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Correlations Between the Quantity of Water Production and Changes in the Water Level in the City of Szeged, Hungary

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Abstract

Water supply of Szeged town is provided exclusively by artesian wells. The paper describes the effect of change of water production to static head of wells. In addition the effect of North Water Work to the static head of water bearing layer under the town is shown. The North Water Work were built in 1986. They are situated 17 km from the city. According to data the conclusion is the starting operation of the North Water Work and the change of water production highly influence the static head of wells in time and space.

Key words: water production , stable head , water works

Introduction

Primarily because of the extremely low prices there used to be a high level wastage in drinking-water consumption till the end of the 1980s. It put a great pressure on the water works of Szeged forcing them to increase their water production. As a result of this in a number of places where production had taken place from high pressure groundwater wells with positive stable head the stable head of the wells decreased below the surface. This posed an important question of what would be the rate and speed of changes in water level , and how these values would alter in case of such an increase in water consumption. It also brought up the question of how we could improve the situation to moderate the changes in the level of water.

In case of the waterworks of the city of Szeged production is restricted to groundwater aquifers only , so the above mentioned tendencies appear at a larger scale there.

Since the beginning of the 1990s compared to the previous years processes have shown a reversed tendency. There is a sharp decrease in water production due to the large scale increase in water prices.

Thus the earlier development projects expecting an increase in water production have become outdated. Consequently revisions were needed to decide how changes in water production effect changes in the stable head of water.

The system of water supply of the city of Szeged

The city of Szeged is situated on the southern part of the Great Hungarian Plain at the junction of the rivers Tisza and Maros. Seven water works are responsible for supplying the city - with almost 170 thousand residents - with water. The supply of water works is restricted to deep groundwater wells .(Fig.1.) Five of the works constructed in the 1960s and 70s are situated in the city itself. The sixth can be found 14 km North of the town , working continuously from 1986. The seventh lies 5 km west of the town. The 86 wells in groups of 3-5 are located in the town in such a way that each

of them uses a different water-bearing horizon. The wells are producing from aquifers between 150-550 m depths.(Fig.2.)
Till the end of the 1970s the wells were producing from high pressure groundwater aquifers , i.e. production was gravitational. From the beginning of the 1980s diving pumps had to be immersed into the wells as the stable head of water in them grew negative.

Hydrogeological overview

The Great Hungarian Plain overlies a basin filled with Neogene sediments having an average thickness of 2500-3000 meters. This average rate of sediment fill thickness is also true in the case of Szeged and its surroundings.
Differences in relief of the Mesozoic basement were leveled up by the Cenozoic deposits. The first major marine transgression occurred in the Miocene creating deposits of carbonate in the lower part turning into clastic , pelitic deposits in the upper part ,with a thickness of 50-150 meters. The Pliocene begins with marine clastic deposits. In many places there is a significant unconformity between these and the overlying deposits ; rocks with high carbonate content and clastic sediments. By the end of the Pliocene the area had been broken into sub-basins. The prevailing brackish water facies in the area was gradually taken over by fluviolacustric sedimentation with the pass of time.
The determination of the Pliocene-Pleistocene boundary is very difficult in many places using biostratigraphic methods. Thus mainly litostratigraphical methods are used for this purpose. In the succesion we can draw the boundary where coarser , fluvial gravel overlies the fluvio-lacustric deposits. Todays plains then were formed by the filling up and leveling up effect of fluvial sedimentation. The thickness of Pleistocene successions varies between 500-700 meters in the area of Szeged. These succesions are displaying extraordinary variety. Clay , sand and gravel equally occurs in them with different qualities as a result of frequent changes in the paleogeography of the area. These porous deposits together with the Pannonian s.l. layers comprise the major deep level aquifers of the Great Hungarian Plain. (Alföld)
From a hydrogeological point of view we can say that mainly marls and hard sandstones make up the Lower Pannonian s.l. deposits , which store generally little , and slightly salty water. However , the Upper-Pannonian s.l. deposits are made up of alternating layers of sand and silt yielding more water than the previous ones.
Among the Pleistocene fluvial deposits we can find many coarse grained aquifers with quite good water yields. The thickness of the fluvial succession reaches 550-700 meters in the Szeged area. We can divide this Pleistocene aquifer assemblage into five distinct groups. The best water-bearing horizons are those around 300 meters and below 400 meters. According to drilling data of the wells , we can get high pressure groundwater wells with positive stable head even from horizons at 100 meters.
The temperature of the upcoming waters is relatively high. We can gain 30 degrees Celsius thermal water even from a depth of 500 meters. This means approximately 1 degrees Celsius increase in the geothermal gradient per 18 meters.
The quality of the produced water on the basis of the water quality regulations can be considered to be excellent. The water is calcium hydrogen carbonate bearing with low dissolved matter content. The average discharge rate of the wells is 1500 l/min , with 10-15 meters of operational level of headwater.

Data analysis

There are hydrodynamic measurements in the wells with monthly periods. Stable head is recorded in case of the non discharging wells. In case of the producing wells the operational level of headwater , rate of discharge and water temperature is measured. In my paper I analysed data related to the stable head of the wells.
In my opinion it was reasonable to start my analysis with datas from 1978 , since at that time all the wells had a positive stable head of water. In the following years there was a significant decrease in water levels. I divided the wells into groups on the basis of the depth of filters for each and every one of the waterworks. Between the depths of 150-550 meters (Fig.3.) I could identify eight water-bearing horizons. I recorded the annual mean of stable heads of wells having filters at equal depths in tables for each waterworks individually. I put the results onto graphs as well. I worked with datas of the sixth waterworks separately. This way I was trying to get an answer to the question of how the construction of this waterworks affected the city´s aquifers. The construction works aimed at releasing pressure on aquifers right under the town and by extending the area of depression meet the increasing demands for water supply.

Results

We can observe both a significant decrease and rise in the water levels of the examined wells in the Szeged area within the past 20 years. (Fig.4.) According to data presented on Figure 4. two major periods can be distinguished in the history of water production.
The first one lasted from 1978 to 1991. A switch in water production methods from the traditional gravitational discharge to the utilization of diving pumps marks the beginning of this period. During this time there was a continuous increase in water production with minor fluctuations.
The second period started in 1992. We can observe a decrease in the production in this period. On one hand the main reason for this was a fall in the quantity of water utilized due to a rise in the prices. On the other hand the other main contributing factor was that a number of companies had their own wells drilled rather than purchasing water from the works.
Although these factors promoted a more equalized utilization of the aquifers they did not ease up the load on the water-bearing horizons.
The average rate of stable heads was +2 meters in all of the eight depth horizons between 1978-79. This rate got to a turning point in the 1980-81 years. Thanks to the increase in the demands for water the stable heads of the horizons fell below +0 meters. (Fig.5-6.)
There was an increase of 2.5 million m^3 -s in the water production between 1978 and 1982. The waterworks could provide this much supply from the producing wells only by increasing their discharge capacities. The pumping of the wells also contributed to this drastic decrease in water level reaching -1- -2 meters annually.
The load on the water-bearing horizons got stabilized in 1983. From this time we can observe only a minor , equalized decrease in each of the water-bearing horizons. The rate of decrease is 0,5 meters annually. This process lasted as long as 1986 , when the new waterworks 14 km far from the city started a full capacity discharge as well. The effects of this are clearly visible on the graphs: the fall in the water levels got to a halt in all of the horizons - except for the wells filtered at depths of 100-200 meters and 400-450 meters - in case of the aquifers situated right under the city , moreover a 10-40 centimeter rise can be observed till 1988 annually.
From 1988 water production grew more intensive again starting an equalizing process in the

pressure of all the horizons except those between 350-400 and 450-500 meters. The rate of this varied between 0,5-1,5 meters till 1991.
The annual water production got to its peak in 1991 - more than 25 million m^3 -s of water This much supply can be provided by intensifying the discharge of the wells.
In 1992 effects of an increase in water prices could be observed as a starting fall in the quantity of produced water. Less than 19 million m^3 of water was produced in 1996. This had a serious effect on the pressure of the horizons as well. The stable heads of all the wells switched to a rapid increase the rate of which reached 1,5-2,0 meters within the scope of two years.
In the years of 1995-96 pressures of all the wells - except those filtered at 150-200 meters depth , and some of them filtered between 300-350 meters - grew to positive.
We can trace changes in water levels of the wells of the sixth waterworks situated far from the city from 1986. The horizons between 150-200 and 350-400 meters are not filtered here. All the wells except those filtered between 200-250 and 300-350 meters have a positive stable head with minor fluctuations and at rates reaching those of 1986. (Fig.7)
In the years 1985-86 the stable heads of the two above mentioned horizons were around + 0 meters as well. We can observe a gradual increase of water levels not only in case of the waterworks situated in the town itself but in case of this works as well.

Conclusion

During the process of continuous water production a strong connection can be observed between the quantities of water produced and the stable heads of the wells. The water-bearing horizons under discharge respond to changes in the production within an extremely short period of time. Generally after half or one years can we observe a change in the water levels , in some cases however this reaction time can be even shorter: 2-3 months respectively. Presently all the wells in the city of Szeged have positive stable head rates.
If the production continues at the present rate then we might expect that stable heads of the wells will reach values of those of the end of 1970s.
This is quite favorable from the side of water producers since there is no need for construction of new wells and the load on the horizons will hopefully stay at an equilibrium thanks to supplies coming from groundwater.

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Figures

Figure 1. The network of water lines in the city of Szeged
Figure 2. Sedimentary succesions and filtering of wells belonging to group 02. at waterworks No.II.
Fig.3. Filtering of waterworks wells Note: wells out of order were not taken into consideration
Fig.4. Water production at Szeged Waterworks Ltd. between 1975-1996.
Fig.5. Values of stable heads of wells in the waterworks according to the depths filtered works No.IV. 150-200 m depths ; B: works No. III. IV.; V. 200-250 m depths ; C: works No. III. 250-300 m depths ; D: works No. II.; II. ; IV.; V. 300-350 ms depths
Fig.6. Values of stable heads in the waterworks according to depths filtered E: works No II.; III.; IV. depths 350-400 m , F: works No. I; II.; III.; IV.; V. depths 400-450 meters , G: works No. I.; III.; IV.; V. depths 450-500 meters, H: works No. III.; IV.; V. depths 500-550
Fig.7. Stable heads of wells of the Szeged North Waterworks