Proc. Estonian Acad. Sci. Biol. Ecol., 1998, **47**, 3, 221–227
https://doi.org/10.3176/biol.ecol.1998.3.05

EVALUATION OF DRINKING WATER QUALITY OF LOCAL WELLS IN NORTHERN HARJU COUNTY, ESTONIA

Rein RANNAMÄE[a] and Ingeborg VELDRE[b]

[a] Health Protection Service of Harjumaa and Tallinn, Narva mnt. 48, EE-0001 Tallinn, Estonia
[b] Institute of Experimental and Clinical Medicine, Hiiu 42, EE-0016 Tallinn, Estonia

Received 2 February 1998, in revised form 29 April 1998

Abstract. The condition of drinking water sources, mainly shallow wells, was studied in North Estonia and evaluated from the point of view of health protection. Data for two villages are presented as an example.

The chemical and bacteriological analyses showed groundwater pollution with nitrates, iron, ammonia, etc. In one village 25% of the water samples and in the other 10% contained nitrates above the level permissible according to the drinking water standard.

Considering that the water samples of the studied wells did not meet the requirements of the Estonian Water Standard and the concentration of many of the chemical ingredients exceeded their permissible level, it is necessary to systematically control the groundwater wells in rural areas of North Estonia.

Key words: drinking water, water pollution, shallow wells, artesian wells.

The pollution of drinking water in Estonia with nitrogen compounds was repeatedly investigated by our group in the period of 1983–91 (Veldre et al., 1991a, b, 1993, 1996). The importance of the problem was stressed in connection with gastric cancer risk due to high concentrations of nitrates in drinking water (Fraser & Chilvers, 1981; Mirvish, 1983; Forman et al., 1985). High concentrations of nitrates in drinking water may cause infantile methemoglobinaemia and pathological changes in the human organism (Newberne & Nauss, 1980). Nitrates and nitrites in drinking water are in correlation with hypertonia (Heijden & Montizaan, 1988).

Our earlier studies revealed that groundwater in rural areas of North Estonia was considerably polluted, especially with nitrates. The most polluted regions were in northern and western Estonia because the water horizons in these regions

are insufficiently protected or without any protection due to the character of the karstland. For that reason the groundwater is under the influence of pollution from human activities. The insufficient quality of drinking water may cause various disturbances in human health.

The aim of our present study was to investigate the condition of shallow wells in northern Harju County from the point of view of health protection using a bigger number of different chemical and microbiological analytical methods than in our previous studies. In this paper data on the condition of groundwater wells of two villages, Ülgase and Rebala in the municipality of Jõelähtme in Harju County, are presented. These villages were chosen as a background to evaluate the influence of a planned depository of discarded materials at Jõelähtme and because they are typical villages for North Estonia.

MATERIAL AND METHODS

Water samples were taken from local wells twice in 1996: during the spring high water and in summer to characterize the dry period. In the village of Ülgase 19 drinking water sources were studied, among them one central well (OÜ Ülgase) with a depth of 110 m. Among the 18 wells of single homes 13 were shallow (depth from 2 to 6 m) and 5 were artesian wells (depth 10–103 m). In the village of Rebala 20 wells were studied, among them 15 shallow (depth 2–10 m) and 5 artesian wells (depth 15–100 m).

In all water samples organoleptical, chemical, and microbiological parameters were analysed. All the tests were chosen according to the Estonian drinking-water standard EVS 663:1995. Colour, odour, and transparency were tested organoleptically. Chemical analyses were used to assess pH value, alkalinity, hardness, chlorides, iron, ammonia, nitrites, nitrates, and permanganate consumption (in mg O_2/dm^3 $KMnO_4$). Microbiological tests were applied to detect coliform bacteria, thermotolerant coliform bacteria, and heterotrophic bacteria.

The aim of such a choice of tests was to characterize the pollution of drinking water sources with organic compounds from the point of view of health protection. All the analyses were carried out in the laboratory of the Health Protection Service of Harjumaa and Tallinn in accordance with the analytical methods accepted in Estonia.

RESULTS

First we studied the condition of the technical constructions of the wells and of the territory around them, and possible presence of pollution sources. Out of 14 shallow wells in the village of Ülgase the condition of 13 did not satisfy the requirements of health protection (old wells with insufficient framework, etc.).

There were no sanitary protection areas around the wells, close to the wells were animal farms, stables, dunghills, vegetable gardens, and various buildings. All this may influence the water quality. The shallow wells have not been cleaned for a long time. In May 1996 the water surface in many wells was only 0.3–0.5 m below the earth surface. These wells are located on the limestone plateau. The artesian wells had been built without project documentation and without sanitary protection areas around them (Table 1).

Table 1

Condition of wells in regard to the requirements of health protection

Condition	Village of Ülgase		Village of Rebala	
	shallow wells	artesian wells	shallow wells	artesian wells
Satisfying the requirements	1	0	1	2
Not satisfying the requirements:				
all wells	13	5	14	3
defective construction	12	0	13	0
bad condition of the framework	2	0	2	0
lack of a sanitary protection area	8	5	2	3

In the village of Rebala 14 shallow wells do not satisfy the requirements of health protection. The reasons are the same as in the village of Ülgase. Out of five artesian wells in the village of Rebala only two have been built in accordance with the requirements of health protection (Table 1).

The transparency of water in all the wells studied in the village of Ülgase was above 30 cm; the pH value (6–9), concentration of chlorides (as a rule below 100 mg/dm^3), and the hardness of water (below 250 mg $CaCO_3$/dm^3) were all within the limits permissible for high quality drinking water.

The water colour fluctuated from 10 to 130°. In artesian wells it corresponded to the requirements of the drinking water class "good" (≤15°) or "sufficient" (≤25°). In shallow wells the colour was much higher, sometimes it reached 100° and even more. There was a tendency that in spring the colour was more intense than in summer. The content of iron in the water of one shallow well and three artesian wells was twice as high as the limit for the quality class "sufficient" (1.0 mg/dm^3).

In evaluating the water quality special attention was paid to indicators of organic pollution. The concentration of ammonia in the wells of the village of Ülgase, as a rule, did not exceed 0.5 mg/dm^3, which is a value for good water quality. Only in two artesian wells it reached 1.05 mg/dm^3.

The content of nitrites was in most cases below the sensitivity of our analytical methods, which is 0.003 mg/dm^3. In our earlier studies we have obtained analogical results.

The level of nitrates fluctuated from <0.45 to 59.85 mg/dm^3. The concentrations of ammonia and nitrates, as well as permanganate consumption, in the water of shallow and artesian wells in both villages are presented in Table 2.

The results of the analyses of nitrates in drinking water were evaluated in accordance with the requirements of the quality classes of the drinking water standard (Table 3). In the village of Ülgase 13 samples belong to the quality class "very good" and 4 samples show insufficient quality of water.

Table 2

Variation of ammonia and nitrate content and permanganate consumption of drinking water

Characteristic	Village of Ülgase		Village of Rebala	
	shallow wells	artesian wells	shallow wells	artesian wells
Ammonia, mg/dm^3	0.05–0.72	<0.05–1.05	<0.05–6.79	0.06–0.97
Nitrates, mg/dm^3	0.45–59.85	<0.45–59.85	<0.45–67.50	<0.45–58.95
Permanganate consumption, mg O_2/dm^3 $KMnO_4$	4.00–15.52	1.44–12.48	3.28–23.00	2.88–9.60

Table 3

Results of water analyses for nitrate (mg/dm^3) compared with the requirements of the standard drinking water quality class

Village	Number of samples of quality class			
	very good <1.0	good 1.0–10.0	sufficient 10.0–45.0	insufficient >45.0
Ülgase	13	15	5	4
Rebala	3	11	16	10

Permanganate consumption fluctuated within wide limits (Table 2), being only slightly lower in the artesian wells than in the shallow wells. No significant difference was observed between water samples from spring high water and from the dry period. The results of the analyses for permanganate consumption are presented in Table 4.

Table 4

Results of water analyses for permanganate consumption (mg O_2/dm^3 $KMnO_4$) compared with the requirements of the standard drinking water quality class

Village	Number of samples of quality class			
	very good ≤1.0	good ≤2.0	sufficient ≤4.0	insufficient >4.0
Ülgase	0	4	7	26
Rebala	0	0	6	34

In the village of Rebala the transparency of water exceeded 30 cm. Only one artesian well made an exception (transparency 6–8 cm, iron 3.96–4.57 mg/dm^3). The colour of water fluctuated from 9 to 196°, in artesian wells it was 9–62°. The pH value corresponded to the demands of the drinking water standard.

The hardness of the drinking water in the village of Rebala was higher than in the village of Ülgase. The following results were obtained: 6 samples corresponded to the quality class "very good" (<250 mg $CaCO_3/dm^3$), 14 were "good" (250–350 mg $CaCO_3/dm^3$), 17 "sufficient" (350–500 mg $CaCO_3/dm^3$), and 3 samples were of "insufficient" quality (> 500 mg $CaCO_3/dm^3$).

In two shallow wells the concentration of ammonia exceeded its permissible limit. The content of nitrites in one artesian well (0.207 mg/dm^3) and in one shallow well (0.192 mg/dm^3) exceeded the permissible limit. Table 3 presents the distribution of water samples in different quality classes as to the content of nitrates. In the village of Rebala 25% of all samples fail to meet even the requirements of the quality class "sufficient". From the point of view of permanganate consumption the condition of well water is even worse. Table 4 demonstrates that in the village of Rebala only 6 samples met the requirements of the water standard quality class "sufficient", while 34 samples had insufficient water quality.

A comparison of the chemical analyses of the drinking water quality in both villages allows us to conclude that the water quality in the village of Rebala is worse than in the village of Ülgase (higher concentration of nitrates, permanganate consumption, and hardness of water).

According to the microbiological analyses the only well in the village of Ülgase corresponding to the requirements of the Estonian drinking water standard was the artesian well of OÜ Ülgase. The water quality of five wells (four shallow and one artesian) did not meet the requirements of the standard either in spring or in summer. In the others the water quality did not correspond to the requirements from time to time in some of the tests.

In the village of Rebala 15 wells were permanently polluted with coliform bacteria, 17 with heterotrophic bacteria, and 4 with thermotolerant coliform

bacteria. Coliform bacteria were regularly found in the water of seven wells, in the others only occasionally.

In most wells in the village of Rebala coliform and heterotrophic bacteria were found. Thermotolerant coliform bacteria were found seldom. The village of Rebala had only one artesian well and not a single shallow well where the water quality was good from the microbiological point of view.

CONCLUSION

In the villages of Ülgase and Rebala the main drinking water sources are shallow wells and a few artesian wells. The construction of the wells and the maintenance of their technical condition as well as the condition of their sanitary protection area do not correspond to the requirements of health protection. The depth of shallow wells is very small, they get their water from surface and subsurface water. These wells are strongly affected by the condition of the surrounding territory. In the water various organic substances from plants are often found. High permanganate consumption and ammonia concentrations are characteristic of the water. The artesian wells in the studied villages are of different depth and water quality. Out of 11 artesian wells only that of OÜ Ülgase satisfies the requirements of the drinking water standard. The water of other artesian wells often contains too much iron and its permanganate consumption is relatively high.

The concentration of nitrates in all the studied wells has decreased in comparison to 1991; nevertheless, it is high: in the village of Rebala 25% and in the village of Ülgase 10% of the wells contain more nitrates than their permissible limit.

Taking into account that in the water samples the concentration of nitrates as well as other indicators of pollution exceeded their permissible limits we recommend systematical control of drinking water quality in rural areas of North Estonia and taking necessary measures to prevent or diminish groundwater pollution in North Estonia.

REFERENCES

Forman, D., Al-Dabbagh, S. & Doll, R. 1985. Nitrates, nitrites and gastric cancer in Great Britain. *Nature*, **313**, 6004, 620–625.

Fraser, P. & Chilvers, C. 1981. Health aspects of nitrate in drinking water. *Sci. Total Environ.*, **18**, 103–106.

Heijden, C. A. & van der Montizaan, G. K. 1988. Nitrates in drinking water: Health effect and risk. *Hum. Toxicol.*, **7**, 53–54.

Mirvish, S. S. 1983. Intragastric nitrosamide formation and other theories. *J. Nat. Cancer Inst.*, **71**, 3, 629–647.

Newberne, P. M. & Nauss, M. 1980. Significance of environmental nitrates, nitrites and nitrosamines. In *Environ. Health Proc. 14-th Ann. Conf. Columbia, Miss., June 2–5 1980.* Columbia, Miss. S. A. 325, 3–15.

Veldre, I., Karlova, S. & Rannamäe, R. 1991a. Nitraadid põhjavees. *Eesti Arst*, 6, 416–419.

Veldre, I., Karlova, S. & Kerde, A. 1991b. Joogivee nitraadid: ökoloogia ja tervishoid. In *Eesti V Ökoloogiakonverentsi teesid 24–26. apr. 1991.* Tartu, 184–186.

Veldre, I., Rooma, M. & Karlova, S. 1993. Joogivee osatähtsus Eesti rahva ööpäevases nitraadikoormuses. *Eesti Arst*, 3, 166–168.

Veldre, I., Karlova, S. & Rannamäe, R. 1996. Elanike nitraadikoormus ja joogivee nitraatide probleem Eestis. In *Eesti teadlaste kongress. Ettekannete kokkuvõtted.* Tallinn, 339.

PÕHJA-HARJUMAA KOHALIKE JOOGIVEEALLIKATE VEE KVALITEEDI HINNANG

Rein RANNAMÄE ja Ingeborg VELDRE

1996. aastal uuriti tervisekaitse seisukohast joogiveeallikate olukorda Harjumaa Jõelähtme valla kahe küla – Ülgase ja Rebala – näitel. Keemilise ja bakterioloogilise analüüsi tulemusel selgus, et põhjavesi on saastunud põhiliselt nitraatide, raua ja ammooniumiga. Rebala külas ületab nitraatide sisaldus lubatud piirväärtuse 25 protsendis proovidest, Ülgase külas 10-s.

Silmas pidades asjaolu, et uuritud kaevude vesi ei vasta mitme näitaja osas Eesti joogivee standardi nõudeile, tuleks perioodiliselt kontrollida maaelanike joogiveeallikate seisundit Põhja-Harjumaal ja leida võimalusi saaste vähendamiseks.