CHANGES OF THE GROUND WATER REGIME IN THE AREA LOCATED BETWEEN THE RIVERS DANUBE AND TISZA

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ABSTRACT. – Changes of the groundwater regime in the area located between the Rivers Danube and Tisza. Flatlands, especially the Great Hungarian Plain (also known as Alföld) play a significant role in the economic life of Hungary and play a determining role in agriculture and sylviculture. The hydrographical relations of flatlands define the framework of crop farming, within this the changes and movement of ground water in space and time.During the last decades the ground water regime of the Great Hungarian Plain has gone through significant changes. In certain regions, especially in the higher parts of the area located between the Rivers Danube and Tisza (also known as Duna-Tisza köze) the ground water level was significantly and permanently below the average of many years, which created new conditions and risks mainly for agriculture and forest management.

***Key words**: flatland, alluvial plain, groundwater, groundwater monitoring well, ground water level decline, risks, natural environment.*

4. Possible reasons of the changes to ground water level

The changes of ground water stocks in space and time are influenced by several background factors, which have an impact on each other. The impact of such factors has a different influence on the change of the ground water level. The identification of the background factors and the estimation of their calibre are possible by applying mathematical methods (Kovács et. al. 2004).

In the area located between the Rivers Danube and Tisza the following factors are influencing the ground water level changes: precipitation, artesian water exploitation for water supply purposes, ground water exploitation mainly for irrigation purposes, increase of areas covered by forests, water management and other factors.

Also in the area located between the Rivers Danube and Tisza precipitation surplus was experienced in the middle of the 1960s. As a result of the surplus

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waters the ground water level increased. Saline flat areas and deflation coves were covered very often and permanently by water. At this time the internal water channel system construction was completed, and in the areas, which were defined less favourable for agricultural activities trees with high water requirement were planted. From the beginning of the 1970s to the middle of the 1990s the precipitation level dropped below the average, nearly 1000 mm precipitation shortage was experienced in the area. As a result ground water level started to drop, significant amount of the previous lakes and boggy areas dried up. During this time extensive ground water stock exploitation also started for the purposes of irrigation, which also contributed to the further reduction of ground water level. The shortage of rainfall was mitigated by the middle of the 1990s, as a result the intensity of dropping also slowed down and in certain areas the water table started to rise. The increase became significant by the end of the 1990s, meaning significant increase (measurable in decimetres) even in the areas hit by the highest drops.

Besides simplified graphical methods for the analysis of the correlation between precipitation and ground water levels in 2002 a dynamic factor analysis and other mathematical methods were also carried out. As a result of the analysis the most important background factor in the area of Hátság was precipitation, while in other areas, for example in the area located between the Rivers Danube and Tisza underground replacement was also considered significant (Kovács et. al. 2004., Kovács, 2007, Lázár, 2007).

The changes of ground water levels and ground water stocks are also influenced by artificial impacts, which mainly have an influence on the outlay part of the water balance. Water exploitation for various purposes (such as coastal filtering, balneology, irrigation, opencast mining, artesian water and hydrocarbon exploitation) are considered as impact factors caused by human activities (Liebe, 1994). Exploitation of artesian water for industrial and residential purposes has a less significant impact on the changes of the ground water levels in the area located between the Rivers Danube and Tisza. In certain areas however artesian water levels are reducing, therefore the extent of transmission from the ground water stocks – as a result of the increased potential difference – has increased compared to the previous period. Sewage farms have a significant impact among the artificial factors of the income items of the balance sheet.

The increase and location of forest areas and the similar location of the areas affected by ground water declined suggested the possibility of a link (Szodfridt, 1994). Measurements carried out at experiment stations proved the ground water reducing impact of forests (Major, 1994).

In the area Danube-Tisza Interfluves (Duna-Tisza közi hátság) the factors influencing ground water reduction are as follows and their respective share in percentage also indicated (Pálfai, 1994):weather (50%); artesian water exploitation:(25%); ground water exploitation (6%); changes to land utilisation (10%) ; water management (7%); other (hydrocarbon exploitation (2%).

5. Changes of ground water levels in time and space

The area located between the Rivers Danube and Tisza is the driest and hottest part of the country, which is sensitively influenced by the reduced and extreme amounts of precipitation (Major, Neppel, 1988, VITUKI, 2002, Szalai, 2004, Szalai, Nagy, 2006). The changes to precipitation relations together with anthropogenic impacts trigger ground water level reductions of 600 to 800 centimetres in certain districts. Such changes can be studied very well using ground water level graphs.

In Hungary for the evaluation of the quantity of the waters located near to ground level, several thousands of ground water level detection wells were established since the beginning of the 1930s, when regular measurements started. The network is mainly located at flatlands, however in smaller amounts detection wells were also established at hilly areas.

In the area located between the Rivers Danube and Tisza measurements are currently taking place at about 350 ground water detection wells. At certain selected and typical detection wells, established at areas with diversified geological formations during the period between 1951 and 2010 the changes of detected ground water levels in time are indicated by graphs.

In the surrounding areas of 001362 Ladánybene detection well, established in the north-western part of the flatland located between the Rivers Danube and Tisza ground water raised over ground level in the second half of the 1960s, but since this time significant ground water level reduction was experienced (Figure 6).

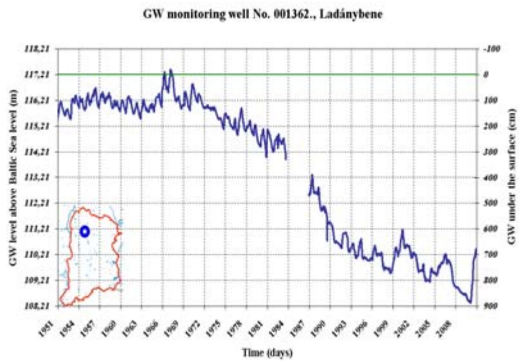

Figure 6. Variation of the water level of the monitoring well No. 001362 Ladánybene. (The green line indicates the ground

The water regime of the detection well showed higher water levels only at the beginning of the 1930s, at the beginning of the 1940s, at the end of the 1960s and at the beginning of the 1970s compared to previous periods. From the middle of the 1970s to the middle of the 1990s however a ground water level reduction of nearly 650 cm was experienced. After a few wet years – 1998, 1999, 2006 and 2010 – the ground water level located at the deeper levels has temporarily significantly increased.

The water regime of the 001401 Öregcsertő detection well established on the eastern edge of the Alluvial Plain Along the Danube shows a regular annual tendency (Figure 7).

In the neighbouring areas smaller ground water level reduction of about 50 cm was detected as a trend during the period between the end of the 1970s and the beginning of the 1990s.

The 004545 Kiskundorozsma detection well is a station established at the Lower Tisza Alluvial Plain (Alsó-Tisza-síkság) area (Figure 8). The altitude of the station is only 87.02 metres above Baltic Sea Level. Accordingly trend-based ground water reduction started only later, in the middle of the 1970s, in a smaller extent (~100 cm) compared to the Hátság areas. At the turning point of 1995 and 1996 significant increase was detected, but the maximum values measured in 1999 and 2000 were identical to the ground water levels measured in the middle of the 1950s and in the second half of the 1960s. The extreme weather conditions experienced in the last decade resulted in 2006 and in 2010 in significant ground water level increase, while in the years 2005 and 2007 resulted in significant reduction in the surrounding areas of the detection well.

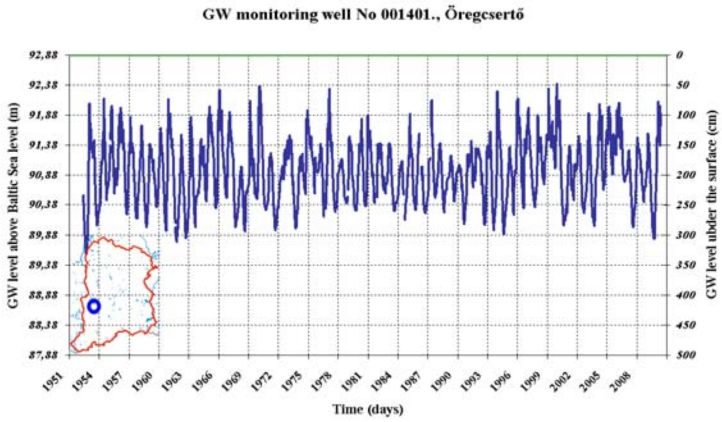

Figure 7. Variation of the water level of the monitoring well No. 00401 Öregcsertő.
(The green line indicates the ground surface.)

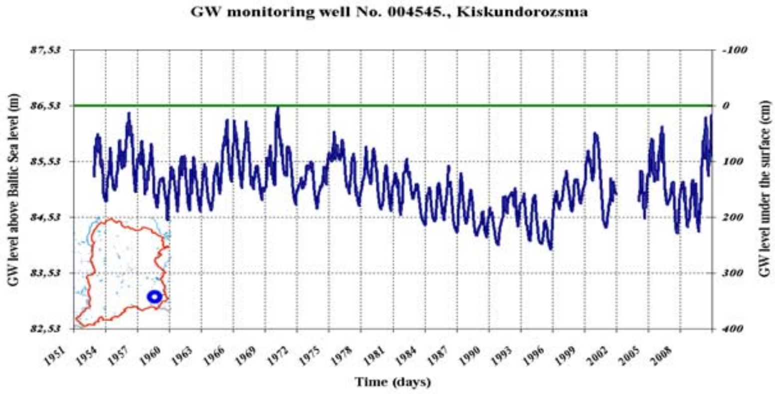

Figure 8. Variation of the water level of the monitoring well No. 004545 Kiskundorozsma. (The green line indicates the ground surface.)

Measurement data showed significant ground water reduction in the highest areas of the Bácska Plain (Bácskai-síkság). The track of the 004520 Borota detection well is similar to the detection well No. 1362. It is a significant difference, that the water table was located 500 to 800 centimetres below ground level in the 1950s and 1960s. Ground water levels were the highest at the beginning of the 1970s. The ground water levels dropped by over 600 cm also in this area by the mid 1990s (Figure 9).

Rainy periods were usually followed by significant ground water level increase, sometimes resulting in an increase of 70 to 80 cm. The ground water level increase was however only temporary, which was usually unable to counter-balance significantly the water shortage of the area.

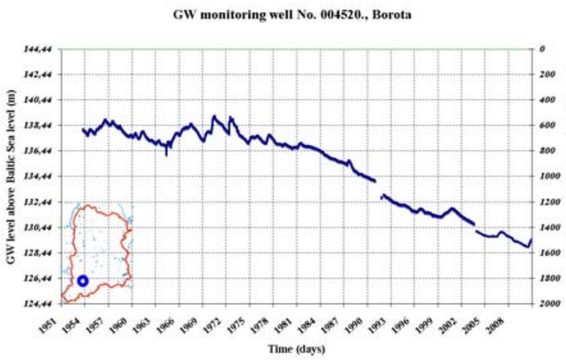

Figure 9. Variation of the water level of the monitoring well No. 004520 Borota. (The green line indicates the ground surface.)

By the utilisation of the –point based– values measured at the given detection wells based on edited maps it is possible to elaborate territorial evaluations. After comparison with different reference periods the typical characteristics of the changes can also be revealed (VITUKI, 2010).

Variability in space and time is shown by maps elaborated in accordance with the recommendation of the (World Meteorological Organisation (WMO) presenting the average ground water level difference distribution for the period between 1971 and 2000 and the annual mean ground water level difference territorial distribution for the years 2009 and 2010.

Compared to the average value measured between 1971 and 2000 the southern part of the area located between the Rivers Danube and Tisza in 2009 was characterized by lack of precipitation, while the northern part experienced large amounts of precipitation. In certain areas, mainly in Bácska Plain (Bácskai-síkság) a precipitation shortage of over 100 mm was detected, but also the south-eastern parts of the flatland located between the Rivers Danube and Tisza and extensive areas in the Lower Tisza Alluvial Plain (Alsó-Tisza-síkság) were suffering from the lack of precipitation. Precipitation surplus was only measured in the north-eastern edges of the flatland located between the Rivers Danube and Tisza.

In most parts of the area located between the Rivers Danube and Tisza ground water level reduction was experienced, slighter increase was only detected at the edges (Figure 10).

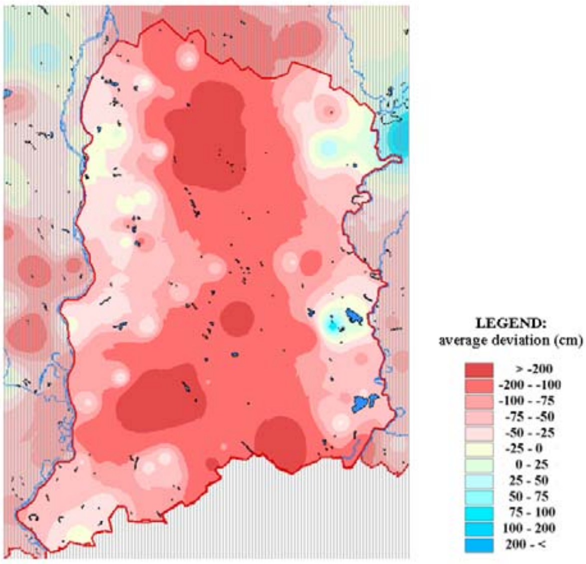

Figure 10. Average deviation of the depth of the ground-water table in 2009 from the average depth of the period 1971-2000.

The highest areas, i.e. the north-western, south-western and south-eastern parts of Hátság experienced the largest drop in ground water levels (over 200 cm). Other areas of Hátság experienced also significant difference varying between 100 and 200 cm. In the areas located west and east of Hátság the surface is lower-lying, here the ground water level decline remained below 100 cm.

The spatial distribution of precipitation in the area located between the Rivers Danube and Tisza was diversified in 2010. In the western part of the Alluvial Plain Along the Danube (Dunamenti-síkság) and in the Bácska Plain (Bácskai-síkság) the annual total precipitation was over 1000 mm. In other areas, such as the northern, north-eastern and south-eastern areas the precipitation level remained below 900 mm.

Based on the comparison of the total precipitation measured in the year 2010 and the average measured between 1971 and 2000 it can be stated that in most parts of the area located between the Rivers Danube and Tisza significantly more – 400 to 500 mm more- precipitation was measured than in the base period. In the northern, north-eastern and south-eastern parts of the assessed area in 2010 a precipitation surplus of 300 to 400 mm was measured.

As a result of the rainy period in the autumn of 2009 and the wet year of 2010 ground water stocks were topped up even in the districts hit by the largest reduction of ground water level. The extensiveness of the previously adjoining areas hit by significant decline has significantly reduced during the year and split into two parts. In the north-western and north-eastern areas the previously detected significant reductions were still detected, however the measurement data taken from the detection wells established at these areas showed significant topping up, in certain cases over 100 centimetres.

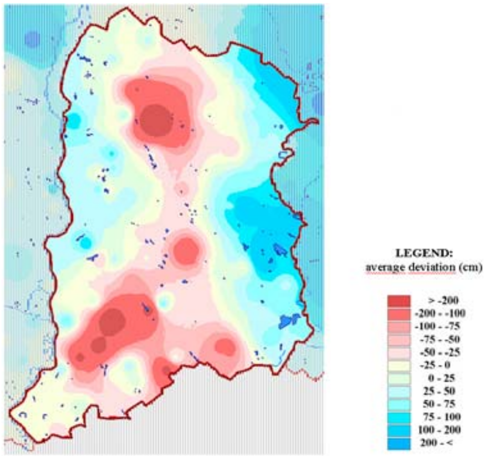

Figure 11. Average deviation of the depth of the ground-water table in 2010 from the average depth of the period 1971-2000.

In the south-western and southern areas similar phenomena was detected. In the area of the Bácska flatland (Bácskai-síkvidék) the replacement of the ground water located 15 to 20 metres below ground level will be significantly delayed. Towards the east, along the state border the ground water level decline experienced at the edges of the area located between the Rivers Danube and Tisza as a possible cross-border impact is in relation with the similar phenomena detected for the last few decades in the northern edges of the area called Vojvodina (also known as Vajdaság) (Figure 11).

In the middle, lower-lying areas of Hátság an increase of 50 to 100 cm was measured, in the neighbouring areas of certain detection wells even higher values were measured. In the Alluvial Plain Along the Danube (Dunamenti-síkság) and Tisza Valley and in the transitional areas between Hátság and flatlands along the valleys significant increase was detected with an asymmetric territorial distribution. In the eastern areas the increase was typically over 100 cm, on the western side, on the northern and on southern part of the Alluvial Plain Along the Danube (Dunamenti-síkság) the increase was below 100 cm, and in the middle areas the increase was over 100 cm.

6. Impact of ground water changes to the natural environment, and risks

The area located between the Rivers Danube and Tisza constitutes the Great Hungarian Plain (Alföld) flora-landscape (Europannonicum) of the flora course typical in the area located between the Rivers Danube and Tisza (Praematricum s. str.). The appearance of the landscape significantly changed in the last thousand years. It is a cultural landscape split by plough-lands, gardens, vineyards, meadows and during the last decades ever increasing amounts of uncultivated areas. The former vegetation can only be seen in the protected areas, in the larger dune systems, in the Natura2000 and in other, smaller-larger isolated areas. Uncultivated areas are covered by weeds (e.g. ragweed [Ambrosia artemisifolia L.]) and invasive breeds (e. g. silkweed [Asclepias syriaca L.]) and they are spreading heavily.

In the area located between the Rivers Danube and Tisza the relations of ground water play a significant boundary condition in the life of the area's flora and fauna (Figure 12). The composition of species habituating the areas were/are regulated by the precipitation relations and the location of the ground water. In the case of a permanent dry period and permanently low ground water level the degradation of the plantation and drying up of wet habitats have a significant impact on the animals (Hoyk, 2006, Rakonczai, 2011). As a result of the elimination of their habitat, irreversible processes can also be expected. The drying up of previous saline lakes, the changes and alteration of their habitat type and the composition of their species is an expressive example. During rainy years (1998-1999, 2010) even the appearance of an open water table meant only temporary favourable living conditions for the habitats similar to the previous ones, however the occasional abundant precipitation and increased ground water levels are not sufficient enough to maintain a flora and fauna of saline lakes. The restoration of lost habitats is in many cases impossible, and their regeneration would only be possible in the next centuries.

Figure 12. Snow and frozen inland waters in a former bed of an ancient lake near Üllés (at the edge of the south-eastern part of the Hátság) in February, 2011 (left) and in September as a meadow (right).

7. Summary

The area located between the Rivers Danube and Tisza; within this the area of Hátság with a special water management system deserves special attention in terms of the observation and evaluation of the underground water stocks and their quantity. Especially in the case, when we also take into consideration the available information on presumed changes of ground water levels occurring during the global climate change, as further risk-increasing factors.

In the highest parts of the area located between the Rivers Danube and Tisza the ground water level decline has already started in the beginning of the 1970s and spread to the lower areas of Hátság. The territorial expansion of the reduction and the extent of the occurring changes reached their maximum by the end of the first three years of the 1990s. The process slowed down, stagnated and in certain areas reversed in the middle of the 1990s.

During the wet years of 1998-1999, 2006 and 2010 in the lower-lying areas significant ground water level increase and internal water flooding were detected. In the higher areas, where the ground water was located deeper down, significant but not permanent increase was detected compared to the previous years.

The ground water decline hitting the area of Hátság still very hard, shows a varying intensity and is controlled by multiple background factors. The decline of ground water levels, extreme changes detected during the last decade constitute a risk both for the natural environment and for agriculture and sylviculture. The mitigation of the impact of ground water reduction, searching for solutions, and reduction of risks are expected from complex analyses using the background factors having an impact on the relation of ground water levels.

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