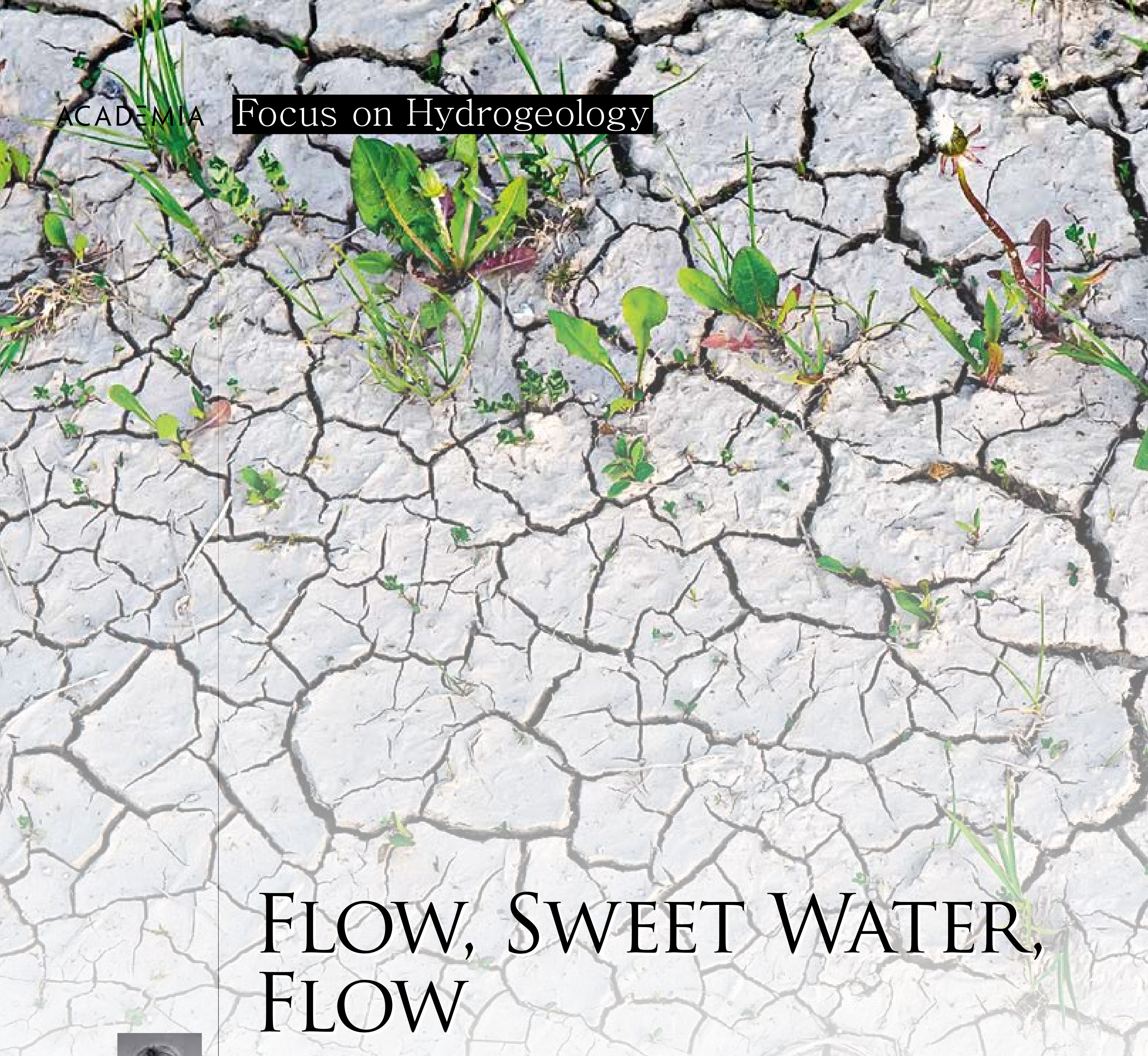
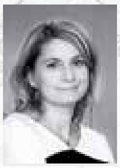


Flow, Sweet Water, Flow



Dr. Małgorzata Woźnicka is a hydrogeologist working at the Polish Geological Institute. She is responsible for implementing projects by the National Hydrogeological Service, such as protection of underground water and analysis of factors which affect its quality.

malgorzata.woznicka@pgi.gov.pl

Drought: the very word instills dread, conjuring up images of dried-up wells, barren earth, and – perhaps worse still – empty taps and long lines to access wells. Is Poland likely to experience significant water shortages?

Dr. Małgorzata Woźnicka
Agnieszka Kowalczyk, MSc

Polish Geological Institute
– National Research Institute

People are afraid of running out of water, especially since most of us are used to literally having it available on tap. Long periods without rain and recurring snow-free winters provoke speculation about potential future threats. And yet on the other hand, droughts, just like floods, are natural phenomena and there is nothing unusual about them occurring every now and again. Poland's temperate climate means that droughts here are not as severe as in other parts of the world; however, in some regions water

shortages can be problematic due to fluctuations in the water table and the resulting "hydrogeological lows."

Variation in the water table

Although the notion of a hydrogeological low is not very rigorously defined, it is generally assumed to refer not to an occasional isolated event but to a prolonged period during which the levels of groundwater are lower than a certain arbitrary minimum. The depth of a water table always fluctuates over time, following variations in meteorological conditions, in particular changes in the distribution and total precipitation and air temperature. Superimposed on these irregular cycles, lasting several years, are seasonal changes and multiyear cycles. When both of these aspects together drive a decline in water levels, they create conditions conducive to the development of a hydrogeological low

In addition to meteorological factors, water table levels are affected by various hydrogeological (geological structure), geographical, geophysical, and even cosmic (mainly heliogeophysical) factors. This combination of elements means that all observation points fluctuate in a particular manner. It also means that when two points are close to one another but experience different hydrogeological conditions, their water table levels are likely to fluctuate at different rates at times and become asynchronous: water levels may be falling in one location and rising in the other. In the reverse situation, when distant points (sometimes spaced as far as over 100 km apart) have similar conditions, they can be synchronous and their water levels may change at similar rates.

Fluctuations in water table levels are also affected by anthropogenic factors such as excessive drainage or exploitation of underground water, which occur during

Agnieszka Kowalczyk, MSc
is a hydrogeologist forecasting the quality of the water table and assessing hydrogeological threats in Poland.

agnieszka.kowalczyk
@pgi.gov.pl

post-drought periods as farmers attempt to counter their losses by irrigating fields. Such collection from shallow groundwater can end up exacerbating naturally-occurring hydrogeological lows, or bringing them on faster.

In the generally accepted terminology, a hydrological low is the most extreme manifestation of a drought, which occurs in three stages: atmospheric, soil, and hydrologic. It is this latter stage that results in hydrologic (surface water) and hydrogeological (underground) lows. Under natural, undisturbed conditions, reduced rainfall is noted first; surface and groundwater levels decline after a while, with underground water levels falling after a considerable time lag.

> With an understanding of the causes of droughts in Poland and ways of alleviating their impact, we are no longer helpless in the face of the problem.

Like other stages of drought, hydrogeological lows can affect extensive areas and occur in different regions. Note that the phenomenon develops slowly, which means it is difficult to pinpoint exactly when it starts. When underground water levels are low, we also observe powerful autocorrelation, which means it is easier to forecast the starting point of a hydrogeological low and much harder to determine when it will end. Every consecutive "dry" year further exacerbates the low as a result of accumulated adverse meteorological conditions. However, atmospheric droughts generally let up before a soil drought develops, and even if it does, it generally does not proceed into the hydrological phase. However, the more advanced the drought, the less reversible it becomes.

Hydrogeological lows affect land ecosystems which are directly dependent on groundwater. Their development depends on the retention level in the watershed when the post-drought period starts, which is usually driven by the hydrogeological situation during the previous year. The distribution of the low in the watershed shows a certain codependence: first we see the lowering of shallow underground water levels in inflow regions, followed by a transit zone down the watershed, to river valley drainage areas.

Playing with drought

Hydrogeological lows have many negative effects. First of all, there may be problems with the drainage of water from shallow water-bearing levels; losses are likely to be experienced in agriculture and hydropower, and negative changes observed in the chemical composition of shallow underground water. During persistent lows, the piezometric pressure in lower water-bearing layers may decrease, which in extreme cases leads to reduced yields of extracted water. Periods of hydrogeological low can also result in the degradation of ecosystems dependent on underground water.

In Poland, one of the worst hydrogeological lows was recorded in the early 15th century. According to chronicles from the time, the extremely low levels of rainfall which persisted for three years dried up many rivers, and water levels in the Vistula fell so much that the river stopped flowing in a few places.

Today, direct effects of lows are felt almost exclusively in regions not covered by mains water (which is generally for technical reasons – for example, the mountainous terrain in the Szczyrk commune has thus far made it impossible to install mains water pipes). However, they are usually very sparsely populated areas where water is supplied from individual shallow wells (dug, drilled, artesian, etc.).

Beyond such regions, Poland has considerable resources of water stored in water-bearing geological formations at a range of depths beneath the surface. Their total volume is estimated to be approx. 3,000 km^3, which is over 120 times greater than overall volume of all lakes and retention reservoirs. Around half the annual river outflow to the Baltic Sea originates from underground sources. The total volume of underground water resources available for exploitation in Poland is 13.5 km^3. Around 3.5 km^3 is extracted annually, satisfying approx. 70% of the requirements of the Polish population. On the national scale, the renewable underground water reserve is high, at around 80%.

Does this mean we have no need to worry about water supply problems? Forecasting droughts is difficult, but our understanding and methodology are improving, which means we can take action to alleviate problems in regions most likely to be affected. To rule out any potential shortages of drinking water, we should build facilities capable of extracting underground water from deeper water-bearing levels, which are isolated from the surface and more abundant. Having developed a better understanding of the causes of droughts in Poland and a range of technologies to alleviate their effects, we are no longer helpless in the face of the problem.

Having developed a better understanding of the causes of droughts in Poland and a range of technologies to alleviate their effects, we are no longer helpless in the face of the problem.

Małgorzata Woźnicka
Agnieszka Kowalczyk

Further reading:

Biuletyn Państwowej Służby Hydrogeologicznej (2015), Warsaw: PSH Archives (www.psh.gov.pl) – A synthesis of work performed by the National Hydrogeological Service in 2015.

Kowalczyk A. (2016). Niżówka hydrogeologiczna – przyczyny i skutki [Hydrogeological Low – Causes and Consequences]. *Technologia Wody* nr 49 (5/2016).