JEE Journal of Ecological Engineering

Journal of Ecological Engineering, 2025, 26(2), 162–168
https://doi.org/10.12911/22998993/196723
ISSN 2299–8993, License CC-BY 4.0

Received: 2024.11.08
Accepted: 2024.12.15
Published: 2025.01.01

Influence of rainfall on fluctuation of the water table in wells in the village of Bratkowice, Podkarpackie Province

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ABSTRACT

The purpose of the study was to determine whether the aquifer in the 15 wells shows a rapid response to increased recharge after precipitation or lack thereof during dry months. The 15 wells located in Świlcza village were selected for monitoring. The average depth of the well was 4.7 m. The deepest was 7 m deep, and the shallowest was 3.1 m deep. Of the 15 wells, only two were in use. Water intake has not changed the position of the water table. The greatest fluctuations in the water table were recorded in shallow wells up to 0.8 m deep during the dry months. The greatest lowering of the water table in the dry months was recorded in well No. 13 by 0.72 m from the highest state (water was taken for watering plants) and in well No. 5 by 0.80 m from the highest state. From well No. 5 water was not drawn.

Keywords: wells dug, groundwater table fluctuations, rainfall

INTRODUCTION

Water plays an important if not the most important role in the cycles of nature, being an irreplaceable element for the functioning of the environment and thus the existence of every living thing. It is one of the few renewable resources, but quite irregular in time, and all areas of the economy cannot function without it. Frappart et al., (2022) draws attention to groundwater, which is an essential component of global hydrological cycles plays an important role in the sustainability of ecosystems (Zektser and Loaiciga, 1993; Jackson et al., 2001; Sophocleous 2002; Griebler and Avramov, 2015; Frappart et al., 2019). Groundwater is an essential source of water for various human needs, including domestic water supply, irrigation, and industry. Groundwater is often the last freshwater resource available for domestic use and irrigation after surface water is depleted, especially in densely populated areas (Siebert et al., 2010).

The slow changes associated with a warming climate are causing a reduction in average annual precipitation in certain regions and show significant irregularities. Climate warming is most often associated with drought, floods, drying up of surface water, and melting glaciers. Most of the time, we are not aware of the impact this has on groundwater. Evidence of the consequences of climate change-induced impairment on our environment is growing by the day (Ripple et al., 2022), but the resulting impacts on groundwater are still largely unknown (Riedel 2019). Since groundwater is the most important source of raw drinking water (Margat and Van der Gun 2013), the possible negative effects of global warming on its quantity and quality cannot be ignored. Also, Perner et al., (2022), points out that climate change is negatively affecting groundwater quality.

Reduced precipitation and its significant irregularity mean that groundwater resources are slowly depleting and in many regions are becoming an important source of water. Increasingly, we are seeing a decline in the water table in surface water reservoirs, which in many cases are a source of water supply for the population and industry (Stanek-Tarkowska 2022). Drawing for groundwater slowly depletes the reserves stored there and leads to the formation of depression funnels. The lack of replenishment of groundwater by precipitation causes the phenomenon of hydrological drought and, in many regions, causes the drying up of wells.

Precipitation is the only source that replenishes groundwater resources. Precipitation water penetrates deep into the ground, where it accumulates, forming aquifers. Static water resources can be divided into renewable and non-renewable. The former includes groundwater, the amount of which flows per unit of time through a section of an aquifer. Through recharge with infiltration water, they can be renewed (Chełmicki 2002; Jokiel et al., 2017). The process of such renewal extends over time. It can take several years to take into account the exchange of moisture in the soil, and even several hundred years for aquifers located deeper. Non-renewable waters include stored water in other aquifers that are isolated from the land surface by impermeable formations.

Underground water is still the main source of drinking water, especially in small villages where a water supply systems are unavailable. There are relatively many such localities in the subcarpathian region. However, rapid lowering of the groundwater table and even drying up of inefficient natural springs are increasingly observed. The purpose of the conducted research was to check the reaction of change of the water table in wells under the influence of rainfall or lack of rain.

MATERIAL AND METHODS

Study area

The study was conducted for two years from January 2021 to December 2022 in Bratkowice (50° 6′ 56″ N, 21 ° 51′ 35″ E) municipality of Świlcza Subcarpathian province. The monitoring included 15 wells dug in private farms (Figure 1). The study included a monthly measurement (at the end of each month) of the depth of the water table in the wells using a hydrological whistle. The height of the casing was subtracted from the read value. The values shown include the level from the surface of the ground to the water table in the well. Mounded wells are vertical holes with a diameter of 8–1.5 m or more, which have a enclosure called a casing. This casing can be made of concrete coils, stone, or burnt brick. The depth of a given well depends on hydrogeological conditions, i.e., the location of the aquifer, grain size, and rockiness of the soil of the area (Warowny 1972). Meteorological data cames from the University of Rzeszow station.

In the present study, monitoring was carried out in 15 wells dug located on the premises of households in the village of Bratkowice, Rzeszow County, Subcarpathian Province. Figure. 2 shows the locations of the selected wells. All households in the area where the wells were surveyed are connected to the water supply system.

Although there are three waterworks in the municipality, the closest is “Bratkowice - Dabry’. They are drawn from them from three deep wells with a capacity of S1 = 80 00 m^3/h, S2 = 60 00 m^3/h, S3 = 68 00 m^3/h, respectively. Water from the wells is routed to the Water Treatment Station, where the processes of iron and manganese removal, and disinfection are carried out, then it is pumped to an equalisation tank and is further pumped to the network (with a cross section of 225 mm), and is then supplied to all villages in the Świlcza municipality (Świlcza Municipality Study 2010). Residents of Bratkowice, despite being supplied with water by the water supply system, use well water to varying degrees. Each of the owners of the property on whose land the well was located was interviewed about when the well was dug, its depth, and whether they use the well and for what purpose.

RESULTS AND DISCUSSION

Annual precipitation in Poland in 2022 ranged from about 534 mm to more than 1.900 mm. The highest precipitation was recorded in the Tatra Mountains and Sniezka mountain, the lowest in central Poland and Mazovia. Spatial variation of annual precipitation totals in 2022 indicates that they were in the range of 85–130% of the multi-year norm (1991–2020). Rather, the reduction in precipitation totals in some regions of Poland results in the drying up of shallow domestic wells. A similar trend can be observed around the world. This problem was pointed out by Goldscheider et al. (2006) and Griebel et al. (2019). Slow climate change and the warming felt by all will affect groundwater, which is the most important source of drinking water. In the study area, the annual precipitation in 2021 was 587.2 mm, and in 2022 it was 422.2 mm. In 2022, 165.2 mm less precipitation fell.

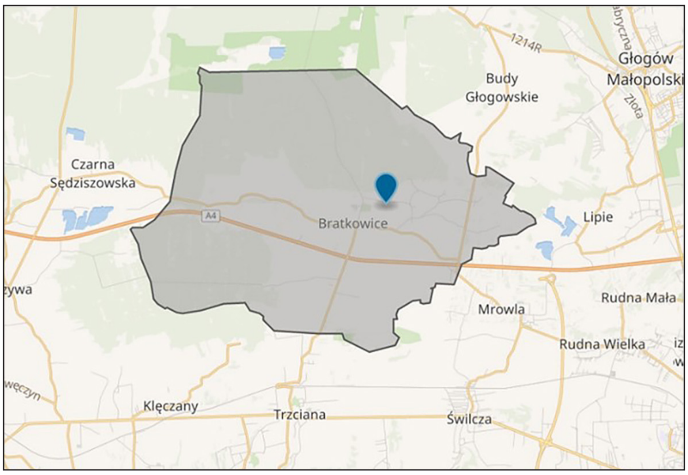

Figure 1. Location of the village of Bratkowice (https://www.swilcza.com.pl/index.php/pl/)

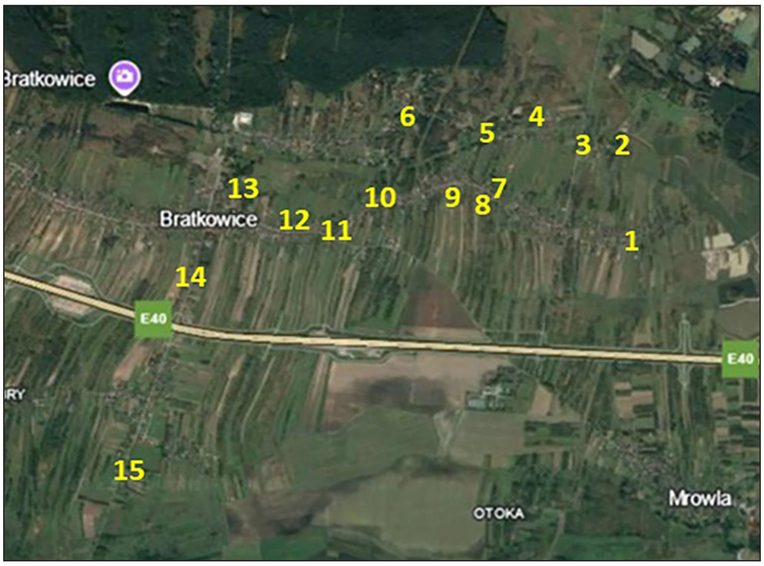

Figure 2. Location of 15 wells in the Bratkowice village. https://www.earth.google.com

The replenishment of groundwater resources is related to the amount of rainfall and snowfall or through surface water (much less frequent). The study was carried out for 2 years in Bratkowice village, of the 15 wells only 3 were unused and decorative, water was drawn from one occasionally for food purposes No. 3 from well No. 15 for watering livestock, while in the remaining 13 wells water was drawn for plant watering purposes (Table 1).

The area of Bratkowice is characterised by shallow groundwater, as indicated by the depth of the wells (Figure 3) the average depth among the 15 wells is 4.71 metres. The type of own intake depends on local conditions, mainly on the depth of the aquifer, terrain, and soil type. Mounded Dug wells, due to construction technology, are often shallow wells, reaching up to 10 m below the ground surface (Hackett 1988). Therefore, there can be great risks regarding the adequate quality of water captured by wells dug. Due to the risks associated with water contamination in dug wells or lack of water in them, most households in Poland are connected to the water supply system.

The monitoring of selected wells showed significant fluctuations of the water table according to the amount of precipitation.

The shallow groundwater table in this situation is subject to large fluctuations related to precipitation recharge and the significant permeability of the formations that make up the roof. In the area of Bratkowice, there are soils classified as loose sands, silty sands and weakly clayey sands. The thickness of these formations on the surface

Table 1. Description of the well with the year of digging, depth and use (data from owners)

No. of wells	Description of the well's environment	Year the well was dug	Method of use well	Depth of well (m)
1	The well is located 3 m from the wall of the building around the green lawn	1965	Only for watering the garden	3.8
2	The well is located 5 m from the farm building around the green permaculture	1975	Only for watering the garden	4.5
3	The well is located 1 m from the wall of the apartment building around the green lawn	1950	Occasionally, water is drawn for drinking purposes	3.6
4	The well is located 7 m from the farm buildings in the vicinity of green bushes	1940	Only for watering the garden	3.6
5	The well is 1 m from the access road to the residential building and 3 m from the outbuilding	1920	Not used	3.1
6	The well is located 7 m from the farm buildings in the vicinity of green bushes	1900	Only for watering the garden	7.0
7	The well is located 2 m from the wall of the apartment building covered with paving stones all around (1x1m)	1970	Only for watering the garden	6.5
8	The well is 1.5 m from the wall of the apartment building covered with paving stones all around	1950	Drinking animals and watering plants	6.0
9	The well is located 4 m from residential buildings surrounding paved with concrete tiles.	1997	Only for watering the garden	5.5
10	The well is located 4 from the abandoned house	1952	Not used	3.5
11	Located well 0.5 m from the entrance gate surroundings paved with cobblestones	1974	Not used	5.0
12	The well is located 1.5 m from an abandoned residential building; the area is neglected around the bushes	1970	Not used	4.0
13	The well is located 6 m from the apartment building at the base covered with paving stones around the green well-kept lawn	1980	Only for watering the garden	5.5
14	The well is located 2 m from the wooden farm buildings. and the border of two plots of land	1930	Only for watering the garden	4.5
15	The well is 1.5 meters from the apartment building on a paved path.	1968	Drinking animals and watering plants	4.5

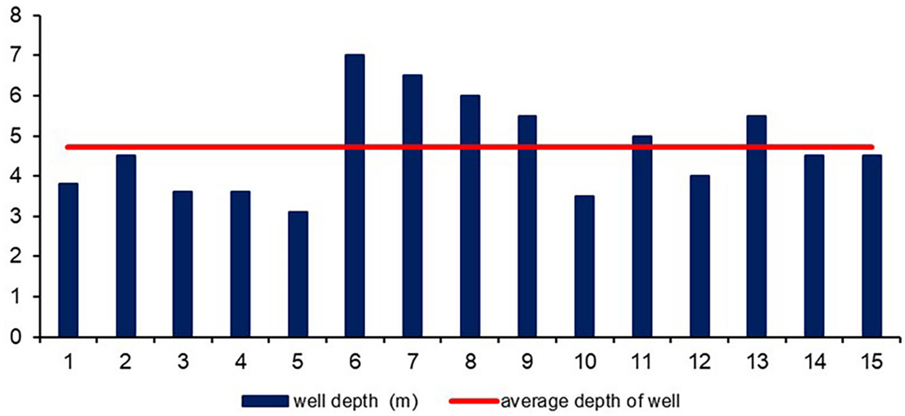

Figure 3. Depth of wells in the Bratkowice area

is evidenced by numerous open-pit pisak mines. Soils composed of permeable formations more easily transmit water, recharging the aquifer. Shallow groundwater responds much more quickly to recharge in the form of rain or snowmelt. It can be assumed that they will also respond just as quickly to lack of recharge. Jedruszkiewicz et al. (2016) found a similar relationship in their study. On the contrary, deeper-lying aquifers have a longer response time to recharge, or lack thereof. Figure. 4. shows a summary of two-year measurements related to the fluctuation of the water table in selected wells and the amount of rainfall.The study showed that the fluctuations in the groundwater table depended on the amount of rain and the depth of the well. Shallow wells definitely reacted more quickly to changes related to aquifer recharge. All wells showed an increase in the water table during periods of increased precipitation. In contrast, during the dry months, the water table decreased significantly. Although water was drawn from well Nos. 3 and 15 for drinking or watering animals, it has had not a major impact on the water table. The largest decrease in the water table in the dry months was recorded in well No. 13 by 0.72 m compared to the highest state (water was drawn for

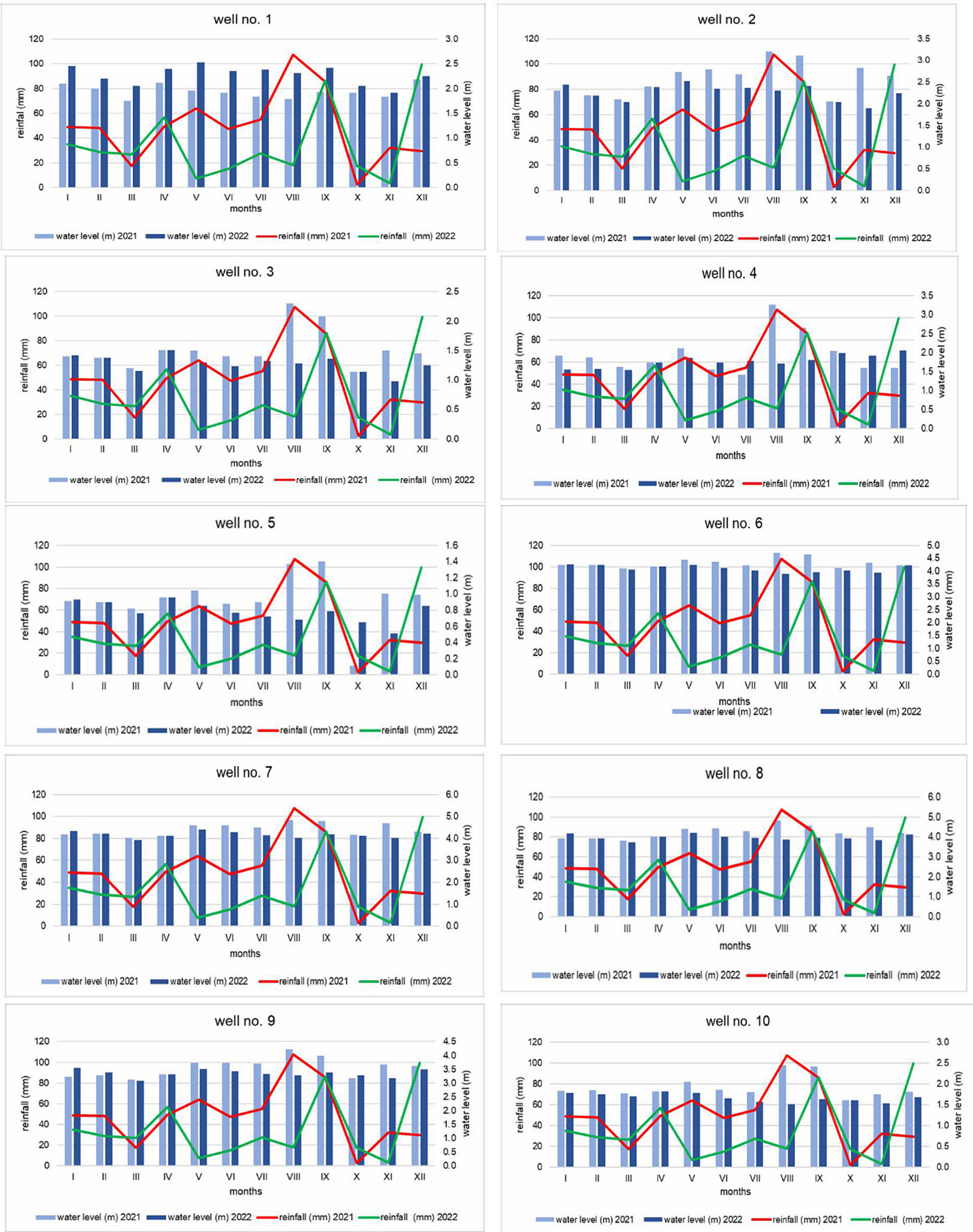

Figure 4. Comparison of the position of the water table in relation to rainfall

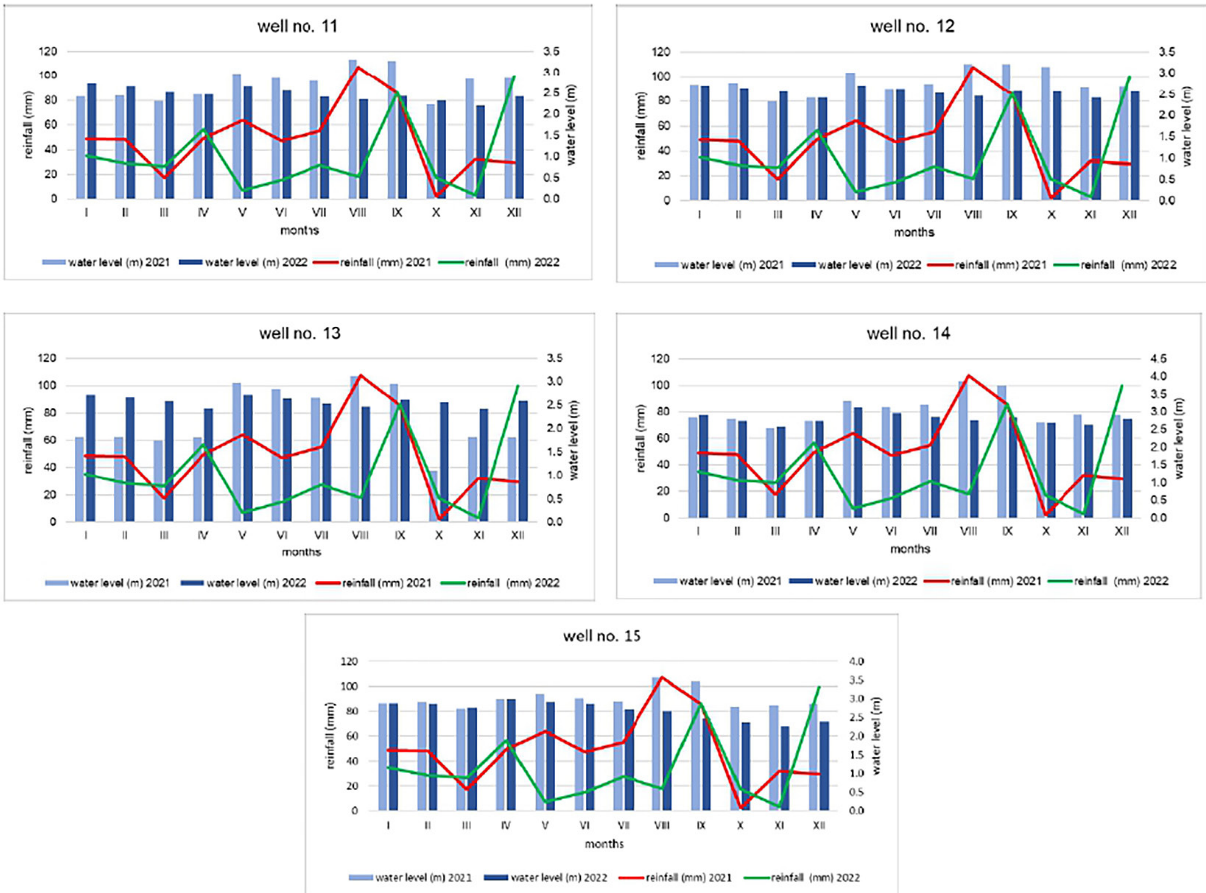

Figure 4. Cont. Comparison of the position of the water table in relation to rainfall

watering plants), and in well No. 5 by 0.80 m from the highest state. The water was not drawn from well No. 5 was not drawn.

Acknowledgments

The research was supported by funds from the Ministry of Science under the Regional Excellence Initiative Program. Contract no. RID/SP/0010/2024/1.

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