INVESTIGATION OF ENVIRONMENTAL POLLUTION IN INDUSTRIALLY CONTAMINATED AREA WITH EXTENSIVE ANIMAL PRODUCTION

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SUMMARY

We examined quality of potable water in 20 wells, 3.5 to 14 m deep, of varying capacity in a village in industrially contaminated area with extensive animal production. Our investigations focused on common chemical and bacteriological indicators of contamination. In addition to that 71 elements were determined by the AAS method. The limits for heavy metals were exceeded in three wells (Ni in one, Sb in two and As in one). One or two chemical indicators of pollution were exceeded 10 wells, 3 in two well and 5 in one well. None of the wells could be considered completely safe from the bacteriological point of view.

Keywords: drinking water, environmental pollution, heavy metals, bacteriological quality

INTRODUCTION

Almost every country in the world faces problems with the quality of drinking water. Sources of drinking water are polluted by various human activities in many different ways. Some pollutants cause immediate problems but some can be seen only after longer period. Contamination of atmosphere results in accumulation of metals and toxic chemicals in the soil from which they can be leached to ground and surface water, particularly in regions exposed to acidic rains. Animal production and human wastes can contaminate water with pathogenic bacteria, viruses and protozoa and some macronutrients. Buildup of chemicals in organisms and a food chain may impair different processes in the body and contribute to cancer. In advanced countries the sources of drinking water are protected and those intended for mass consumption are frequently checked and, if necessary, treated (Ondrašovič et al., 1997). However, considerable number of people is still depended on individual sources the quality of which may be questionable and is not protected by regular disinfection.

The aim of the present study was to investigate the quality/pollution of individual water sources in an industrially polluted area with some extensive animal production and determine the safety of water used for drinking and preparation of food.

MATERIAL AND METHODS

Our investigations were carried out in the period of one year in a village (approximately 500 inhabitants) with extensive animal production, located in environmentally polluted region affected negatively by mining activities and processing of complex Fe and Cu ores. We examined water in 20 wells, 3.5 to 14 m deep, of varying capacity. The village is not connected to mass drinking water supply.

Our investigations were divided to chemical and microbiological part. The chemical examination included determination of pH, ammonium (NH_4^+), nitrites (NO_2^-), nitrates (NO_3^-), chlorides (Cl^-), phosphates (PO_4^{3-}), free chlorine (Cl_2), chemical oxygen demand (COD_{Mn}) and additional 71 different elements including heavy metals. Spectrophotometric methods were used for determination of ammonium, nitrites and phosphates (Nessler reagent; sulphanilic acid and N-(1-naphthyl)-ethylenediamine dyhydrochloride; ammonium molybdate, ascorbic acid, antimony potassium tartrate). Nitrates were determined by ion selective electrode (ORION Research), chlorides and free chlorine by titration (argentometric and iodometric, resp.) and chemical oxygen demand by boiling with potassium permanganate for 10 min. In addition to these determinations 71 elements were determined twice by the AAS method.

Microbiological examination included determination of colony counts at 22°C and 37°C on meat-peptone agar, coliform bacteria and *E. coli* on Endo agar at 37° and 43°C with confirmation by lactose fermentation.

RESULTS AND DISCUSSION

Results of AAS examination for some metals for which the respective national standard (Statutory order of SR No. 354/2006 of the Civil Code) has set maximum contaminant levels (MCL) are presented in Table 1. The results show that MCL were exceeded in three wells. Higher concentration of nickel (27 µg.l^{-1}) was detected in Well 6, of antimony in Well 16 (12 µg.l^{-1}) and of both antimony and arsenic in well 18 (8.6 and 19.0 µg.l^{-1}, resp.). However, considerable variations were observed between the wells. MCL for other metals of interest were not exceeded (Se, Ag). From among other metals for which limits are specified in the respective regulation (Mn, Al, Fe, Cu, Zn and Na only the acceptable level of iron (0.2 mg.l^{-1}) was exceeded in 15 wells. The highest concentration of Fe in Well 4 reached 0.460 mg.l^{-1}.

Tab. 1 Level of selected metals determined by the AAS method

Well No.	**Sb**	**As**	**Cr**	**Cd**	**Ni**	**Pb**	**Hg**
	MCL (µg.l^{-1})						
	5	**10**	**50**	**3**	**20**	**10**	**1**
1	0.52–0.72	0.70–0.81	0.05–0.53	0.130–0.080	11–12	0.05–0.06	<0.006–0.007
2	0.52–0.68	0.55–0.62	0.30–0.42	<0.018–0.018	7.8–8.6	0.03–0.05	<0.006–0.006
3	1.80–2.30	0.71–0.85	0.28–1.00	<0.018	13–15	0.01–0.04	<0.006–0.007
4	0.43–0.80	0,71–1.20	3.30–5.70	<0.018–0.018	3.7–5.3	0.06–0.17	0.010–0.03
5	0.41–0.61	0.45–0.81	0.18–1.30	0.056–0.063	8.2–12	0.09–0.14	<0.006–0.007
6	0.79–1.80	1.10–1.90	0.05–2.50	<0.018–0.018	16–27	0.03–0.04	<0.006
7	1.40–2.50	0.30–1.20	0.18–057	0.075–0.082	5.8–6.8	0.02–0.04	<0.006
8	0.35–1.10	0.62–1.50	3.30–5.60	<0.018–0.026	2.9–3.3	0.03	<0.006–0.03
9	0.20–1.20	0.39–0.77	1.60–1.80	0.018–0.030	7.9–8.0	0.03	<0.006–0.006
10	0.10–0.17	0.93–1.40	11.0–16.0	<0.018–0.018	1.7–2.6	0.02–0.04	0.007–0.008
11	0.11–0.25	1.90–2.00	6.30–4.80	<0.018– 0.037	2.0–6.6	0.02–0.03	<0.006–0.006
12	0.27–2.00	0.25–0.58	0.34–0.72	0.026–0.048	1.2–1.4	0.03–0.16	<0.006–0.007
13	2.00–1.00	1.10–1.10	0.15–1.00	<0.018–0.018	1.3–2.7	0.07–0.13	<0.006–0.010
14	1.20–2.60	0.82–1.50	0.11–0.45	0.018–0.063	1.3–3.1	0.06–0.43	<0.006
15	0.48–1.70	0.35–0.84	0.18–0.31	<0.018–0.026	0.9–3.4	0.02–0.09	<0.006

Table 1. Continuation

Well No.	Sb	As	Cr	Cd	Ni	Pb	Hg
	MCL (μg.l^{-1})						
	5	10	50	3	20	10	1
16	2.90–12.0	1.50–5.80	0.10–0.37	<0.018	0.6–3.2	0.02	<0.006
17	3.10–4.10	1.90–5.00	0.14–0,72	<0.018–0.018	1.2–4.3	0.03–0.06	<0.006
18	2.10–8.60	4.20–19.0	0.12–0.54	<0.018	1.3–3.1	0.02	<0.006
19	1.50–2.40	1.50–3.00	0.13–0.67	<0.018	1.2–2.4	0.02–0.06	<0.006–0.006
20	1.30–0.95	1.70–1.10	0.78–0.59	0.018–0.026	1.0–1.2	0.02	<0.006–0.008

MCL – maximum contaminant level

Metals are inorganic substances that occur naturally in geological formations. Some are essential for life and are naturally available in our food and water. In addition to them, drinking water may contain metals which cause chronic and acute poisoning. Contamination of water resources by poisonous metals occurs largely through human activity. These activities include industrial processes, such as mining and processing of metal ores, agricultural activities, discarding of wastes in landfills (ALLOWAY, AYRES, 1993).

Arsenic in drinking water causes bladder, lung and skin cancer, and may cause kidney and liver cancer. Arsenic harms the central and peripheral nervous systems as well as heart and blood vessels, and causes serious skin problems. It also may cause birth defects and reproductive problems (NRDC, 2001).

We have become interested in the concentration of antimony in drinking water since 1998, on the basis of WHO recommendation, particularly with respect to its carcinogenic effects. Continuous exposure to antimony may result in lung diseases, heart problems, diarrhoea, vomiting and stomach ulcers (ATSDR, 1992).

Nickel concentrations in groundwater depend on the soil use, pH, and depth of sampling. The average concentration in groundwater in the Netherlands ranges from 7.9 μg.l^{-1} (urban areas) to 16.6 μg.l^{-1} (rural areas). Acid rain increases the mobility of nickel in the soil and thus might increase nickel concentration in groundwater (ICPS, 1991). In groundwater with a pH below 6.2, Ni concentrations up to 980 μg.l^{-1} have been measured (RIVM, 1994). Allergic contact dermatitis is the most prevalent effect of nickel in the general population. Soluble Ni exposure increased risk of cancer.

Our chemical examination focused on inorganic indicators of contamination of water with wastes (pH, ammonium, nitrites, nitrates, chlorides, phosphates and chemical oxygen demand), and some efforts to alleviate the potential consequences of such contamination (free chlorine).

The pH value in well ranged from 6.03 to 7.68 so there is no indication of excessive acidification in the area. Of all remaining chemical parameters determined in water ammonia, phosphates and free chlorine were exceeded each only in one well at one sampling. Nitrites exceeded the acceptable level (0.1 mg.l^{-1}) in three wells, in each only in one sample. Out of 20 wells only in 7 none of the examined parameters were exceeded but one of these 7 wells showed increased concentration of antimony. Mean levels of nitrates, chlorides and chemical oxygen demand for the period of examination are shown in Fig. 1 and 2. The acceptable limit for nitrates in drinking water is 50 mg.l^{-1}, for chlorides 100 mg.l^{-1} and for COD_{Mn} 3 mg.l^{-1}. On the basis of chemical examination Well No. 6 appeared to be most contaminated as in this well 5 of the determined chemical parameters were exceeded.

Determination of plate counts of selected micro-organisms revealed that total coliforms were present in all wells (in 10 ml volume) and in every one of them *E.coli* were detected at least at one sampling. This indicates that none of the wells could be considered safe from the bacteriological point of view. Moreover, in 8 wells we detected free chlorine, in one (No.7) above the permissible level (0.3 $mg.l^{-1}$), which suggested an individual, although unsuccessful effort to make the water safer by chlorination.

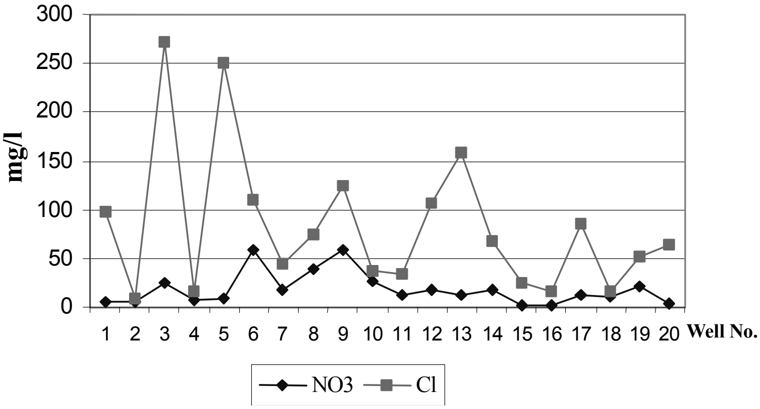

Figure 1. Mean concentration of nitrites and chlorides in examined well

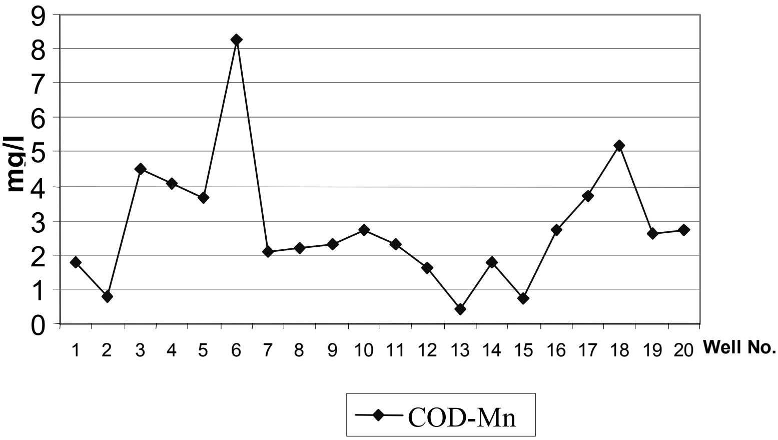

Figure 2. Mean values of COD_{Mn}

Agricultural production in the respective area resulted obviously in general contamination of soil and groundwater. Although the number of families keeping some farm animals has decreased recently, pigs and cattle are still kept and their manure is applied to gardens and adjoining fields. Moreover, the rules for protection of individual sources of drinking water (STN 75 5111, 1993) have not been observed which contributes to the unfavourable situation.

Similar situation was reported in the study conducted by da Silva Alberto (2002), who observed similar situation in another location in SR and observed relationship between precipitations and plate counts of coliform bacteria and E.coli in individual sources of drinking water.

CONCLUSION

Results of examination of individual water sources in industrially contaminated area with extensive animal production showed that the levels of heavy metals were exceeded only sporadically only in three wells and the maximum values were not even twofold of the maximum contaminant level except for Sb on one occasion (2.5-fold). However, the general contamination of the area due to extensive animal production and failure to comply with rules for protection of water sources caused that none of the wells was completely safe from the microbiological point of view.

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