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EXAMINATION OF THE GROUNDWATER QUALITY IN A SETTLEMENT OF EASTERN HUNGARY

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Abstract: The water quality from groundwater wells in a small town, called Mikepércs, situated on the SW edge of the Nyírség, eastern part of Hungary, is investigated. By the time of the research, the sewage network had not been yet constructed in Mikepércs, thus the inhabitants collected the sewage in septic tanks. In Mikepércs the tanks usually had not adequate insulation and therefore the majority of the sewage (more than 90% according to our estimations) was emitted into the soil. As there are sandy soils around the settlement the sewage can filter into the soil and reach easily the groundwater level at depth of about 1.5-3 m below ground surface. According to our preliminary expectation we have detected significant pollution in most of the groundwater wells in Mikepércs, especially concerning orthophosphate, nitrate and ammonium pollutants, which concentrations were much over the hygienic limit value. Besides the watering of animals, sometimes people drink groundwater so we can say that consuming of groundwater can cause both human and animal health risk.

Keywords: Eastern Hungary, water quality, groundwater pollution, health risk

1. Introduction

Among the underground water deposits the groundwater is one of the most endangered because the contaminants from the surface can easily reach it (Bolgár and Pál, 2005; Farsang and Fejes, 2009). Some decades ago the groundwater was the most important drinking water resource in Hungary but the situation is markedly changed and nowadays groundwater is rarely used as drinking water. On the other hand, the former dug wells can still be found in the villages and the suburbs, and they are still in use. People use them to water ploughlands and domestic animals but sometimes even to wash cars. Furthermore, the owners of the wells – usually elder people – drink groundwater from the wells saying that they used to drink it from their childhood without any problems and that its taste is much better than that of the tap-water. Knowing the water quality of the wells, this means serious health risk. The percentage of households supplied with sewer system has increased rapidly in Hungary the last years: from 56% in 2002 became 70% in 2008; in this period 700 thousand properties have installed sewer system (MTTE, 2009). Nevertheless, many country settlements where a great deal of the sewage filters into the soil can still be found.

The present quality test was carried out in a settlement where the sewer network had not been constructed by the time of the examination, and the domestic sewage was collected in septic tanks not supplied with adequate insulation, allowing the soil and the groundwater to be exposed to a great demand. Considering the data of the amount of the water consumption and the sniffed sewage we determined that at least 90% of the sewage of the settlement filtered into the soil. In the course of our research the water quality of the dug wells and the temporal changes of these parameters were examined. Moreover, we studied whether the use of groundwater poses any human or animal health risk. Since the sewer network has been constructed after we finished the examinations, this research can serve as a basis to determine the positive effects of the sewerage.

2. Materials and Methods

Examinations were carried out monthly in the 14 dug wells of Mikepércs: from June 2005 to June 2006 and from July 2007 to July 2008 (Fig. 1). Between these two series of measurements a year passed. During the designation of the wells we endeavoured to cover the whole area of the settlement.

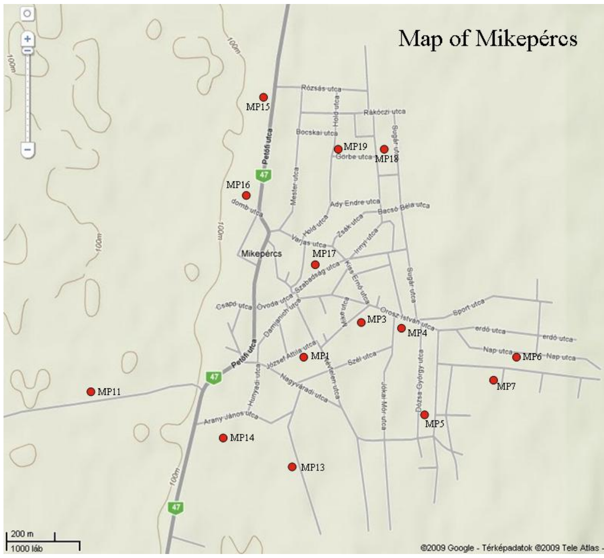

Fig. 1. The location of the groundwater sample wells in Mikepércs

The sampling was carried out with a ball water sampler, and the samples in hermetically closed plastic flacons were transported to the geography laboratory of the University of Debrecen. When the samples were taken, the electric conductivity and the temperature were measured in the field with a Schott electronic conductometer. The depth of the groundwater table was also measured for every sample. The determination of nitrate, orthophosphate, ammonium and organic matter and the measurement of the pH were carried out in the laboratory a day after the sampling (Literáthy, 1973).

The results were saved in an Excel database and the diagrams were also made with this software. In the course of the statistical analyses Kolmogorov-Smirnov normality tests were performed. Since most of the data were not normally distributed, Spearmann correlation coefficient was applied during the correlation analysis. SPSS 8.0 software has been used in the statistical analyses and to make further diagrams.

3. The examined settlement

Mikepércs is situated in the eastern part of Hungary, about 5 Km south from the town of Debrecen. Mikepércs has diverse pedological conditions as the settlement is located at the boundary between the Hajdúság and the Nyírség. The loess area of the Hajdúság extends to the western part of the settlement where chernozem soils were formed. Soils of sandy texture can be found in the greater part of the settlement that belongs to the area of the Nyírség. These soils are much more sensitive than the chernozems because of the coarser granulometric composition, the less content of organic matter and the weaker buffering capacity. The depth of the groundwater in Mikepércs is 1-3 m, but in the higher reliefs more than 5 m deep groundwater table can occur. The groundwater flows from the north-east to the south-west, towards the Kondoros-stream that runs near the west part of the village.

In the Mikepércs settlement of 4000 inhabitants the water supply network is almost complete but the construction of the sewer system has begun only in the second half of 2006. The sensitivity of the confined groundwater bases under the settlement and the significant pollution of the groundwater stress out the urgency of the sewerage program. This program was finished only after the second examination period, by the end of 2008, so the positive effects of the sewerage could not be demonstrable in this examination series.

4. Results and Discussion

During the examined periods the depth of the groundwater was higher than on the average because precipitation was significantly higher that the mean precipitation of many years (600 mm). At the time of the first examination series (from June 2005 to June 2006) precipitation was 904 mm, whereas from July 2007 to July 2008 749 mm precipitation fell (Fig. 2). In most wells the groundwater level fluctuated between 100 and 250 cm during the first examination period but it was at average 80 cm deeper during the second period of the examination (Fig. 3). Beside the less precipitation in the second period, the quite little precipitation (485 mm) during the 12 months between the two studied periods also played a significant role.

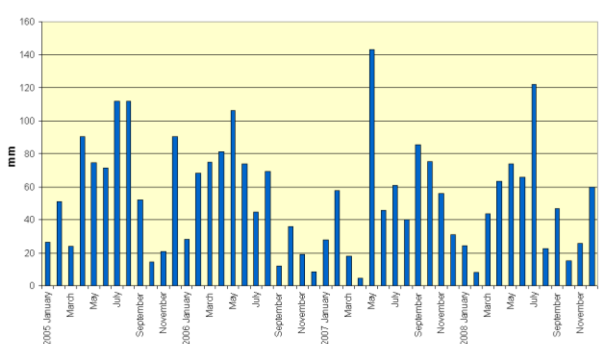

Fig. 2. The monthly precipitation distribution from 2005 to 2008 (Source: VITUKI RT.)

The electric conductivity of the water samples gives the total ion content of the samples (Szabó, 2008; Szalai, 2008). In the first period the conductivity was 1000-2800 μS/cm and in the second period it was a bit less with the values ranging from 900 to 2300 μS/cm, which can be considered as ordinary in a non-sewered settlement (Fig. 4). (Pál and Bálint 2007).

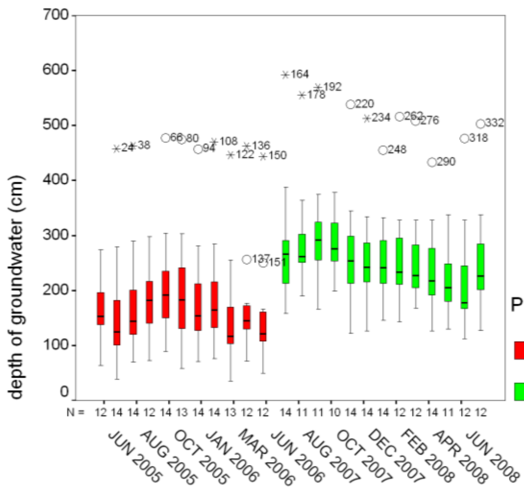

Fig. 3. Changes in the depth of the groundwater in the two examination periods.

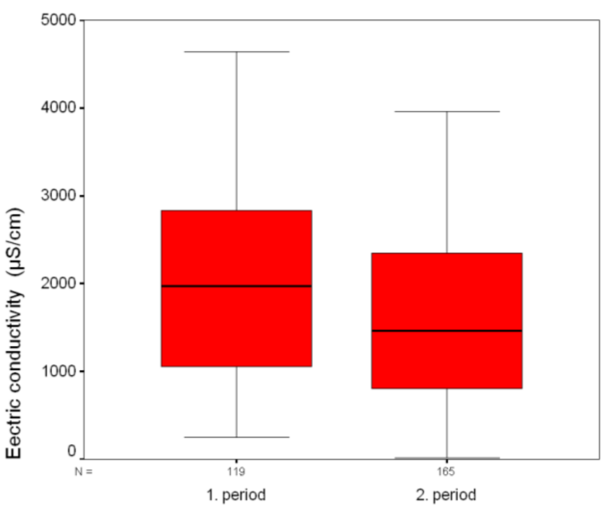

Fig. 4. The electric conductivity in the first and the second examination periods.

Definitely, the less precipitation and the deeper groundwater level gave rise to the weaker values of the second examination period. In the first period the bottom of the non-insulated tanks near several wells got under the groundwater level; that is why the total ion content of the well-water could increase. Although the electric conductivity does not give information about the type of the ion found in large quantities in the sample, certain conclusion can be drawn out with the correlation analysis. Strong positive correlation can be found between the electric conductivity and the nitrate content ($r=0.715$, $p<0.01$). This proves that nitrate accumulated mainly in wells containing other ions – that also play significant role in the change of the conductivity – in high concentration.

The **pH** of the examined water samples were slightly alkaline (Fig. 5). In both examination periods a maximum in the autumn-winter months and a minimum in the spring-summer months can be observed but all the measured values were inside the (B) limit values (pH<6.5 and pH>9.0) determined in the joint decree no. 10/2000 (VI. 2.) KÖM-EÜM-FVM-KHVM.

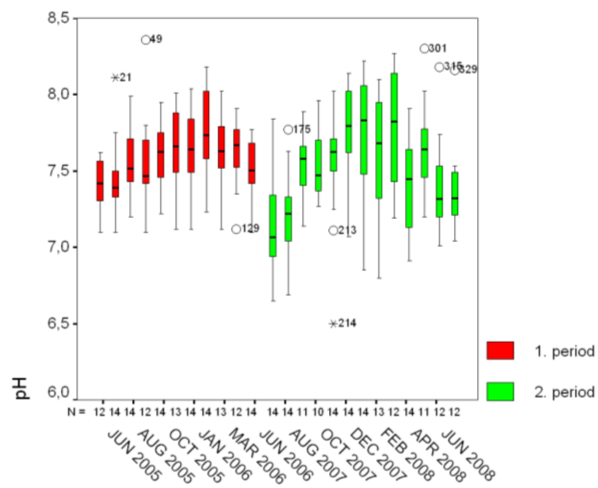

Fig. 5. The pH of the water samples monthly from June 2005 to June 2006 and from July 2007 to July 2008.

The majority of the wells contains **ammonium ion** in really high concentrations; this clearly indicates anthropogenic contamination. In 17% of the samples collected in the first period, the measured concentrations were lower than the contamination (B) level determined in the decree no. 10/2000 (0.5 mg/l) so regarding 83% of the samples the ammonium content exceeded the limit value. Considering the second examination period the situation was better: ammonium concentrations in 38% of the samples were under the contamination level. On the other hand there were extreme contamination values exceeding many times the contamination level; they refer to direct sewage disposal.

In addition to the municipal wastewater the improper management of the manure derived from livestock farming could contribute to the extremely high concentrations. In both periods the highest ammonium concentrations were experienced in the autumn-winter months. During these months the organic nitrogen is converted into ammonium and the oxidation of the ammonium is retarded due to the cold weather as the activity of the nitrite bacteria slows down below 10 °C and the ammonium ions accumulate into the water (Fig. 6) (Bíró et al., 1998).

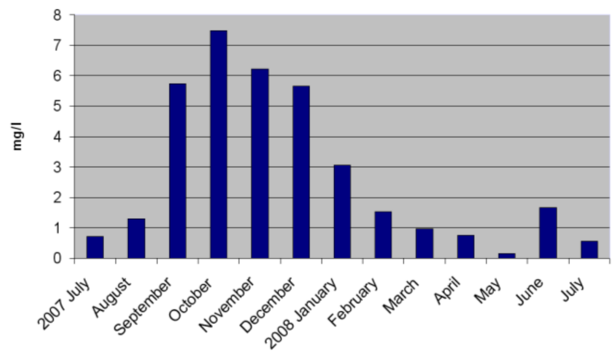

Fig. 6. The ammonium concentrations in the second examination period, means of 13 wells (The data of the well MP19 were excluded because extremely high concentrations were measured in this well).

25 mg/l is the limit value (B) of **nitrate concentration** in underground water bodies, determined in the decree no. 10/2000. Regarding the nitrate content of the wells the results are quite disadvantageous since the nitrate concentration exceeded the limit value in 90% of the collected samples. Moreover, more than fivefold concentration of the limit value was measured in 51% of the samples and values exceeded 500 mg/l also occurred. Knowing the high ammonium concentration, it is no wonder that the water of the wells is strongly polluted as in the presence of oxygen the ammonium is oxidized to nitrite than nitrate (Pál et al., 2009). High nitrate concentration is due to the sewage filtering from the sewage tanks but the nitrogen fertilizers spreading in the vegetable gardens near the wells could also contribute to the high concentrations (Szabó et al. 2007). It can be seen in both examination periods that the highest concentrations were measured in the wells that are situated in areas with the highest groundwater level and where non-insulated sewage tanks were near the wells (Fig. 7).

The **phosphorus** content of the underground water can derive from natural sources, e.g. from the weathering of certain rocks, but the higher concentrations can always be traced back to anthropogenic effects. The most significant anthropogenic source is the sewage but the residues of phosphorus fertilizers used in the agriculture can also cause phosphorus accumulation (Szalai et al., 2004).

The **orthophosphate** pollution of the examined groundwater wells is also significant. Almost 94% of the examined water samples exceeded the 0.5 mg/l (B) contamination limit value determined in the decree no. 10/2000; in 60% the excess of the limit value was more than fivefold (Fig. 8). In Mikepércs the main pollution source is the municipal wastewater, the use of phosphorus fertilizers is not typical in the centre of the settlement. More considerable pollution occurred in the first examination period owing to the higher groundwater level since in most cases of the sewage tanks near the wells the bottom level was situated under the groundwater level and therefore the sewage could directly mixed with the groundwater.

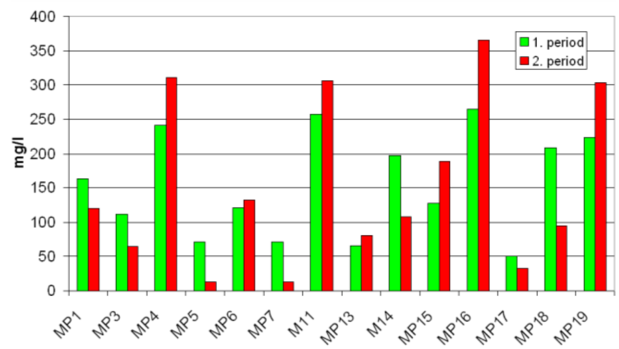

Fig. 7. The mean nitrate concentrations of the examined wells in the first and the second examination periods

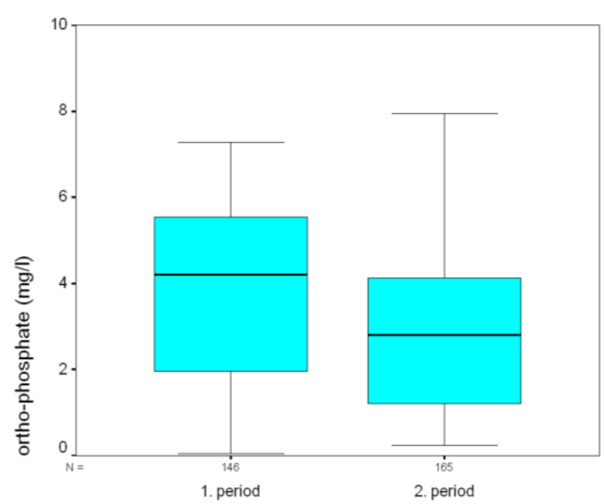

Fig. 8. The orthophosphate concentrations in the two examination periods

5. Conclusions

- The water quality of the examined groundwater wells is extremely inadequate in Mikepércs.
- Regarding the examined water quality parame-

ters the measured concentrations of most collected samples exceeded the limit values. In the cases of the ammonium, nitrate and orthophosphate the situation was extremely adverse.

- The problems occurred because the sewer network of the settlement constructed by the end of 2008 was not put into operation at the time of the examinations so the inhabitants stored the sewage in badly insulated or non-insulated septic tanks. From these tanks 90% of the sewage filtered into the soil, leastways this is backed up by the data of the amount of the water consumption and the sniffed sewage.
- The relatively little depth of the groundwater (1-3 m) and the sandy soils (letting through the pollutants very quickly) found in the most part of the settlement contributed to the pollution of the groundwater.
- The water quality of most examined wells was proved to be worse in the first examination period – because of the higher groundwater levels – since the water levels exceeded the bottom level of several sewage tanks at the times of high water levels and therefore the sewage could directly mixed with the groundwater.
- The decree no. 41/1997 (V. 28.) states that "As far as possible water of drinking-water quality should be used for the watering of animals." Unfortunately, it was not carried out in the cases of the examined households (possessing dug wells) since the inhabitants water the animals everywhere with the water from the dug wells but the quality of this water is not adequate regarding the directions. On the other hand, they had the possibility to use water of drinking-water quality as the water conduit system is entirely constructed in the settlement.
- Knowing the water quality of the wells this practice raises serious questions related not only to the animal but also to the human health since the toxic substances deriving from the polluted water can get into the milk and meat of the animals and the consumption of them can cause several serious problems in the health of human beings.

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