EVALUATION OF DRINKING WATER SOURCE IN DEPENDENCE ON SEASON AND GROUNDWATER QUALITY

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INTRODUCTION

Quality of drinking water depends on location of the source and pollution of the respective region originating from industrial but also agricultural production. One can assume that both quantitative parameters, i.e. capacity of the source, and qualitative properties are affected also by climatic conditions, particularly temperature and precipitations, which vary throughout the year. The submitted study investigates the relationship between results of chemical and microbiological examination in relation to respective climatic conditions and the quality of ground water.

MATERIAL AND METHODS

Material

The investigated water source was located at a distance of 820 m from a village and approximately 185 m above its location Geomorphologically, the relief of the location can be characterised as hilly. Climatic-geographical type of the area is hollow basin with moderately warm climate. The soil type is sabulous clay.

Methods

Microbiological examination

The microbiological examination included determination of colony counts at 22 °C and 37 °C and coliform bacteria in accordance with the STATUTORY ORDER of SR No. 354/2006 and methods by ŠTĚPÁNEK et al. (1982) and HOLODA et al. (2006).

Chemical examination

Of the chemical parameters of drinking water quality we determined pH, ammonium ions, nitrates, chlorides, phosphates, free chlorine and COD_{Mn} according to respective ISO standards, HORÁKOVÁ et al. (1986) and by HACH (1992).

Statistical evaluation of results

We calculated parameters of regression line on the basis of normal equations. The evaluation concerned the potential influence of temperature and precipitation on the plate counts of selected micro-organisms. It was logical to assume that the plate counts (CFU) depend on the variable Y. The regression line equation assumes general form $y = a + b.x$. According to this equation we can, on the basis of empiric values of X, estimate the values of Y. Thus in our case, using the real values of temperature or precipitations (X), we could estimate the theoretical level of plate counts CFU.

The scale of relationship tightness according to determination coefficient (R^2), expressed in per cent and read from the scale by GROFÍK et al. (1987) is (at small rounding) as follows: $R^2 < 10\%$ low relationship, $10\% \leq R^2 < 25\%$ moderate relationship, $25\% \leq R^2 < 50\%$ considerable relationship, $50\% \leq R^2 < 80\%$ tight relationship, $80\% \leq R^2$ very tight relationship.

The coefficient of determination expresses relative proportion of the influence of independent variable X on dependent variable Y (POLAČEK M., 1996).

RESULTS AND DISCUSSION

The water source was constructed for the purpose of supplying an Agrotourism centre with drinking water. In the beginning it was used for construction purposes which guaranteed preliminary clean up and adjustment of the internal space of the well. However, the results of subsequent microbiological and some chemical examinations failed to comply with the requirements on drinking water.

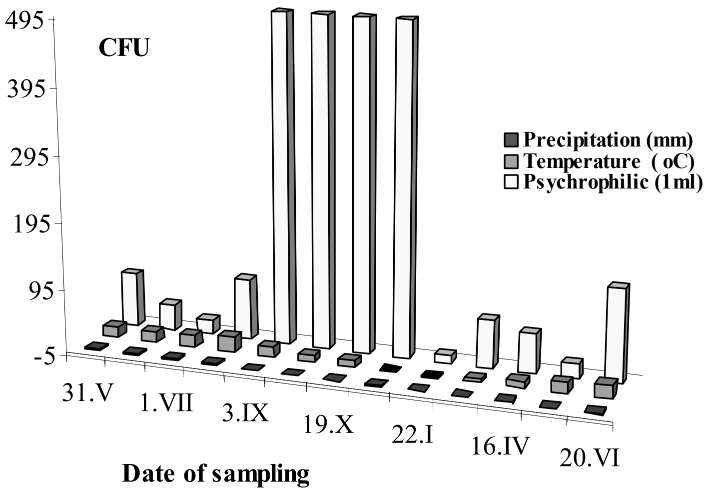

Figure 1. Plate counts of psychrophilic micro-organisms (CFU_{22}) at microbiological examination of drinking water source between May 31, 2001, and June 20, 2002

Figure 1 shows plate counts of psychrophilic micro-organisms (CFU_{22}) determined between May 31, 2001, and June 20, 2002. Psychrophilic plate counts reflect general contamination of water (ONDRAŠOVIČOVÁ, 2005). Maximum acceptable level of these bacteria in drinking water intended for mass consumption is 200 $CFU.ml^{-1}$ (STATUTORY ORDER No 354/2006). Fig. 1 indicates that between September and November 2001, when 4 samples were examined, the limit was exceeded considerably and reached even 500 CFU in 1 ml of water.

When evaluation the two additional groups of micro-organisms, namely mesophilic and coliform we also observed that their plate counts were increased similar to psychrophilicplate counts (Tab. 1).

Table 1. Plate counts of mesophilic micro-organisms (CFU_{37}) at microbiological examination of drinking water source between May 31, 2001, and June 20, 2002

	May 31	June 26	July 1	July 13	Sept. 3	Sept. 30	Oct. 19	Nov. 27	Jan. 22	March 12	April 16	May 6	June 20
Precipitations mm)	2.2	1.9	2	2.6	0.3	0.4	0	0.8	0.7	0.2	2.1	0.3	1.3
Temperature (°C)	16.1	15.9	18.3	22.3	14.1	9.2	9.6	–0.8	–3.1	4.8	9.8	16.1	20.4
Mesophilic (1ml)	52	36	18	114	58	58	116	111	4	23	13	7	48

The requirement on plate counts of total coliforms (Tab. 2) concerning drinking water intended for mass consumption (absence of coliforms in 100 ml of examined water) was met only in one case. The examined source failed to meet even the less strict requirement on water for individual consumption (absence of coliforms in 10 ml of water) (ONDRAŠOVIČ et al., 1996).

Table 2. Plate counts of total coliforms at microbiological examination of drinking water source between May 31, 2001, and June 20, 2002

	May 31	June 26	July 1	July 13	Sept. 3	Sept. 30	Oct. 19	Nov. 27	Jan. 22	March 12	April 16	May 6	June 20
Precipitations (mm)	2.2	1.9	2	2.6	0.3	0.4	0	0.8	0.7	0.2	2.1	0.3	13
Temperature (°C)	16.1	15.9	18.3	22.3	14.1	9.2	9.6	–0.8	–3.1	4.8	9.8	16.1	20.4
Total coliforms (1ml)	98	62	12	21	25	57	50	48	0	6	28	5	23

Figure 2 shows statistical evaluation of plate counts of psychrophilic bacteria in dependence on environmental temperature by means of the coefficient of determination which for psychrophilic micro-organisms corresponded to R^2 0.0693, or 6.9%, i.e. low relationship to temperature. Similar results were obtained for mesophilic micro-organisms, with R^2 equal to 0.0042, and for coliforms with R^2 equal to 0.01141.

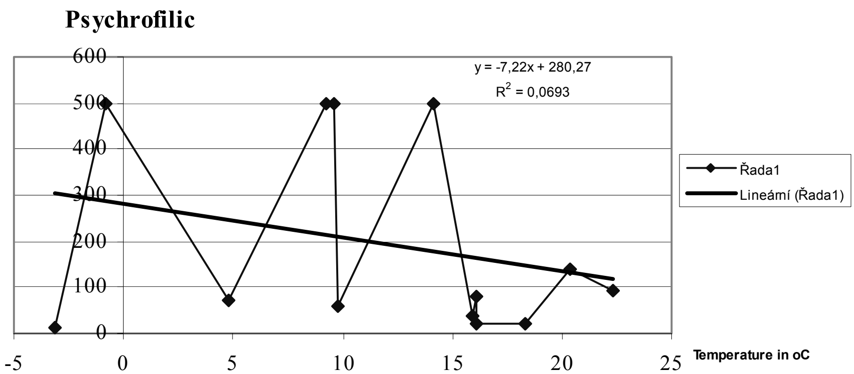

Figure 2. Relationship between temperature and plate counts of investigated groups of micro-organisms

On the basis of presented results and their subsequent evaluation which confirmed contamination of the water source, we carried out examination of water quality in the location taking all samples on the same day (July 27, 2002). In addition to village Varhaňovce, which served for comparison, we examined additional 11 water sources by examining in respective villages individual water sources (wells) and also water from public water main supplying the village (Tab. 3). The aim of this stage was to evaluate quality of ground water in the respective location. The results obtained (high plate counts of micro-organisms) point to contamination of ground water.

Table 3. Plate counts of investigated groups of micro-organisms in water samples from sources in selected villages

Place of sampling	Source	Psychrophilic (1 ml)	Mezophilic (1 ml)	Coliforms (10 ml)
Varhaňovce	Well	237	119	285
	Water main	117	55	64
Brestov	Well	NC	NC	NC
	Well	295	184	NC
	Water main	0	5	12
Bunetice	Well	NC	405	NC
	Well	NC	279	NC
Ortaše	Well	65	16	260
Šarišské Bohdanovce	Well	NC	396	NC
	Well	138	196	300
Vtáčkovce	Well	NC	NC	NC
	Well	300	360	144
	Stream	455	254	NC

NC – uncountable

The presence of ammonium ions in water is considered a proof of fresh decomposition processes. They are harmful due to their direct effect on organism and also serve as indicators of immediate pollution of water with organic substances including urea, faeces and similar, which increases risk to organisms. Higher concentrations of NH_4^+ in ground water may result from chemical and biochemical reduction of nitrates if they are of organic origin (ĎUREČKO, 2000). The maximum acceptable level in drinking water (0.5 $mg.l^{-1}NH_4^+$) was exceeded in all samples which is indicated by mean value of this parameter reaching 0.9 $mg.l^{-1}NH_4^+$ (Tab. 4). Determination of the level of NO_3^- showed that the maximum value detected was 23.0 $mg.l^{-1}$ which is below the maximum acceptable limit 50 $mg.l^{-1}NO_3^-$. Results of chemical oxygen demand only in 3 out of 13 cases corresponded to the requirement, i.e. were below 3 $mg.l^{-1}$. According to the findings for Cl_2, water from public water main in Brestov was disinfected which was also reflected in microbiological findings for this particular water source (Tab. 3).

Table 4. Results of chemical examination of sources of drinking water in the investigated location ($mg.l^{-1}$)

Place of sampling	Source	pH	NH_4^+	NO_3^-	Cl^-	PO_4^{3-}	Cl_2	COD_{Mn}
Varhaňovce	Well	6.4	0.83	7.0	111.1	0.22	0	3.4
	Water main	65	0.81	5.3	11.9	0.19	0	2.9
Brestov	Well	6.1	0.81	10.0	23.8	1.84	0	3.1
	Well	6.1	0.88	9.9	24.8	2.06	0	4.3
	Water main	6.5	0.77	3.6	7.5	0.24	0.29	2.4
Bunetice	Well	6.2	0.89	23.0	14.3	0.34	0	3.2
	Well	6.1	0.86	3.0	35.7	1.50	0	4.8
Ortaše	Well	6.7	0.68	5.3	44.7	0.03	0	3.1
Šarišské Bohdanovce	Well	6.9	0.75	19.0	184.6	0.11	0	3.9
	Well	6.7	0.84	2.3	198.5	0.21	0	3.9
Vtáčkovce	Well	6.4	1.71	4.5	5.6	0.21	0	2.4
	Well	6.2	0.94	6.1	151.8	0.11	0	3.1
Range		6.1– 6.9	0.68–1.71	2.3–23	5.9–198.5	0.03–2.06	–	2.4–4.8
Mean		6.4	0.90	8.25	67.8	0.59	–	3.4
Vtáčkovce	Stream	6.4	0.79	7.4	35.7	0.11	0	4.0

CONCLUSION

Results of examination of water in the village Varhaňovce showed that despite minimum possibility of contamination of the source from the outer environment with regard to its location, water from this source did not comply with the basic chemical and microbiological requirement on drinking water. Statistical analysis performed by means of the coefficient of determination indicated that environmental temperature had minimum effect on microbiological findings when considering examination of 13 water sources.

Results of examination of additional 12 water sources in the location from the microbiological and chemical point of view point to pollution of ground water in the respective area.

ACKNOWLEDGEMENT

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