MISCELLANEA GEOGRAPHICA
WARSZAWA 2002 Vol. 10

Zdzisław Mikulski

THE INCREASE IN RESERVOIR RETENTION IN POLAND

We started in the Middle Ages by building fishponds. Later on, small structures appeared, damming up water on small rivers and streams, making it possible to use water power for turning the water wheels in mills, sawmills, fullers, etc. The very first dams and weirs, leading to the establishment of water reservoirs, appeared in the 19^{th} century, first for purposes of electric power generation, then for flood protection, and finally for water supply of towns and settlements, farming and manufacturing. Although the second half of the 20^{th} century brought a rapid increase of the reservoir retention, the overall retention capacity corresponds to not quite 7% of the entire river runoff in Poland. An improvement of this situation can be achieved not only through the increase of the number of reservoirs, but also through the full utilisation of all forms of water retention in a catchment area.

The beginnings of the artificial reservoir water retention in Poland are associated with the construction of fishponds, and then with the appearance of the small water power generation plants. The first mentions of the construction of fishponds date back to the $12^{th}-13^{th}$ centuries. One of the earlier books in our technical literature, the work of Olbrycht Strumieński (born in the first half of the 16^{th} century, died around 1609) on building and maintenance of fishponds (Cracow, 1573), is an evidence that the small water reservoirs were quite common in Poland. Their further development was closely linked to the construction of the small water power generation plants, designed to turn the mill wheels, the sawmills, the fulling-mills, etc. The resulting reservoirs served various purposes, including fish farming.

Liquidation of the majority of water mills and hydropower generation plants after the World War II resulted in a quite distinct decrease of the surface water retention and a deterioration of the water resource situation in general. Lack of adequate statistical data makes any quantitative assessment of this decrease very difficult. Statistics encompasses only the water bodies (reservoirs) of at least 1.5 million cu. m. The issue of the so-called small retention was the subject of a special issue of the journal *Gospodarka Wodna* (Water Economy). In the main paper of this volume, W. Mioduszewski (1997), distinguishes several forms of small retention, including small retention of surface water, "understood as accumulation of water in natural and artificial flows, ponds, and small reservoirs" — the latter having been treated by the author elsewhere (Mioduszewski, 1977a,b), with classification into:

— smallest reservoirs,	$H < 1.5$ m	$V < 10^6$ cu. m
— small reservoirs,	$H = 1.5$ m to 5 m	$V < 5\times10^6$ cu. m
— medium-sized reservoirs,	$H = 5$ m to 10 m	$V < 10^7$ cu. m.

The smallest reservoirs encompass the dug out ponds and the dammed reservoirs with the height of damming not exceeding 1.5 m. The bigger reservoirs are the ones with capacity exceeding 10^7 cu. m.

The bigger retention reservoirs were first built only in the 19th century. The very first such reservoir located on the present Polish territory was constructed on the river Brda in the locality of Mylof, in 1848, with the capacity of 16.2×10^6 cu. m. (the largest 19th-century reservoir in Poland). The next one, also in the part of Poland which belonged in the 19th century to Prussia, is the Leśna reservoir on the Kwisa river (a confluent of Bóbr in Lower Silesia), with the capacity of 18×10^6 cu. m, completed in 1907. In the years 1909 – 1917 seven further reservoirs were constructed, with capacities ranging from 2 to 54×10^6 cu.m (the latter figure being the capacity of the reservoir of Pilchowice on the river Bóbr). The majority of these reservoirs were located in the basin of the Odra river and on the smaller rivers flowing directly to the Baltic Sea. The overall capacity of all the water reservoirs until the World War I within the present boundaries of Poland amounted to slightly more than 120×10^6 cu. m, with 18.6 sq. km of total surface. The majority of them had power generation as the main objective (eight reservoirs), although some were also built for flood control (Mylof on Brda, Leśna on Kwisa, Pilchowice on Bóbr, and Pierzchały on Pasłęka), while the only agriculturally-oriented reservoir built at that time (built for irrigation purposes) was Bledzew on Obra.

In re-established Poland, after the World War I, the first, small, power generation reservoir of 5.5×10^6 cu. m was built already in 1923 in Gródek on the Wda river. It was followed in 1929 by the reservoir of Żur on the same river, with the capacity of 16×10^6 cu. m. In 1936, the long-lasting construction of the reservoir on the river Soła in Porąbka was completed. This reservoir, of 28.4×10^6 cu. m, was the first one intended for flood protection (primarily for protecting the city of Cracow against flood). A year later (1937) the reservoir in Kozłowa Góra on Brynica was put to use, meant for supply of water for the Upper Silesian region. Finally, in 1936, when the construction of the reservoir in Porąbka was finished, the project of building the then largest flood-and-power-generation reservoir in Europe in Rożnów on the Dunajec river, with the capacity of 166.6×10^6 cu. m was started. The work on this reservoir was finished already during the World War II, in 1941.

It is worth noting that the total capacity of the reservoirs built between the world wars by Poles on the present territory of our country (232.3×10^6 cu. m) exceeded that of the German-built ones (203.5×10^6 cu. m) within the present

Polish territory. In this period the power-generation-oriented reservoirs dominated already quite clearly, mainly due to the German-built objects. The rather small retention reservoirs dominated, with capacities ranging between a couple and several dozen million cubic metres. Exceptions consisted of: the reservoir in Otmuchów, a multipurpose reservoir built for flood control, navigation, and power generation, and the reservoir in Pilchowice on Bóbr, with flood control and power generation as objectives.

Two important construction projects started earlier were finished after the World War II, in 1948 the reservoir of Turawa on the Mała Panew river, with the capacity of 106×10^6 cu. m, with flood control, navigation and power generation as objectives, and a year later, in 1949, the reservoir of Czchów on Dunajec, with the capacity of 12×10^6 cu. m, a compensating reservoir for the previously mentioned one in Rożnów.

The issues related to water reservoirs found their place in the long-term plan of water economy, elaborated in the years 1953–1956 by the Committee for Water Economy of the Polish Academy of Sciences. It was assumed then that the "capacity of the artificial reservoirs, which could be built in Poland, is estimated at 7.0 cu. km" (*Zarys planu...*, 1959). Special attention was paid in this context to the right-bank tributaries of upper Vistula, with construction of large reservoirs on each of the bigger tributaries being recommended.

In 1956 a large retention reservoir was finished in Goczałkowice on Little Vistula, with the capacity of 167×10^6 cu. m, built primarily for the supply of water to Upper Silesia. Two years later, in 1958, a subsequent water control stage was built on Odra in Brzeg Dolny, securing water retention capacity of 8×10^6 cu. m. It was already at that time that the awareness of the necessity of constructing multi-purpose reservoirs arose. The issue of the costs of construction of the larger reservoirs dominated. This, of course, did not concern the special purpose reservoirs — e.g., Czchów on Dunajec (a compensatory reservoir) or Brzeg Dolny on Odra (for navigation purposes).

It has already then become of key importance to conduct appropriate water economy in the reservoirs (especially in the multi-purpose reservoirs) and to elaborate the recommendations and the instructions of operation of the reservoirs. Julian Lambor, an outstanding specialist in hydrology and water economy was entrusted with carrying out this work. Thus, in 1962, a unique publication in the field, entitled *Water economy in retention reservoirs* (in Polish) appeared; it showed the role of reservoirs in water economy, the principles of managing the flood control reserve, the needs of power generation, navigation, municipal economy, and industry, and finally also the principles of elaboration of the instructions of conduct of water economy in the retention reservoirs (Lambor, 1962).

During the 1960s as many as 13 retention reservoirs of diverse purposes were built, including the Polish largest water reservoir in Solina on the river San (472×10^6 cu. m), designed for flood control and power generation (in 1968), and the first damming of Vistula, below the town of Włocławek (in 1970), with the reservoir of the capacity of 408×10^6 cu. m, and the surface of

70 sq. km. The total capacity of the reservoirs built during that period amounted to 1311×10^6 cu. m.

The decade of the 1970s brought further 14 somewhat smaller reservoirs, of the total capacity of 423×10^6 cu. m, and the total surface area of 75 sq. km. These were mainly multi-purpose reservoirs, with the domination of flood control, municipal and power generation functions. An exception consisted here of smaller reservoirs for agricultural purposes built along the Wieprz–Krzna canal. The reservoirs meant uniquely for municipal purposes were built also at that time, i.e., Pogoria III on the Pogoria river, Zemborzyce on Bystrzyca, Dziećkowice (supplied by Soła), and an exclusively industrial reservoir of Niedów on Witka.

In the 1980s eight retention reservoirs were put to use with as many as five in the year 1986, including three large ones: Jeziorsko on the Warta river (203×10^6 cu. m), a multi-purpose reservoir used mostly for flood control; Dobczyce on Raba (125×10^6 cu. m) for securing water supply for the city of Cracow; and Mietków on Bystrzyca (70×10^6 cu. m), another multi-purpose reservoir. Of particular importance is, however, the construction of the Polish biggest (680 MW) pumped-storage power station in Żarnowiec on the lake of the same name, the lake being the lower reservoir of the station. The upper reservoir, located on one of the hills surrounding the Żarnowiec lake, has the capacity of 16×10^6 cu. m. Another reservoir was built on the Czarna Staszowska river at Chańcza, constructed uniquely for the flood control purposes. The total capacity of the reservoirs constructed during this decade was 480×10^6 cu. m.

Finally, in the last decade of the 20th century only four reservoirs were built, with the total capacity of 363×10^6 cu. m: Klimkówka on the Ropa river (44×10^6 cu. m), for flood control, power generation, and municipal needs (in 1994), Siemianówka on Narew (80×10^6 cu. m), for municipal, power generation, and agricultural purposes (1995), and last, but not least, the system of reservoirs being designed already for a few decades, at the Czorsztyn-Niedzica stretch of the mountain river of Dunajec (232×10^6 cu. m), with Sromowce Wyżne (8×10^6 cu. m) as the compensatory reservoir (1994). This beautiful engineering structure marked the closure of the 20th century in the field of construction of retention reservoirs in Poland (see Table 1).

The enclosed diagram (Fig. 2) presents data from the GUS (Central Statistical Office), (*Ochrona Środowiska*, 2000) and implies that the most intensive development of the system of retention reservoirs in Poland occurred in the 1960s.

The total capacity of the water reservoirs — small, medium, and large (that is, with capacity exceeding 1.5×10^6 cu. m) — existing in Poland equals 3410×10^6 cu. m and together with the only 19th-century reservoir, i.e., Mylof on Brda, the total amounts to 3427×10^6 cu. m, which is equivalent to the mere 5.7% of the river runoff in Poland. Taking into account the capacities of the smallest reservoirs (including also the dry flood protection reservoirs and the flood polders in the valley of Odra of altogether approximately 200×10^6 cu. m

Table 1.

The capacity and the surface area of the retention reservoirs in Poland

No.	Period	Capacity 10^6 cu. m	Surface area sq. km	Totals for nos.	Capacity 10^6 cu. m	Surface area sq. km
1	1907–1917 (German)	105.6	12.4			
2	1922–1943 (German)	203.5	38.8			
3	1923–1941 (Polish)	232.3	29.5			
				1 — 3	541.4	80.7
4	1948–1958	293.0	57.4			
				1 — 4	834.4	138.1
5	1960–1970	1311.3	176.9			
				1 — 5	2145.7	315.0
6	1971–1979	423.1	80.4			
				1 — 6	2568.8	395.4
7	1983–1987	478.8	75.0			
				1 — 7	3047.6	470.4
8	1994 –1997	362.9	48.8			
				1 — 8	3410.5	519.2
9	19^{th} century	16.2	6.2			
	Totals			1 — 9	3426.7	525.4

of capacity) and roughly 4,700 fishponds with the total capacity of approximately 500×10^6 cu. m, we obtain the upper bound on the reservoir retention capacity of more than 4×10^9 cu. m. This is equivalent to 6.7% of the river runoff in Poland. The total surface area of the medium and large water reservoirs is roughly equal to 530 sq. km, equivalent to 0.17% of the country's surface. Together with the small and smallest reservoirs this share comes up to 0.2% of the country's surface.

The figures quoted here show in an obvious manner that the retention secured by our water reservoirs constitutes a marginal share in the surface water resources in Poland, so that one can hardly speak of a true capacity of managing the river runoff in our country. At the same time the variability of the runoff of Polish rivers (appearance of the dangerous floods and of the very low flows) makes it necessary to regulate the runoff with the help of the retention reservoirs. The magnitude of this need of regulation is well illustrated by, in particular, the magnitude of the surface runoff as the component of the total river runoff. Recent calculations of the water balance in Poland in the 20^{th} century indicate that the annual river runoff of roughly 60 cu. km includes the direct runoff of 27 cu. km (Mikulski, 2000). This rough

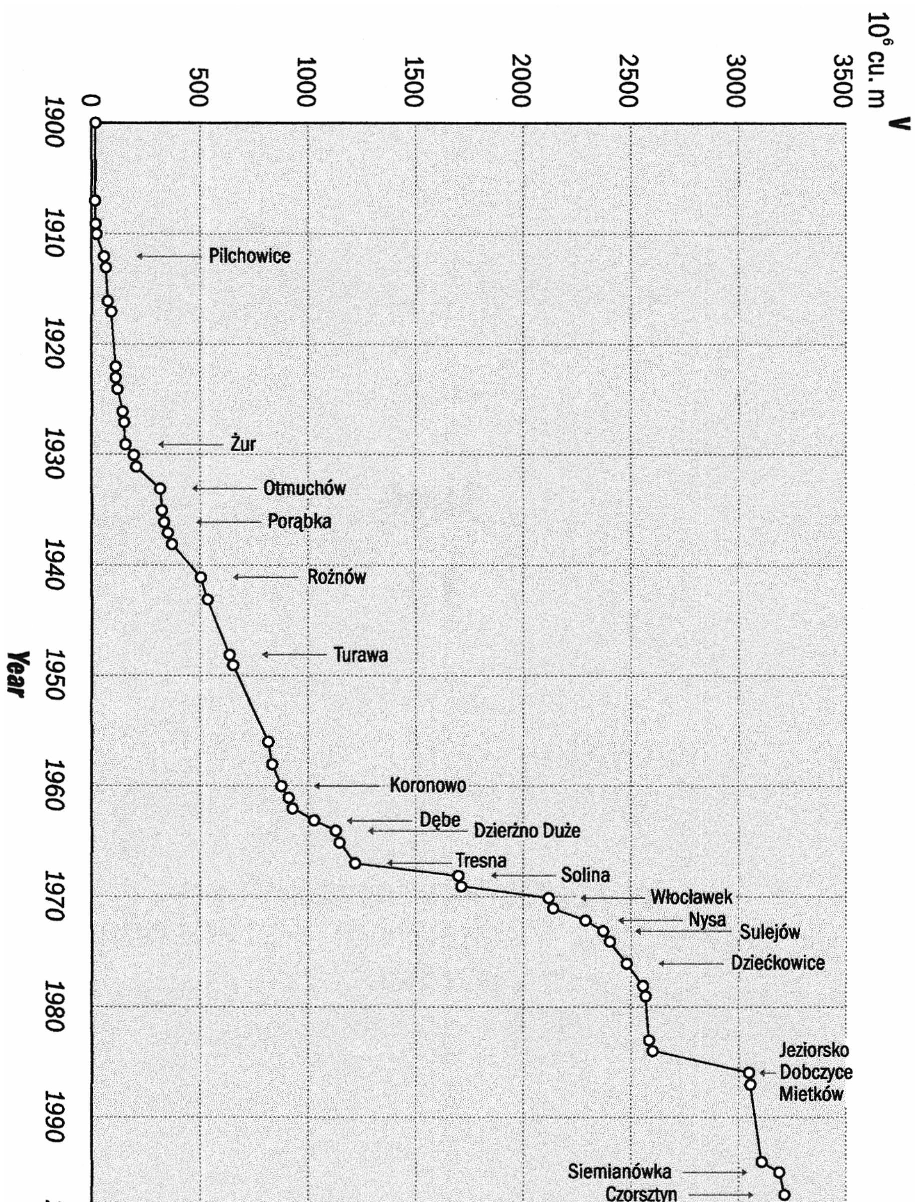

Fig. 2. The increase of reservoir capacity in Poland, in the period 1900 – 2000.

estimate should be lowered through the increase of the retention capacity of the watersheds by the extension of all other forms of retention. It will only then be possible to rationally speak of the magnitude of the necessary reservoir retention in Poland.

REFERENCES

Lambor J., 1962, *Gospodarka wodna na zbiornikach retencyjnych* [Water economy in retention reservoirs; in Polish], Arkady, Warszawa.

Mikulski Z., 2000, The development of research on water balance in the 20th century in Poland and an attempt of its assessment, *Miscellanea Geographica*, vol. 9.

Mioduszewski W., 1997, Mała retencja a ochrona zasobów wodnych [Small retention and protection of water resources; in Polish], *Gospodarka Wodna*, 3 (578).

Mioduszewski W., 1997a, Mała retencja i polityka melioracyjna [Small retention and the land improvement policy; in Polish], [in:] *Użytkowanie a ochrona zasobów wód powierzchniowych w Polsce*, Komitet Naukowy przy Prezydium PAN "Człowiek i Środowisko", 17, Instytut Ekologii PAN, Oficyna Wydawnicza.

Ochrona Środowiska 2000, [Environmental Protection 2000; in Polish], 2000, GUS, Informacje i opracowania statystyczne, Warszawa.

Zarys Planu Perspektywicznego Gospodarki Wodnej w Polsce [An Outline for the Long-Term Plan of Water Economy in Poland; in Polish], 1959, Vols. 1 and 2, Komitet Gospodarki Wodnej PAN, PWN, Warszawa.

Fig. 1. Retention reservoirs in Poland. Redrawn from the map sheet 32.1: Surface waters — Z. Babiński, *Atlas Rzeczypospolitej Polskiej*, Warszawa 1998.