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EXAMINATION OF LONG TIME SERIES DATA OF GROUNDWATER LEVEL CHANGES IN THE HÁRMAS-KÖRÖS SUB-CATCHMENT AREA

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Abstract: *Nowadays, agricultural production is highly exposed to the increasingly frequent extreme environmental events (drought, alternating inland water). In Hungary, the South Alföld Region is the driest area in the country. In 2022, 200 millimeters of precipitation fell in this area instead of the average annual precipitation of 500-550 millimeters, which results in a precipitation deficit of 300-350 millimeters. Adapting to such extremes means technical and financial difficulties for farmers. An accurate knowledge of forecasting systems (meteorological forecasts) and local natural systems (topography, soil properties, groundwater properties, vegetation cover) would make adaptation easier. The long-term, seasonal changes in the groundwater level it can be said to be constant, but if we take some examination, we can determine that this is not the case. It is difficult to identify the causes of fluctuations only by observing short-term water level records. The long-term groundwater-level records in the Hármas-Körös Sub-catchment area, were thoroughly analysed along with the results from the cumulative rainfall, and knowing the prevailing soil type. With our analysis, we assess the trends of the groundwater level (by examining the water levels of eight groundwater monitoring wells) and expected changes by examining the twenty-year monthly average data series of the sub-catchment area.*

Keywords: *groundwater level, groundwater monitoring wells*

INTRODUCTION

Groundwater is a key resource in the Alföld areas needs for agriculture production used such irrigation water. Groundwater in this area formed from the infiltration, it means, replenished after precipitation. Groundwater collects above the uppermost waterproof layer, but still below the surface in the aquifer rock water that completely fills the gaps in the soil and in the direction of the slope of the waterproofing layer makes slow movements (UBELL, 1954)

Fluctuations in the groundwater level depends on the topography, local precipitation and temperature conditions, the water permeability of the surface, the material and location of the subsurface layers, the depth of the groundwater table, the effect of water from deeper layers, and the flow conditions of the underground water (TÓTH, 1999, NAGY, ET AL., 2019).

Groundwater is not static, it usually rises in autumn and starts to sink at the end of spring and beginning of summer. Groundwater fluctuations are different in the Hungarian Great Plain. In the monitoring wells along the rivers (Tisza and Körös), it follows the fluctuation of the river's water level with a delay and flattening, so that several rises and falls can be observed on an annual basis (RÓNAI, 1961).

The rate of change is also faster in the valley mouths and filling cones of the rivers. Groundwater movement is typical in the Alföld sand areas. It is relatively lively, but the amplitude of the swing is not large in annual terms.

In the deeper loess areas (where the groundwater level is at 5-8 m), the dynamics of long-term groundwater level changes show greater differences. Examining time series of 10-16 years, the path length of its subsidence and ascents can reach several meters (SZÜCS, 2017).

Soils of Alföld is very different. Using a new soil grouping, soils with the following properties can be identified. Pseudomyceliar Chernozems are characterized by fine secondary calcium carbonate accumulation at shallow depths and satisfy the World Reference Base (WRB) chernozems criteria. Alluvial Chernozems develop on alluvial sediments. Meadow Chernozems are influenced by groundwater and correlate with Gleyic Chernozem. Meadow Solonetz soils have high sodium saturation and have typical columnar texture B horizons. Solonchac Meadow soils are traditional soils with less influence of soluble salts occur in deeper horizons. The definition of tyipic Meadow soils are hydromorphic features at a shallow depth, with high or low organic matter, clay or secondary carbonat (MICHELI, ET AL., 2006).

In areas with a clayey, saline surface, the groundwater fluctuation is small and slow. Except for the summer period, when the saline and clay areas crack due to drying, and these cracks penetrate down to the groundwater level. At this point, the evaporation of the ground water starts, and in a few weeks the groundwater level drops by meters. The summer rains do not make up for this subsidence, because the clay in the upper 5-10 cm depth swells due to the precipitation, blocking the connection between the ground water level and precipitation.

Groundwater is primarily fed by atmospheric precipitation. Groundwater can be recharged by rainfall that infiltrates through the water table. Heavy rain events can also induce changes in groundwater levels, with some water infiltrating to the water table, but much running off and not reaching groundwater. After particularly heavy rains, we can experience a faster rise of the groundwater and then a slower downward movement. The groundwater table is influenced by surface runoff, evaporation and water use by vegetation (DONG, ET AL., 2019).

In Hungary, the average annual rainfall is 500-750 mm, but there are significant differences between the regions. There is no significant trend in the amount of annual precipitation for the period 1901-2020, only the spring period shows a significant decreasing trend (-17.2%). Annual precipitation amounts decrease in the western part of the country, while a slight increase can be observed in most of the Great Plain. On average, the number of rainy days decreased and the length of dry periods increased. In the last 40 years (1981-2020) the increase of precipitation is also significant on the national average (OMSZ, 2019B)

Temperature has a significant effect on the formation of the groundwater table level through the influence of evaporation, thus affecting the amount of water that can infiltrate. Temperature directly affects the quality of precipitation. The case of negative temperatures, solid precipitation (snow) does not directly contribute to the rise of the groundwater table.
The yearly average temperature in Hungary is between 9 and 11 °C. Values above 10 °C are typical in the Great Plain. The temperature has an increasing trend, which can be observed in yearly and also in seasonal averages. The most intensive warming occurred in the last 40 years. The yearly number of heat wave days in the Southern Great Plain increased by 12-14 days (OMSZ, 2019A).

Based on the long time series data, groundwater subsidence trends have been established in Hungary since 1970. By the mid-1980s, the rate and extent of the lowering of the water level corresponded to the state resulting from the development of meteorological conditions (precipitation, temperature). From the second half of 1980, the rate of groundwater level lowering accelerated. In the period 2000-2006, the rate of subsidence stagnated. Based on the lowering of the water level, the Hungarian Regions were classified into different categories during the examination of 185 underground water catchments. The Southern Great Plain was placed under the category of water bodies in poor condition (GONDÁRNÉ, 2011).

MATERIAL AND METHODS

The study area of our research, the 2-16 Hármas-Körös watershed management planning sub-unit. The area is almost totally flat. The elevation above sea level is typically between 82 m (near river, oxbow) and 86 m (at loess areas in the eastern part).

In this area six soil types can be identified. Besides the chernozem character, the association of saline meadow and marsh soils due to the hydromorphic effect shapes the soil types (STEFANOVITS, 1992). The following soil types can be found on the digital soil maps prepared based on the latest soil research. Near the monitoring wells there are the following soil types: Szarvas 2833, 2832 alluvial meadows soil, 2278 solonchac meadows, 2835 meadow solonetzes. Near the well Öcsöd there are meadow chernozems soils, Near the Kardos there are meadow soils, soil accumulation in deeper layers. Near the Csabacsűd there are pseudomycellar chernozems. Near the Békésszentandrás there are meadow soils, soil accumulation in deeper layers.

The eight groundwater monitoring wells which data were used in the research are located within a distance of 15 km from town Szarvas (*Figure 1*.).

Figure 1. Location of the monitoring wells in the study area.

The data was provided by the Körös-Vidéki Water Interspectorate. The data are daily data, measured every three hours, which were processed into monthly average data using Excell software. Using the data of a twenty year groundwater data series, we determine the magnitude of the fluctuation of the groundwater table and the occurrence of extreme values for each well. By examining each well separately, we can determine whether these extremes are limited to a single season or can occur throughout the year.

RESULTS AND DISCUSSIONS

The long time series data show us the following results. Groundwater data for the long-term winter (accumulation period, November 1-April 30) and summer (May 1-October 30) periods are separated from each other.

Figure 2 clearly shows the parallelism between precipitation and groundwater level changes. In the figure, it can also be observed the parallel of the time shift between the increases in the groundwater level and the amount of precipitation, which is determined by the prevailing soil type.

Our main finding is that a strong sinking of groundwater can be observed in the examined area. This is shown by the results of Szarvas 2833, 2835 and 2832 and Öcsöd wells. The decline can be observed from the 2010s, in Öcsöd from 2014.

The depth of groundwater level varies between 100 and 150 cm in the case of the monitoring wells. Among the examined wells, the Csabacsüd well requires a separate explanation. The groundwater here is a deep aquifer and the soil type is pseudomyceliar-chernozem. The supplementary effect of precipitation does not contribute to a significant increase in the groundwater level.

During the winter periods, the groundwater fills up. The eight monitoring wells filled up to an average of 201 centimeters, with an extreme values in 2006, when the groundwater level at well 2832 Szarvas was 59 centimetres. The smallest (the lowest extreme) filling was 380 cm at the Csabacsűd monitoring well.

The lowest groundwater levels during the summer period show an average depth of 458 cm. The lowest groundwater level was recorded in 2021, at 577 cm for the Öcsöd monitoring well.

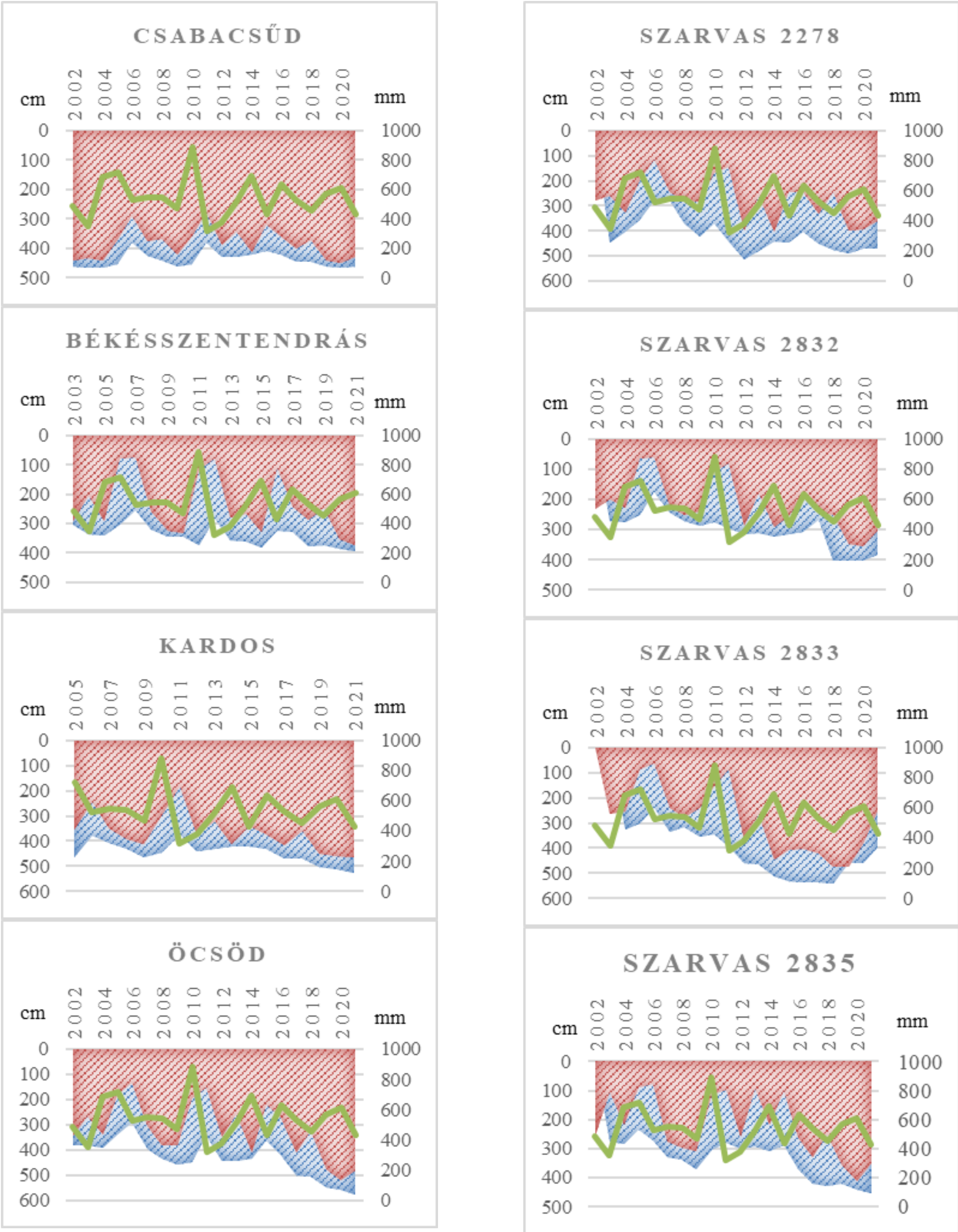

Figure 2. Groundwater level changes between 2001-2021 years

maximum deep of groundwater cm   minimum deep of groundwater

precipitation mm

CONCLUSIONS

The analysis of the long time series data of the investigated monitoring wells in the Hármas-Körös Sub-catchment area proves that the groundwater shows a close correlation with the climatic conditions (precipitation and temperature). The change in the groundwater level shows a close relationship with the amount of precipitation. The constantly rising annual temperature factors has also a great impact on groundwater changes.

It can be concluded that the groundwater level has been continuously decreasing since 2010. In extreme cases, it approaches a depth of 6 meters. This significantly affects agricultural production by increasing the cost of irrigation.

In the case of the Csabacsűd monitoring well, we experience an inhibitory effect from the soil. The Szarvas 2832 and 2833 wells can be characterized by a higher water level. Here, the effect of the backwater and the irrigation channel prevails.

If the tendency of groundwater subsidence does not decrease, only irrigation farming will survive. In this case, the water volume of the surface watercourses will also be exposed to risk.

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