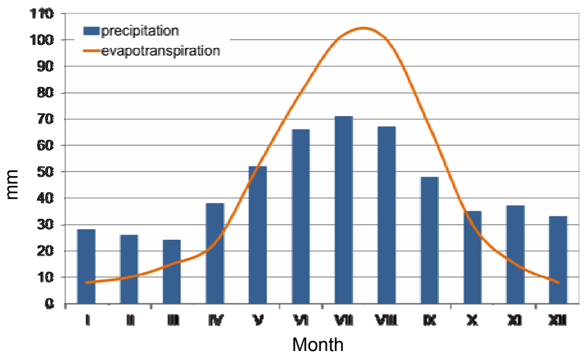

Fig. 1. Annual distribution of precipitation and evapotranspiration source: own study

precipitation is significantly lower than the evapotranspiration. Plants use the soil and ground water supplies stored during winter and when these supplies are completely used – droughts occur [EC 2012; MIODUSZEWSKI 2008; RADCZUK 2002]. On the other hand, after snow melting and more significant rainfalls a rapid surface runoff to rivers cause floods.

According to many authors [GUTRY-KORYCKA *et al.* (ed.) 2003; MIODUSZEWSKI 1997] agriculture intensification and unification of plants habitats, including forests, construction of drainage systems as well as urban development and resulting changes in surface character cause intensification of water and matter cycle in river catchments contributing to occurrence of droughts and floods (Fig. 2). In other words, as a result of many different measures a natural water retention capacity of the catchment has decreased while the runoff paths have been streamlined what cause rapid runoff of precipitation and snow melting waters to river [GUTRY-KORYCKA *et al.* (ed.) 2003].

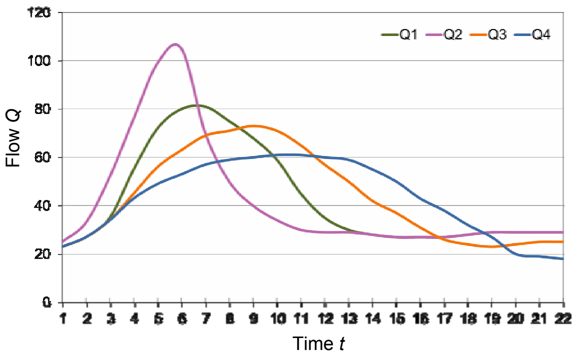

Fig. 2. Exemplary hydrogram of the food wave: *Q*1 – agricultural watershed, *Q*2 – municipal watershed, *Q*3 – forest watershed, *Q*4 – agricultural watershed with "small retention"; source: own study

Intensification of the water cycle causes increase of the load of nutrients transported to rivers and lakes. With slow water runoff from the catchment nitrogen and phosphorous can be consumed by plants while with rapid runoff water is transported to the receivers (surface waters, Baltic Sea) causing its eutrophication.

Taking into consideration points given above it is very easy to justify the need of water retention. Almost all specialists, starting from ecologists and ending on hydrotechnics and politicians claim that intensification of surface runoff occur due to human economic activity. It is also widely believed that the expected climate changes in Poland will cause decrease of precipitation in summer and increase in winter [KOWALCZAK 2007; MIODUSZEWSKI 2008]. If we assume that these believes are true, and there are no reasons not to do so, than the basic task of water management in coming years will be measures for decreasing the rate of water runoff from catchment. And this objective can be reached by technical and non-technical measures.

The group of methods which can be used for increasing of water retention of small basins is used to call in Poland as "small water retention". It is in opposition to "great water retention" which is represented by water storage in big reservoirs. In other words we a talking about "water retention in river basin", not as previously "water storage in different kind of reservoirs" [CRWFS 2012].

Nowadays, there are two main activity areas in water management:
– water retention and limiting of the effects caused by its excess or deficiency;
– reasonable management of the existing water resources.

Both problems can, at least partially, be solved with use of "small water retention techniques".

When we talk about water retention we usually mean storage of rain or snow melting waters in the place of origin. It means that it is necessary to limit its rapid runoff from the surface or small water courses (ditches, streams). It should be emphasized that retention of rain waters is free of charge while there are fees for extraction of surface and ground waters in most of the EU countries. It results from the Water Framework Directive – the basic EU document regulating issues of protection of water management.

Increasing of water retention in catchment seems to be the most environmental friendly and fulfilling conditions of the sustainable development method allowing improvement of water balance [CIEPIELOWSKI 1995; GLENN 1993; KOWALEWSKI 2008; MIODUSZEWSKI 1999]. It should be noted, however, that the current state of development of catchment and river valleys as well as the high population density prevent full restoration of catchment water storage capacity and limit the effects of extreme events through human adaptation to them (e.g. displacement of people from areas at risk of flooding, restoration of wetlands used for agriculture or urban development, increasing retention in places where it can cause flooding of buildings etc.). Regardless of the manner and intensity of economic land use, including agricultural, forest and urban areas, in each case one should try to limit the rapid rain and snow melting waters as it equals reconstruction of the natural water retention capacity of the river catchment.

IMPLEMENTATION OF THE "SMALL WATER RETENTION" PROGRAM IN POLAND

There were several attempts in Poland to improve the structure of water balance with use of small water retention development (Tab. 1). The need to increase water resources for agriculture as well as the state of the natural environment and opportunities for flood protection were emphasized. The first major action of promotion of "small water retention" (mainly the construction of small water reservoirs) was carried out at the turn of 60s and 70s last century. Prof. Dziewoński was the first who used "small water retention" [DZIEWOŃSKI 1971; RADCZUK 2002].

Table 1. The measures which have been undertaken in the frame of the "small water retention" program in Poland

Years	The aim of the measures	The law basis	Effects
1960–1965	the water storage for irrigation, small water reservoirs	the initiative of Agricultural Universities	a few small water reservoirs
1975–1985	constructed of small reservoirs for irrigation and power stations	the Government Resolution, the Church Fund	some old weirs were reconstructed and power station installed
1995–2010	the Program of Small Water Retention – improve of water balance	the agreement between Ministry of Agriculture and Environment	small hydraulic structures, retention – 860 mil. m^3 (description in the text)
2000–2010	protection of wetlands, especially peatlands	the Program of environmental protection – local initiative	several small water reservoirs, weirs on ditches, protection of peatlands
2010–2014	the Program of small water retention in forests	the Program financed by European Union	revitalization of wetlands, constructed water reservoirs, increasing of groundwater level

Source: own elaboration.

At the end of the 70s the Polish government adopted a resolution which recommended the reconstruction of small reservoirs and hydraulic structures for raising water level in rivers. The Resolution on promoting the development of small hydropower comes from the same period. Some financial support was coming from the "Church Fund" as well. There are no data to assess the effectiveness of these measures. The fact is that in the 70s and 80s dozens of dams and reservoirs have been reconstructed, and part of them is used to produce electricity. Not always, these investments were friendly to the environment.

In 1995, another step to improve the structure of the water balance of small catchments has been made [KOWALCZAK *et al.* 1997; KOWALEWSKI 2004]. An agreement between the Ministry of Agriculture and Food Economy and the Minister of Environmental Protection, Natural Resources and Forestry of Poland on cooperation in the field of the development of small water retention was signed. Parties to the agreement recognize, among others, that it is appropriate to financially support activities such as:

– reconstruction, modernization and construction of dams on the existing drainage facilities for the use of water for agricultural irrigation , decreasing runoff of surface waters and the protection of peat soils;
– additions and modernization of drainage – irrigation facilities on moors, designed to preserve the ecological balance of ecosystems;
– construction of dams on streams and ditches to raise the ground water level in adjacent areas;
– construction of small water reservoirs, raising water level in lakes in order to retain water for agriculture and other activities of this type;
– retention of spring water, snowmelt and precipitation in ponds, post excavation pits, and local depressions.

The main attention was paid to stop snowmelt and rain waters in the site of their origin, using technical measures limiting the outflow of water on the surface of the land.

In 2002, the need for the development of small retention has been highlighted again by signing an agreement "on cooperation to enhance the development of small water retention, and dissemination and implementation of environmentally friendly methods of water retention." The agreement was signed by Minister of Agriculture and Rural Development, Minister for the Environment, Chairman of the Agency for Restructuring and Modernisation of Agriculture and the President of the National Fund for Environmental Protection and Water Management (NFOŚiGW). For several years after the signing of the agreements, investors were able to obtained financial support, among others, from NFOŚiGW. NFOŚiGW organized competitions for the best investment in field of small water retention [BIELECKA *et al.* 2006; KOWALEWSKI 2013].

As part of the agreement small retention development programs covering mainly rural areas have been developed and approved by the regional parliaments. The programs, for which Regional Drainage and Water Facilities Boards were responsible, are very diverse due to the general concept of actions, considered elements of small retention, level of detailes within information, environmental impact assessment, costs, evaluation of economic efficiency [BŁACHUTA *et al.* 2011; GUTRY-KORYCKA *et al.* (ed.) 2003]. For some provinces model calculations were performed to optimize the needs of small water retention, taking into account elements such as precipitation, flow variability, flood risk, agricultural use, the presence of valuable natural areas, catchment management, etc. As the result, maps of the priorities of small retention have been prepared. In contrast, there is no numerical analysis of needs of retention – how much water and for what purposes should be impounded. The sources indicate mainly a general need to improve the structure of the water balance in relation to the small Polish water resources The planned increase in the volume of retention waters was based mainly on small water bodies (ponds), which is predicted to get the retention of the order of 860 million m^3 (4789 reservoirs). Adjusted natural lakes for additional storage of water (620 pcs) is assumed to increase the retention of 263 million m^3, and storage of water in the drainage system (basic and detailed) is expected to increase it by another 18 million m^3. In total in the country storage of 1141 million m^3 is foreseen in the framework of the small retention program by the end of 2015. It is estimated that the investments made under these programs resulted in an increase in water retention in the country by an average of about 15 million m^3 per year while in provincial programs the increase was planned to be ca. 60 million m^3 per year [KOWALEWSKI 2007]. On Figure 3 the main measures has been specified, which has been constructed in the frame of the "Program of small water retention" during the years 1997–2010.

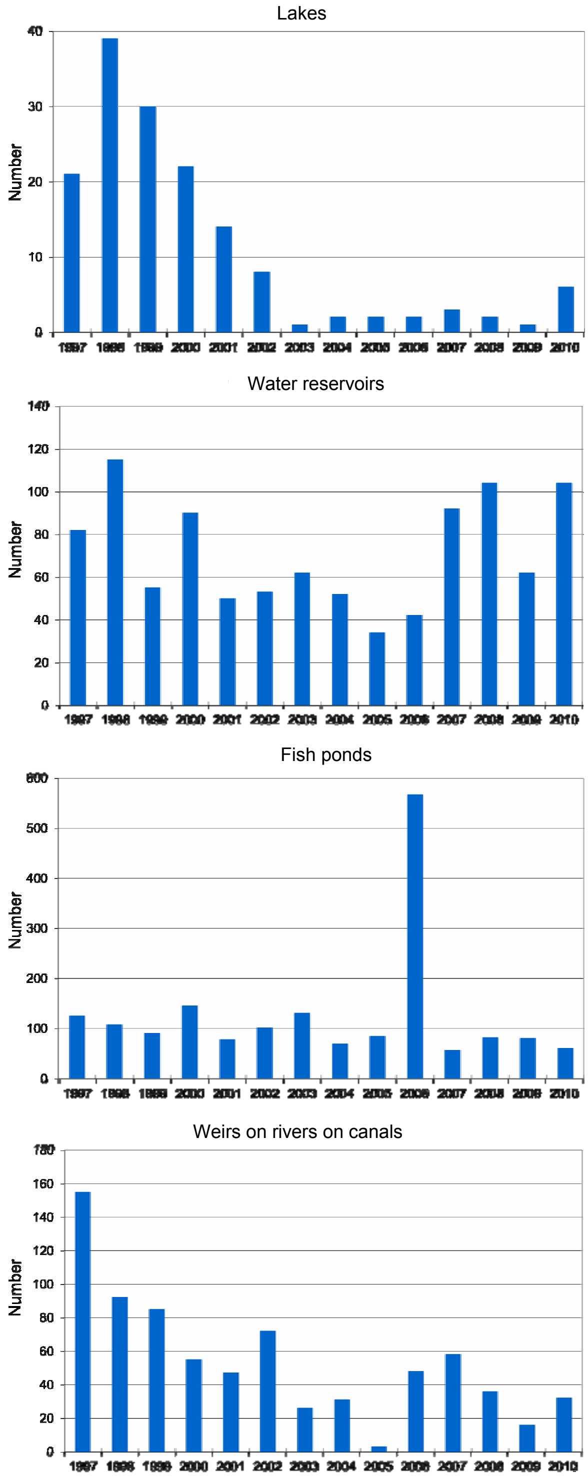

Fig. 3. The main structures constructed in the 1997–2010 year in the programme of small water retention; source: KOWALEWSKI [2013]

The main measures were water reservoirs, and weirs constructed on river and canals, mainly for irrigation. It is a difficult to assess to what extent these objects is the result of implementation of the program of development of small retention and to what degree they are the result of efforts undertaken by investors previously. The largest funds are directed to the construction of reservoirs (54.8%) and damming constructions on channels and ditches of the canals and drainage network (25.4%). In contrast, the non-technical forms of water retention are almost completely ignored. Details regarding the implementation of the small retention program apply only to investments made in consultation with the provincial boards of drainage and water devices.

There are different sources of finance for small water retention. Mainly the Program was supported by National and Voivodeship Found or Environmental Protection (Fig. 4). Some finance is coming from private sources (others). There are mainly for constructed of fish ponds.

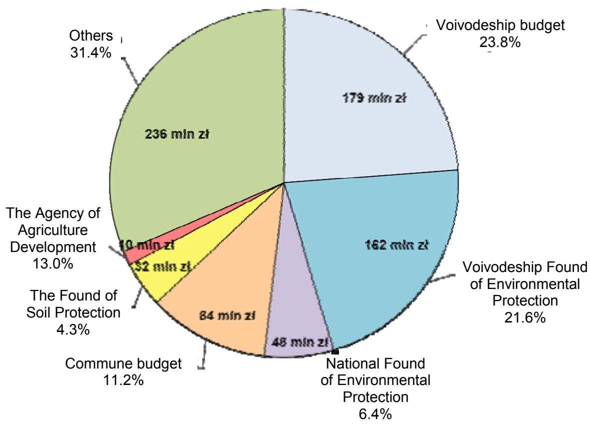

Fig. 4. The source of finance for small water retention programme during the years 1997–2010; source: KOWALEWSKI [2013]

Quite active actions in scope of small retention have been undertaken on by the State Forests and environmental organizations A large number of small dams in the ditches and watercourses as well as a number of reservoirs serving primarily as the way of improvement of the ecological status of forest habitats and wetlands have been constructed. For example, in the Białowieża Forest dozens of small reservoirs and ponds to increase moisture and improvement of the living conditions of amphibians have been constructed [BIELECKA *et al*. 2006].

Currently, a large project to improve water resources in forest areas, funded by the European Commission is under implementation. As part of this project several thousands of small dams, including water reservoirs and weirs on ditches will be completed [CKPŚ 2008].

It is worth mentioning that in other countries, attempts are being made to improve the water balance – with use of small retention methods. In 1985, the President of the United States initiated a program under the slogan "no net loss of wetlands". Under this program, among others, tens of thousands of small water reservoirs with a total area of more than 4 million hectares have been built mainly in rural areas [MIODUSZEWSKI 1993].

In recent years the need for better integration of environmental concerns in water management has been highlighted. It is believed [UNECE 1993] that it is not possible to manage water resources without taking into account the whole range of issues related to the use of the catchment, soil and air quality, the state of fauna and flora as well as human presence. Also, the Water Framework Directive is clearly focused on integrated water management and aimed at protection of the natural values of aquatic and water – dependent ecosystems.

Widely understood small water retention meets most of the conditions posed for the ecological methods of water management in both, agricultural landscape and forest and urban areas. Agricultural areas both because of its nature and the fact that they occupy almost 60% of the country are an important element of regulation of the circulation of water in river basins. Increasing of the retention capacity of rural areas can significantly contribute to the improvement of the structure of water balance in the country.

FORMS AND METHODS OF SMALL WATER RETENTION

Despite the long history, the concept of "small water retention" is not fully defined. In very broad terms, it can be assumed that these "are all technical and non-technical measures to improve the structure of the water balance of the catchment by increasing its natural and artificial water retention capacity". Using the above definition, it is possible to name such forms of retention as: landscape (settlement), soil, surface and underground ones [MIODUSZEWSKI 1997].

A new phrase "Natural Water Retention Measures" became visible in recent years. It has been defined as "measures that aim to safeguard natural storage capacities by restoring or enhancing natural features and characteristics of wetlands, rivers and floodplains, and by increasing soil and landscape water retention and ground water recharge" [GOMEZ *et al*. 2013]. A similar definition has been given by the European Commission: "measures aimed to safeguard and enhance the water storage potential of landscape, soils and aquifers by restoring and maintaining ecosystems, natural features and characteristics of water courses and by using natural processes" [EC 2012; GOMEZ *et al*. 2013].

The above given definitions shows us significantly similarities between measures called "small water retention" and "natural retention". Small water retention covers slightly wider scope of actions as it includes technical measures for increase of the water retention capacity of the catchment. Phrases "natural retention" and "water harvesting" can be included into one phrase "small retention".

Small water retention or natural water retention stands out from other retention methods by the fact that we are dealing with the so-called automatically working uncontrolled retention, which capacity is difficult to determine. Increasing of the landscape, soil surface water and groundwater retention alters the circulation of water in the basin, but this process cannot be adjusted on demand.

Increasing of the uncontrolled retention increases only the potential to collect waters at times of its excess and longer retention in the soil, ground or on the surface [MIODUSZEWSKI 1997]. An overview of techniques possible to use for improvement the structure of water balance has been given in Table 2.

Other distribution of methods of water retention results from the location and type of action:
– in the catchment area through its proper development and use;

Table 2. Systems and methods of water retention in rural areas

Water resources	Systems and methods
Landscape (habitat) retention	Systems shaping the proper structure of land use through: – system of arable fields, grasslands, forests, ecological lands and ponds – afforestation, creation of protective belts, woodlots shrubs, creation of bruises and terraces – increasing of the surface of wetlands bogs, swamps
Soil retention	Cultivation systems shaping water management in a soil profile: – improvement of the soil structure, agricultural drainage, liming, proper agro-techniques, proper crops rotation, increase of organic matter in soil
Soil and ground waters aquifers	Cultivation – drainage systems limiting surface runoff: – limitation of the surface runoff – increase of soil filtration capacity – anti-erosion, phyto-drainage and agro-drainage measures – regulated outflow from drainage system – ponds and infiltration wells for storage of rainwater from sealed surfaces
Surface waters	Hydrotechnical systems of division and storage of water: – small water ponds – regulation of outflow from ponds and small reservoirs – water storage in drainage ditches and channels etc. – retention of water outflowing from drainage systems – increasing of the valley retention including construction of polders

Source: MIODUSZEWSKI [1997], modified.

– in the riverbed and river valley through the construction of small water reservoirs and damming devices (regulation) of the outflow of surface waters.

The first group of actions include a non-technical methods based on increasing of the retention capacity of the catchment, including soil. Correct agricultural use of soil anti erosion measures, afforestation, buffer strips, ponds play an important role in increasing of the share of wetlands in the catchment area, etc. Many authors [GLENN (ed.) 1993; GUTRY-KORYCKA *et al.* (ed.) 2003; MIODUSZEWSKI 1999; PIERZGALSKI *et al.* 2002] emphasize the importance of land use and its influence on the quantity and quality of water resources. Therefore, in non-technical methods one can distinguish planning methods (spatial arrangement) and methods that are dependent on agricultural use.

It is relatively hard to evaluate the effect of landscape shaping and changes in the land use on increasing of water retention. Values of the water retention capacity defined as the part of the precipitation that do not flow directly to the river have been given in Table 3. These values are approximate as they have been estimated basing on the method C [GLENN (ed.) 1993; POCIASK-KARTECZKA (ed.) 2006]. Nonetheless, a significant variability of the retention capacity is visible depending on the land use structure and the type of soil. It is also possible to influence the water cycle by implementation of changes in the land use structure of the catchment.

Table 3. Estimation of potential natural water retention (mm)

Land use	A. Very permeable soils (sands, gravels, lessees)	B. Rather permeable soils (silt, sandy clay)	C. Permeability below average (clay with humus, silty clay)	D. Low permeability (clays)
Fallow	76	41	25	16
Root plants	149	85	52	38
Pastures	397	162	89	63
Meadows	592	184	103	72
Forest	762	207	109	76

Source: own study.

The second group, called the technical one, include all construction works related to hydroengineering and drainage and many professionals mistakenly limits the notion of small retention to this group of actions.

Technical methods – one can include most works from hydrotechnics and drainage to this group. The aim of these methods is delay of surface water runoff. This includes construction of small water reservoirs, raising of water table level in lakes, damming streams, ditches and channels, drainage water retention, the use of proper methods of drainage of rainwater from sealed surfaces (roofs, squares, streets) to allow percolation of water in adjacent unsealed areas, restoration of small streams and flood valleys with use of technical methods.

Planning methods – shaping the proper spatial use within catchment is one of the most important elements in water management. It focuses on the creation of such a spatial arrangement in which rapid outflow of rainwater and snowmelt is possible. Such activities can include the development of an adequate system of arable fields, grasslands and forests, the creation of plant protective belts (shrubs, trees), recreation of as many ecological lands as possible, including ponds, wetlands, etc. Some calculation has shown that the changes of land use can have an impact on river flow.

Methods dependent on the land use style (agrotechnical) – use of appropriate methods of agricultural land use in the catchment can contribute to improving both the quality and quantity of water. Key activities in this area is to improve the structure of agricultural and forest soils, anti-erosion measures, maintenance of appropriate forest communities, preventing the formation of privileged runoff tracks in forest, preserve areas of infiltration in urban areas.

NON-TECHNICAL MEASURES OF SMALL WATER RETENTION

Non-technical forms of small water retention include all activities associated with increasing capacity of water storage in river basins due to changes in land use. These forms are the most similar to the natural forms of water retention. Water storage capacity in the landscape is increased (detention reducing run-off and increase of the retention capacity of soil).

Wetlands, speaking on the ability to retain water by the swamps, one should clearly distinguish:
– swamp soil retention capacity is the ability of soil to store water in pores
– retention capacity of the swamp is ability to store water on the surface of the area,
– retention capacity of the plateau areas that origins as a result of decrease of groundwater runoff manifests itself by the origin of peat bogs on the borders of the aquifer.

Rainwater can be retained in soil pores between the ground surface and groundwater table. The higher the level of groundwater, the lower the retention capacity of soil as it is defined as the volume that can be filled with inflowing water (flooding, precipitation). In natural swamps where water table is situated on the surface, the volume of soil retention is virtually zero. Therefore, every drop of water that falls on the surface of such swamp, in theory, could flow freely into the river. This does not mean that the drainage of wetlands reduces the size of the flood wave. Natural swamp covered with clumps of sedges and shrubs are characterized by a large hydraulic resistance. Moreover, they are usually areas with small denivelations of the area. Therefore, the snow melt water as well as flood waters very slowly leave the surface of the swamp. Marshy river valleys act as of water retention reservoirs. Water that spilled on the surface of the swamp slowly flows into the river, thus flattening the flood wave occurs on a section of the river below swamp area. This phenomenon is clearly visible in the wide (over 10 km) Biebrza valley bottom. Sometimes water is kept here on the surface for a few months. A drop of water flows freely, but very slowly.

Forests, forest areas, like swamps, are characterized by a high probability of rainwater retention. There is a significant amount of literature devoted to assessing the impact of forest on the structure of the water balance of river basins. The prevailing opinion is that forests regulate water circulation by retention in periods of rain and increase the alimentation of rivers during periods without precipitation.

The positive role of the forest in reduction of the size of floods caused by rainfall and snowmelt in areas with large land denivelations and poorly permeable soils is not in doubt, although – it is difficult to demonstrate this impact in the form of the assessment of flow rates in rivers. Forests play particularly important role in areas with varied relief and – poorly permeable soils. They limit rapid water runoff from the surface of the land, gathering water in undergrowth [CIEPIELOWSKI, DĄBKOWSKI 1995].

A slightly different situation occurs when forested areas are plains with sandy soils. In this case, the reduction of effective infiltration can occur what stands for reduction of the aquifers alimentation. This is due to the fact that prior to afforestation most of the water from melting snow and rainfall infiltrates into the ground. Water uptake by vegetation increases as forest transpiration is higher compared to other habitats. On the other hand, some authors believe that the increase of forest area causes an increase in rainfall up to 30%. Measures are taken to slow down the outflow of water from forest areas by investing in small retention, particularly in the drained areas. This work is carried out under the project "Increase the retention capacity and the prevention of floods and droughts in forest ecosystems in the lowlands" and it includes:

– restoration of wetlands by raising the groundwater level;
– construction and reconstruction of small water reservoirs, dams on streams, etc.

Areas used for agricultural purposes. On the one hand, agricultural use of the land is often underestimated as a method to improve the retention capacity of the catchment, on the other hand, a number of recommended agronomic measures significantly improves the structure of the water balance of the basin.

All agronomic measures improving soil structure can be included in the small retention measures. The increase in the humus content, elimination of plow surface, improvement of the structure heavy soils increase the water retention capacity. Even a small improvement in the retention capacity can cause retention of a large volume of water. For example, increasing of retention capacity by 10 mm (10 $dm^3 \cdot m^{-2}$) per hectare gives 100 thousand m^3 of water. From the plants needs point of view is not very large volume of water, but at a catchment scale such amount can greatly reduce the likelihood of flooding.

Correct methods of cultivation, such as reduced frequency of plowing and plowing along contour lines can be included in non-technical measures. In other words, all the anti-erosion and agro-drainage measures cause reduction of the water outflow rate, and thereby contribute to increasing the water retention capacity of agricultural areas. Similar effects and consequences can be caused by phyto-drainage measures. Creation of a plant protective belts, leaving ecological enclaves in the agricultural landscape such as ponds or clumps of trees and shrubs, is nothing more than increasing of the ability to retain water.

TECHNICAL MEASURES OF SMALL WATER RETENTION

Any actions that will increase the volume of water retained in the catchment area, achieved through the implementation of specific structures and water installations are included in the technical measures of small retention.

Water reservoirs. Water reservoirs have always been an important element of human environment. Traces of reservoirs built for irrigation purposes 3–5 thousand years BC can be found in India, ancient Egypt and Greece. In Europe, in the Middle Ages and in modern times, it was common to dam rivers for economic purposes (watermills, small hydropower plants, fish ponds, etc.). The invention of the steam engine reduced the need for generating energy from water. But even after World War II one could count almost 8,000 small mill dams and hydroelectric power plants in Poland. Today only a few have left.

Under the name of "small water reservoirs" one can mean various types of water bodies, usually made by man. They are both dug ponds, including fish ponds as well as reservoirs formed by the partition of the river bed and valley by dam, equipped with valve device. Reservoirs are usually supplied by the current flow in the watercourse. They can also be so called dry reservoirs periodically filled while the occurrence of larger flows after heavy rains or snowmelt. There are many other sources of supply of the reservoirs such as groundwater flow, surface runoff, drainage water intakes, water pollution control etc. [BERNINGER 2012; KOPROWSKI, ŁACHACZ 2013; ŁOŚ 1997; MIODUSZEWSKI 2012]

There is no official classification of reservoirs. Therefore, sometimes even reservoirs with a capacity of up to 5 million m^3 are classified as small [DZIEWOŃSKI 1971]. Such reservoirs can have adverse impact on ecological values of the river valley and they should be equipped with passes. It has been proposed to adopt the classification of the reservoirs as shown in Figure 5. All micro and small reservoirs that do not

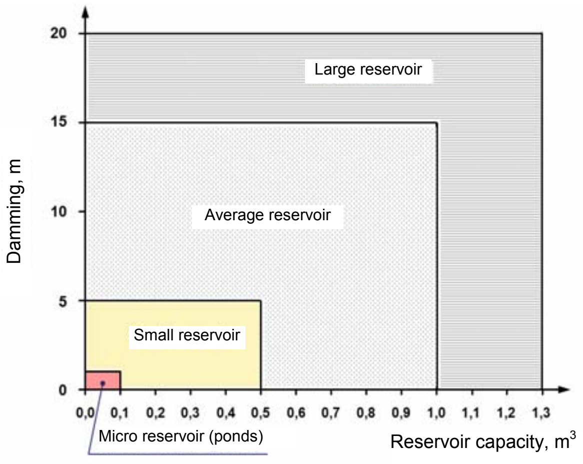

Fig. 5. Classification of water reservoirs; source: MIODUSZEWSKI [2012]

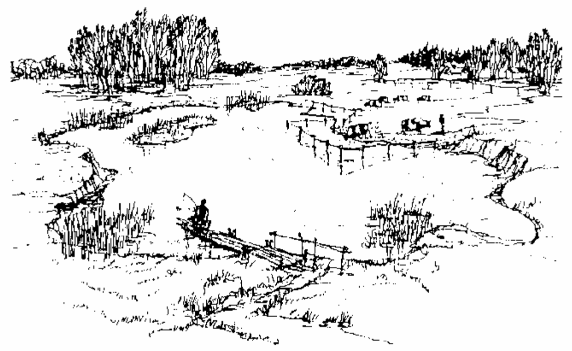

Fig. 6. The shape of the banks of the dug reservoir; source: MIODUSZEWSKI [1997]

pose any threads to the environment should be included in small retention measures.

Water reservoirs play a very important role in human economy and in the natural environment [MEIJER *et al*. 2012, UNECE 1993; Virginia DCR 2011]. Taking into consideration the purpose and way of use of tanks, they can be divided into:

– water storage tanks for household purposes: retention of water for irrigation of agricultural and forest lands, public and farm supply in water, fish farming, flood control, to produce energy (small hydro plants);
– reservoirs used for recreational and esthetic purposes: swimming, gardening (parks), fishing (Non-commercial fish farming);
– environmental reservoirs: the enclave of flora and fauna, bioflilters (constructed wetlands) or filters for water purification;
– tanks used to improve the structure of the water balance: supply of underground water reservoirs, flood protection, erosion reduction, retention of runoff from sealed surfaces [MEIJER *et al*. 2012].

Reservoirs may carry out one or more or several of the above-mentioned functions. For example, the reservoirs created as ecological ones can be used for amateur fishing, or as waterholes. Some features, however, exclude each other – e.g. tanks constructed for water supply for citizens and farms to cannot be used as waterholes or swimming.

Very often it is difficult to reconcile the interests of the nature with economic functions, such as the production of electricity. Small streams almost all flow, except the high flows, may be passed through a turbine. Hence, usually lack water for proper operation of the passes.

Small reservoirs have simple structures and can often be constructed in an economic way. Nevertheless, they should be treated as engineering structures, requiring not only technical knowledge but also environmental one. The basic principle of planning of small reservoirs is to give them a varied shape, such as in Figure 6. In case of damming of the streambed it is desirable to design damming devices, that do not impede the movement of fish. There are several constructions of such structures [MIODUSZEWSKI 2012]. From the environmental point of view, it is important to properly shape the borders of the reservoirs to allow plants growth in selected sites [CKPŚ 2008; Virginia DCR 2011].

Proper shape of the edges and bottom of the tank to a large extent determines its natural beauty. Vegetated reservoirs are often used as an element improving water quality. The major impact of vegetation on water quality provides, inter alia, the construction of the so-called. "Natural pools". Suitably shaped reservoir holding at least 50% of the surface of its shallow part covered with vegetation ensures good water quality in the "pool" in the recreation part (deep). Shaped reservoir may be used as a "pool" without the use of filters and chemicals to ensure proper sanitary condition of water [MIODUSZEWSKI 2012].

Drainage systems. For the purposes of agricultural intensification large number of small watercourses have been regulated and deepened. Also a number of so called valley drainage systems have been constructed by construction of a dense network of drainage ditches. In large areas of wetlands groundwater table has been excessively lowered. In many cases, it is possible and desirable – without damage to agriculture – to increase the level of water in these streams. Drainage systems (drainage, ditches) remove water during periods of its excess due to needs of crops and very often groundwater table is decreased too much. Usually, for agricultural purposes drainage that secures 6–8% presence of air in the top part of the soil profile is sufficient. There are technical solutions to reduce the excessive outflow of water from the drainage system. This can be done by applying of so called regulated outflow from the drainage network or construction of damming devices (dams) on the drainage ditches [MIODUSZEWSKI 1993].

A number of studies have shown that the reduction of the volume of water flowing out from drainage system, or a system of drainage ditches does not cause a negative impact on agricultural production. On the contrary, this type of regulation of the drain causes the retained water can be used by plants during the growing season, and therefore water conditions for agriculture are improved. In addition, water flowing out from drainage system with regulated outflow carries much smaller loads of nitrogen and phosphorus. Thus, the regulation of outflow contributes to the improvement of water quality in rivers.

Systems with regulated outflow can be constructed in rather flat terrain. With a more varied landscape (large denivelations of drainage pipelines) construction of small reservoirs at the outlets from the drainage system is preferable. Water in these reservoirs is purified and can also be used for irrigation or other purposes. Similar solutions can be applied to systems of drainage ditches.

Urban area. Acceleration of surface flow together with the development of urbanization is an increasingly important problem. It results in the increased frequency of flooding. Reducing runoff from sealed surfaces not only prevents the increase of flood flow, but also enable the use of water for economic and natural purposes. The basic method of increasing the retention of impermeable areas are infiltration reservoirs allowing the supply of the rain water to the aquifer when it is not isolated from the surface. Water coming from the roof and paved part of the yard can be used for irrigation of trees and shrubs. In contrast, the some solutions allows use of for example water flowing down the highway or street to supply the aquifer.

SUMMARY

Activities within the scope of "small water retention" measures is a similar to the "natural water retention measures". These methods can significantly contribute to the protection of water quality and improve the structure of the water balance. Increasing the potential catchment water retention capacity which in many cases has been affected by human activities is an important component of the protection and development of water resources. Small (natural) retention plays a positive role in improving the economic conditions for agricultural and forest areas as well as urbanized areas. It is also an essential element necessary for the preservation and improvement of the natural environment. Dissemination of small retention can be of great help in the implementation of the Water Framework Directive of the European Union, particularly in terms of achieving good ecological status and quality of surface waters.

By its nature, small retention only affects local water resources, and thus its impact on the hydrological conditions and the state of the natural environment is visible only in small catchments and depends on the type, number and location of the action taken. Small retention may play a role in reducing the negative impacts of droughts. Water accumulated in the reservoir can be used for irrigation or for other economic purposes. Also, water retained in soil or in aquifers is a significant resource that can be used by plants.

The issue of water, including small retention, should be further taken into account in making a number of business and planning decisions. Water is one of the most important elements determining the direction and manner of use of river valleys and infiltration areas.

Measures to increase water retention capacity of the catchment area have a number of positive effects, both of social and natural character as well as the economic one. The major advantages of small retention include:

– change of the structure of the river flow, decrease of the size of the flood flow and, in some cases, increase of low flow;
– securing forest and wetland ecosystems needs for water and improvement of the state of the natural environment as a result of elevation of groundwater table level;
– increase of aquifers alimentation what results in increase of groundwater resources;
– securing some of the economic objectives, e.g. reservoirs can be used as water intakes for fire secure purposes, swimming pools, extensive fish ponds, intakes for irrigation or waterholes;
– improvement of natural values, increase of biodiversity of the agricultural landscape through restoration of wetlands and ponds, creation of water dependent enclaves for natural fauna and flora, shaping a micro climate friendly to human;
– protection of surface waters from pollution, prevention of suspended material migration, purification of rainwater from nutrients (nitrogen and phosphorous).

LITERATURE

BERNINGER K., KOSKIAHO J., TATTARI S. 2012. Constructed wetlands in Finish agricultural environments: balancing between effective water protection, multifunctionallity and socio-economy. Journal of Water and Land Development. No 17 p. 19–29.

BIELECKA J., HARDEJ M., KOZŁOWSKA E., STEPANIUK W. 2006. Walory przyrodnicze i hydrologiczne małych zbiorników wodnych wybudowanych w Puszczy Białowieskiej [The ecological and hydrological value of small ponds constructed in Białowieża Forest]. Woda-Środowisko-Obszary Wiejskie. T. 6. Z. 2(18) p. 17–27.

BŁACHUTA J., KAMIŃSKI W., KOWALCZAK P., ROSA J., ZGRABCZYŃSKI J. 2011. Podręcznik dobrych praktyk w gospodarce wodnej na terenach nizinnych – wybrane zagadnienia [Handbook of good practices in water management in the lowlands – selected cases]. Poznań. RDOŚ pp. 88.

CIEPIELOWSKI A., DĄBKOWSKI L. 1995. Problemy małej retencji w lasach [Problems of small retention in forests]. Sylwan. R. 139. Nr 11 p. 31–47.

CKPŚ 2008. Wytyczne do realizacji obiektów małej retencji w nadleśnictwach [Guidelines for the implementation of small retention in forest districts]. Warszawa.

CRWFS 2012. From storage to retention: expanding California's options for meeting its water needs [online]. [Access

03.02.2014]. Available at: http://aginnovations.org/images/uploads/CRWFS_Storage_FINAL.pdf

Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy. OJ L 327.

DZIEWOŃSKI Z. 1971. Gospodarka na zbiornikach wiejskich [Management of the rural water reservoirs]. Gospodarka Wodna. Nr 3 p. 124–129.

EC 2012. Natural Water Retention Measures. Science for Environment Policy. Iss. 32 pp. 42.

GEIGER W., DREISEITL H. 1999. Nowe sposoby odprowadzania wód deszczowych [New methods of rainwater drainage]. Bydgoszcz. Wydaw. Proj. Przem-EKO. ISBN 83-906015-4-0 pp. 334.

GLENN O. (ed). 1993. Soil and water conservation engineering. New York. John Wiley. ISBN 9780471599944 pp. 360.

GOMEZ C.M., COLENTINE D., DELACAMARA G., STROSSPR P., IACOVIDES A., KINELL G., SÖDERQUIST T., UNGVARI G., FRIBOURG-BLANC B. 2013. Concept Note. Natural Water Retention Measures (NWRM) and the WFD and other daughter Directives [online]. [Access 03.02.2014]. Available at: http://nwrm.eu/sites/default/files/documents-docs/nwrmconceptnote_to_regional_stakeholders.pdf

GUTRY-KORYCKA M., NOWICKA B., SOCZYŃSKA U. (ed.) 2003. Rola retencji zlewni w kształtowaniu wezbrań opadowych [Role of the catchment retention in shaping high water levels caused by rainfall]. Warszawa. UW. ISBN 8389502704 pp. 285.

KOPROWSKI J., ŁACHACZ A. 2013. Small water bodies formed after peat digging in Dobrzyńskie Lakeland. Journal of Water and Land Development. No 18 p. 37–47.

KOWALCZAK P. 2007. Konflikty o wodę [Water conflict]. Poznań. Wydaw. Kurpisz S.A. ISBN 9788389738998 pp. 436.

KOWALCZAK P., FARAT R., KĘPIŃSKA-KASPRZAK M. 1997. Hierarchia potrzeb obszarowych małej retencji [Hierarchy of needs of small retention area]. Materiały Badawcze IMGW. Ser. Gospodarka wodna i ochrona wód. Nr 19. Warszawa.

KOWALEWSKI Z. 2008. Action for small water retention undertaken in Poland. Journal of Water and Land Development. No 12 p. 155–167.

KOWALEWSKI Z. 2013. Wdrażanie programu małej retencji w latach 1997–2010 [Implementation of small retention programs in during the year 1997–2010], not published.

ŁOŚ M. 1997. Historia rozwoju małej retencji w Polsce. W: Mała retencja wodna [History of small retention development in Poland. In: Small water retention]. Informator Naukowo-Techniczny SITWM. Nr 1.

MEIJER E., QUERNER E., BOESVELD H. 2012. Impact of farm dams on river flows. A case study in the Limpopo River basin, South Africa. Alterra Report. Nr 2394. Wageningen pp. 68.

MIODUSZEWSKI W. 1993. Ochrona zasobów wodnych w krajobrazie rolniczym w Stanach Zjednoczonych [Protection of water resources in agricultural landscape in the USA]. Biuletyn Informacyjny. Melioracje Rolne. Nr 1/2 p. 67–68.

MIODUSZEWSKI W. 1997. Mała retencja i polityka melioracyjna. W: Użytkowanie a ochrona zasobów wód powierzchniowych w Polsce [Small retention and drainage policy. In: Use and protection of surface water resources in Poland]. Zeszyty Naukowe. Nr 17. Kom. Nauk. Człowiek i Środowisko PAN. pp. 61–68.

MIODUSZEWSKI W. 1999. Ochrona i kształtowanie zasobów wodnych w krajobrazie rolniczym [Protection and shaping of water resources in agricultural landscape]. Falenty. Wydaw. IMUZ. ISBN 83-85735-79-8 pp. 165.

MIODUSZEWSKI W. 2008. Czy Polska jest krajem ubogim w wodę? [Is Poland a country poor in water?]. Gospodarka Wodna. No 5 p. 39–41.

MIODUSZEWSKI W. 2012. Small water reservoirs – their function and construction. Journal of Water and Land Development. No 15 p. 45–52.

MUBAREKA S., ESTREGUIL C., BARANZELLI C., GOMES C., LAVELLE C., HOFER B. 2012. A land-use-based modelling chain to assess the impacts of natural water retention measures on Europe's Green Infrastructure. International Journal Geographical Information Science. Vol. 27. Iss. 9 p. 1740–1763.

PALCZYŃSKI M., PALUCH J., PARUCH A., PALIKOWSKI K., WOJTOWICZ J. 2002. Hydrauliczne aspekty funkcjonowania opóźniacza odpływu w małej zlewni lesnej. [Hydrologic aspects of functioning of runoff inhibitors in small forest catchment]. Czasopismo Techniczne. Inżynieria Środowiska. Z. 5 p. 85–95.

PIERZGALSKI E., TYSZKA J., SZYMCZAK T. 2002. Wpływ przyrostu lesistości i retencji zbiornikowej na zmniejszenie wezbrań w potokach górskich [Influence of afforestation increase and reservoir retention on decrease of high water levels in mountain streams]. Czasopismo Techniczne. Inżynieria Środowiska. Z. 5 p. 141–151.

POCIASK-KARTECZKA J. (ed.) 2006. Zlewnia. Właściwości i procesy [River basin the propriety and processes]. 2nd ed. chang. Kraków. Wydaw. UJ. ISBN 978-83-233-2274-0 pp. 296.

RADCZUK L., OLEARCZYK D. 2002. Małe zbiorniki retencyjne jako element poprawy bilansu wodnego zlewni użytkowanej rolniczo [Small retention reservoirs as elements improving water balance in a rural watershed]. Kraków. Zeszyty Naukowe AR IŚ. Z. 23 p. 139–148.

UNECE 1993. Protection of water resources and aquatic ecosystems. ECE/ENWA/31. Water Series. No 1. New York pp. 50.

Virginia DCR 2011. Constructed wetlands ver. 1.9 [online]. Virginia DCR Stormwater Design Specification 13. [Access 03.02. 2014]. Available at: http://chesapeakestormwater.net/wp-content/uploads/downloads/2012/04/DCR-BMP-Spec-No-13_CONSTRUCTED-WETLAND_Final-Draft_v1-9_03012011.pdf

Waldemar MIODUSZEWSKI

Mała (naturalna) retencja wodna na obszarach wiejskich

STRESZCZENIE

Słowa kluczowe: *gospodarka wodna, hydrologia, obszary wiejskie, rolnictwo, zasoby wodne, zlewnie rzeczne*

W Polsce, co najmniej od lat 60. ubiegłego stulecia używane jest sformułowanie „mała retencja”, które nie jest znane w innych krajach. Pod nazwą „mała retencja” rozumie się różne formy działalności człowieka w celu ograniczenia szybkiego odpływu wód po wiosennych roztopach i większych opadach atmosferycznych. Uważa się, że zretencjonowana woda w okresach jej nadmiaru zasila cieki latem, może być wykorzystana w celach gospodarczych, zwiększa dostępność wody dla roślin uprawnych, przyczynia się do poprawy biologicznej różnorodności obszarów wiejskich.

Wyróżnia się wiele metod retencjonowania wody, głównie poprzez zwiększenie potencjalnych możliwości magazynowania wód powierzchniowych (budowa zbiorników, piętrzenie rzek i jezior), podziemnych (zwiększenie zasilania warstw wodonośnych) i glebowych (poprawa struktury gleb w strefie aeracji). Ze względu na sposób i formę realizacji małej retencji rozróżnia się działania techniczne i nietechniczne. Inaczej mówiąc, mała retencja może być rozumiana jako zestaw działań na rzecz odbudowy naturalnej retencji zlewni rzecznej, często zniszczonej w wyniku działalności człowieka.

W pracy zwrócono uwagę, że podejmowane w Europie w ostatnich latach działania pod hasłem „zwiększenie naturalnej retencji” całkowicie mieszczą się w definicji małej retencji.