THE ROLE OF GROUND AND ARTESIAN WATERS AS NUTRIENT SOURCES IN THE IRRIGATION ON THE GREAT HUNGARIAN PLAIN

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Abstract: One of the most significant attribute of soils is that they function as water reservoirs. Subsurface waters – used as irrigation water – can contribute to nutrient supply, but their pollution has a negative impact on the conditions of cultivation. In our study we present the results of our investigation of ground and artesian water samples from the Great Hungarian Plain, mostly from Kecskemét and its surroundings. Based on the depth of the sampling points, we divided the samples into three categories: between 10-30, 31-70 and 71-275 meters. The results showed that the salt content is decreasing with the deepness, primarily because of the decrease in sodium, hydro-carbonate and chloride contents in the samples. The level of nitrogen and phosphorous-ions were low in almost all water samples. Iron, manganese and arsenic content were the highest in the middle deep waters (31-70 m depth). These results – especially in the case of iron and arsenic – can cause problems in the use of these waters in agriculture for cultivation and irrigation.

Keywords: ground water, artesian water, irrigation, nutrient reservoir, water pollution

Introduction

One of the most significant attributes of soils is that they function as water reservoirs. Subsurface waters – used as irrigation water – can contribute to nutrient supply, but their pollution has a negative impact on the conditions of cultivation.

We have to accept that irregular and unpredictable precipitation is a typical characteristic of our climate (Rakonczai, 2000). That is why irrigation is so important for agriculture in Hungary.

From the point of view of irrigation water sources, we have to point out the zone near the surface – that is groundwater (0-30 m) – which is an infiltration zone with changeable solute content, and it is not a complete underground system. That is way investigation of this system is justified. Under this shallow zone, a 31-300 m deep zone can be found, with migrate waters towards the centre of the Carpathian basin and tempered chemical compounds. (Kuti et al., 1999). Anaerob processes can increase iron, manganese and ammonia content of artesian waters. Increased arsenic content could become a problem in some irrigation waters. In some cases salt content can be high of artesian waters near the surface, the solute concentration can be higher than 1 g l^{-1} (Kuti et al., 1999).

We investigated irrigation waters of the South Great Plain in our work, in order to investigate how they can be used in agriculture especially for horticultural irrigation.

Materials and methods

Irrigation water samples from 2007-2014 were examined at the Soil and Plants Analysis Laboratory of Kecskemét College. We investigated 110 water samples from different wells. Based on the depth of the sampling points, we divided the samples into three categories: between 10-30, 31-70 and 71-275 meters. The place of origin was mainly

Kecskemét and its surroundings, but we had samples from Bács-Kiskun county and agricultural areas in south part of Tiszántúl region.
The rules of sampling were the following: collection of water sample from drilled wells after streaming a few minutes, washed out with well-water of sample collection containers, and it is necessary to close tight immediately after the sampling. After a longer storage the results of the investigation are not reliable.
Examination of pH was made by potentiometer, electric conductivity (EC) by conductometer. Ca^{2+} , Mg^{2+}, Na^{+}, K^{+}, PO_4^{3-}, SO_4^{2-} ions, and Fe-, Mn- As-content were measured by ICP-OES spectroscopy. Investigation of ammonia- and nitrate-content were made by photometer, chloride by argentometer, carbonate and hydro-carbonate ions by neutralized titration. The methods were based on widely accepted standards.

Results and discussion

PH values of investigated underground water samples were between 6.5-7.8, the average was 7.3, stand by a medium deviation with decreasing water depth. Conductivity, which refers to the salt content, shows high variability. Average conductivity value exceeded 1000 μS cm^{-1} in higher layers which is recommended in irrigation waters, while values in medium depth were close to this. Salt content of waters reduced and balanced in lower layers (Table 1.)

Table 1. Changes of pH and EC values by depth

	10-30 m		31-70 m		71-275 m		limit value
	average	deviation	average	deviation	average	deviation	
pH	7,26	0,37	7,32	0,38	7,29	0,25	6,5-7,8
EC, μS cm^{-1}	1020	763	975	833	682	267	1000

The most typical metal ions in the nature are Na, K, Ca and Mg. Chloride and hydro-carbonate ions are the most important among accompanying anions. On the basis of our results, potassium ion was in minimum quantity with low value, which hardly changed with depth (from 1,86 to 2,45 mg l^{-1}). Carbonate ion was not detected in either samples. We show changes of other samples with the depth in Fig. 1. A decreasing tendency of concentration of all ions was detected with the depth.
Average values of ions did not exceed the limit values for irrigation waters, in any cases of ions or depth. It is important, that in case of water samples from shallow depth, and especially of sodium and chloride ion concentration, deviation was large. 4 % of the samples had very high (>400 mg l^{-1} Na^{+}; >500 mg l^{-1} Cl^{-}) concentrations in wells shallower than 42 m.
Different forms of nitrogen and phosphorus show primarily anthropogenic pollution. Most important ions of N and P can be seen in Fig. 2. The investigated water samples were not near the limit values for nitrate and phosphate (50 and 30 mg l^{-1}). It was not the case with ammonium ion, where values exceeded the limit value (0,5 mg l^{-1}) in many cases, in higher layers. But under 45 m it was not the case. Probable farmyard manure was the reason of the higher NH_4^{+} pollution.

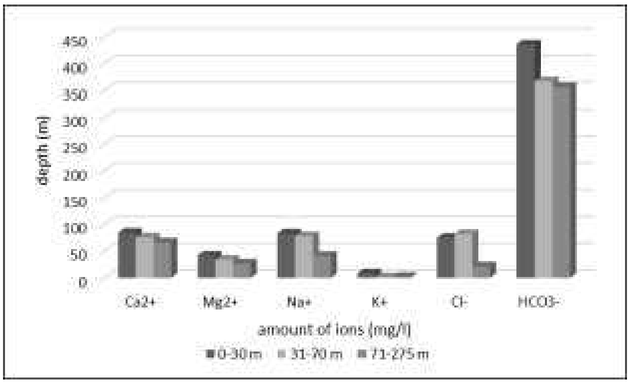

Figure 1. Changes of different ions with the depth

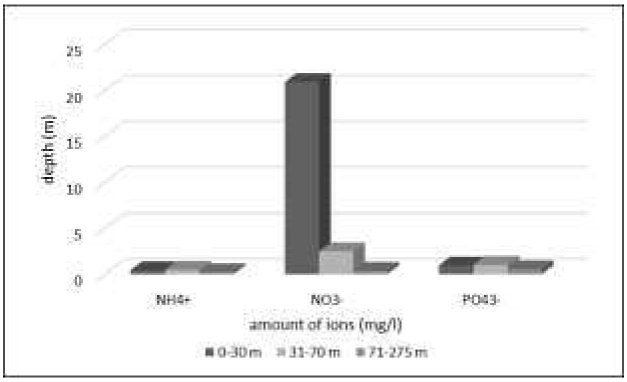

Figure 2. Changes of nitrogen and phosphorus ions with the depth

Iron, manganese and arsenic are the most important micro-pollutants. Concentration changes of these ions can be seen in Fig. 3. Iron exceeds the limit value, which can be clearly seen. We can see very large deviation in case of every investigated pollutants. We detected the highest concentrations in middle depth. Water samples from the deepest layers had the most stable composition both in terms of pH and ion content. Salt content decreased going down, which is favourably influenced irrigation use of these waters. The reduction of salt content was due to the decrease of potassium- and chloride-ions on the one hand, and due to the decrease of hydro-carbonate ions on the other hand.

It is a special feature of groundwater in the Great Plain that different salts are dissolved in the most diverse concentration. Salt content of these waters usually exceeds 1000 mg l^{-1}. Sodium-hydro-carbonate is the most frequent salt in our region. Waters in shallower depth are probably younger. These waters dissolved from the surface directly, or not too far from the place where we can find it nowadays. Composition of water samples is varied because of the water flows beneath the surface, moving up and down. The waters investigated are of medium hardness, potassium content is expressly low, because of the minor clay content.

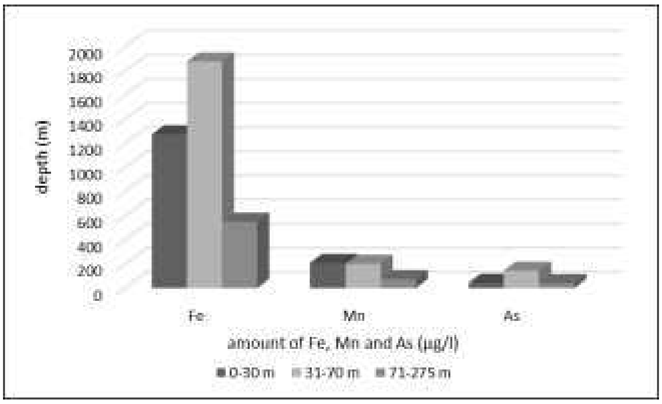

Figure 3. Concentration changes of iron, manganese and arsenic ions with the depth

Water sources under the surface are compromised in many ways. High concentrations of nitrate and chloride ions refer to pollution from the surface, but iron, manganese and ammonium concentration can rise in natural circumstances because of the dissolution from base rocks around the water sources (Nemes, 2007). Iron and manganese content should be avoided under drip irrigation because of the risk of clogging. Higher content of iron and manganese in waters (1,5 mg l^{-1}) is not a problem from the plant nutrition perspective. We can expect increasing arsenic content in case of middle layer irrigation waters on the South Great Plain based on our results.

Conclusions

Drought and inland water have similar frequencies on the Great Plain, but drought affects much bigger area than inner water (Pálfai, 2000). Sand ridges between the Danube and Tisza rivers as well as in the middle and lower parts of Tisza region are the most sensitive to drought. This is the reason, why irrigation and quality control of waters are so important. Usage of subsurface waters for irrigation is important in the future, for example about their function as potential nutrient sources. Their sensitivity to pollution draws attention to the essential task of continuous quality parameter monitoring of subsurface waters both as drinking and irrigation water.

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