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CEMETERIES - A POTENTIAL RISK TO GROUNDWATER

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ABSTRACT

Cemeteries are generating source of environmental impacts among which is featured the risk of ground water contamination by microorganisms that proliferate during the process of decomposition of bodies. The main objective of this work was to monitorate the bacteriological quality of the water from the water table in three cemeteries chosen in accordance with geological and hydrogeological criteria: Vila Formosa and Vila Nova Cachoeirinha, located in the city of São Paulo and Areia Branca in the city of Santos. These cities are situated in the state of São Paulo, Brazil. A total of 67 samples were collected through 36 piezometers installed in the internal area of the above mentioned cemeteries; and were analysed between january and december of 1989. The chosen microorganisms for this study are indicators of fecal contamination, of one pathogenous, besides, two groups of bacterias , degradators of organic material. The results encountered showed that the hygienic and sanitary conditions of the studied waters are unsatisfactory.

KEYWORDS

Cemeteries; groundwaters; coliforms; streptococci; sulfite reducer clostridia; proteolitic and lipolitic bacterias; Salmonella; bacteriological contamination.

INTRODUCTION

Cemeteries are a generating source of environmental impacts presenting the risk of contamination of groundwater by microorganisms that proliferate during the process of decomposition of corpses and by later use of these water by the populations. If it is considered, in a general way, that the location of the cemeteries don't take into account geological and hydrogeological aspects, and because of inadequate construction, they constitute a potential risk for groundwaters. Consequently, this, by itself, presents the unquestionable necessity of greater care with the localization and operation of cemeteries.

Our concerns are with the groundwaters of the water table, being more exposed to biological contamination and susceptible of being captured by shallow wells or sources by the population of low income.

"Mulder (1954) and Bower (1978)" registred several historic cases of the contamination of groundwater that was destined to human consumption, by typical liquids comming from the putrification of bodies.

Our study constitutes the monitoring of the bacteriological quality of the

water table in the internal region of three cemeteries chosen in accordance with geological and hydrogeological criteria- Vila Formosa and Vila Nova Cachoeirinha, located in the city of São Paulo and Areia Branca in the city of Santos. These cities are situated in the state of São Paulo, Brazil.

The objective of the monitoring was to determine if the refered cemeteries are a risk to the water table.

GEOLOGY

The principal criteria used in the choice of the cemeteries was geological. Areas with distinct geological characteristics were selected to evaluate the type of contamination process, with respect to lithology.

In Vila Formosa, tertiary sediments from the São Paulo basin predominate , where the alternation of lenses and layers of varying thickness and grain size is frequent.

In Vila Nova Cachoeirinha, the soil is derived from the alteration of granite being predominantly, with levels more clay rich.

In Santos, as in all of the "Baixada Santista", quaternary sandy, marine sediments with high porosity and permeability predominate. In the coastal regions, the problem associated with cemeteries tend to be manifested in a more intense form, due to the shallow depth of the water table and its fluctuations with sea leval. In the specific case of the Areia Branca cemetery the water table level was encountered at a depth that varied between 0,60 and 2,2 meters.

One other criteria was used in the choice of locations for the study was the existence of space to conduct geophysical survey. Only the Areia Branca cemetery did not meet this requirement.

GEOPHYSICS

The application of the geophysical methods supplied data to supplement the geological data, such as depth to the water table and rock type and to help in the localization of sampling wells and piezometers.

To attain the depth to water and rock type data, resistivity methods were utilized, through the use of vertical electric soundings. These detected the water level between 4 and 12 meters in the Vila Formosa cemetery, and between 4 and 9 meters in the Vila Nova Cachoeirinha cemetery.

To assist in the choise of localizations, the electromagnetic induction method was used, through the use of electromagnetic profiles. The two methods cited are intimately related to the resistivity and/ or conductivity of the subsoil materials, and these properties depend basically on the quantity and quality of the water that satured them. The anomalous values of water conductivity indicate the presence of contaminants agents. In this particular case the anomalies are the result of mineral salts and other substances liberated with the decomposition of bodies, and not through the presence of bacterias and virus.

SAMPLING WELLS AND PIEZOMETERS

At the locations indicated through geophysical interpretation, sampling wells and piezometers were implanted with a dual purpose: measurement of the static water level for groundwater flow determinations, and the collection of samples of aquifer water to determine the level of contamination.

To construct the sampling wells and piezometers a 4" diameter hand auger was used, and the drill cased by PVC tubing 3" in diameter. These casing were grooved horizontaly with openings of 2 milimeters in at last one meter lenght. The grooved portion of the tube was wrapped with a screen of inert material to

reduce the oppenings. The annular space, was filled with gravel as a pre-filter and above this, by the original soil material removed from the borehollе and around the superior part of the tube, a sanitary protection was constructed. Figures 1 and 2 show respectively the plan of the piezometers installed in the mentioned cemeteries, and a piezometer, located in the Areia Branca cemetery.

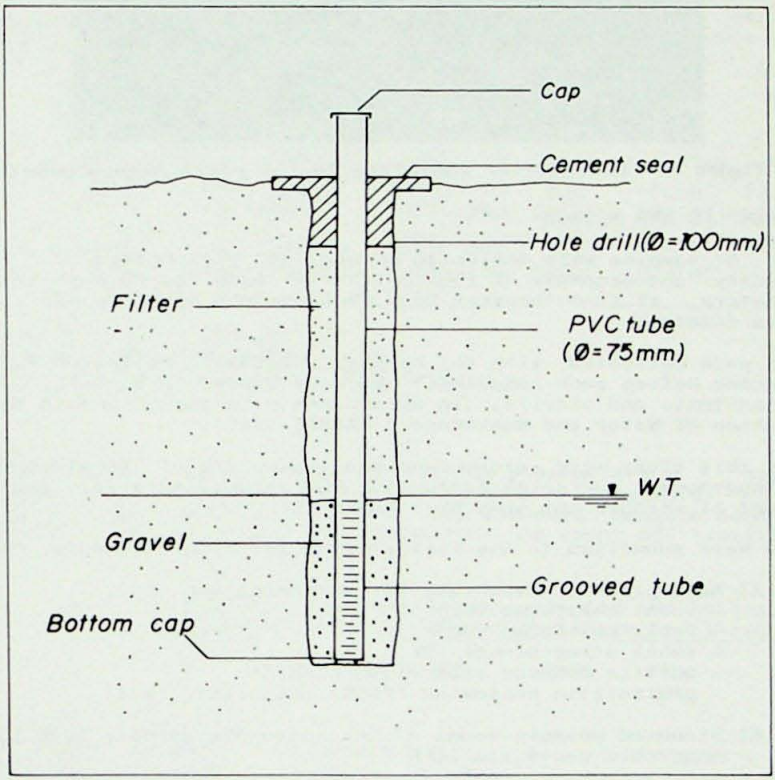

Figure 1 - Installed Piezometers design

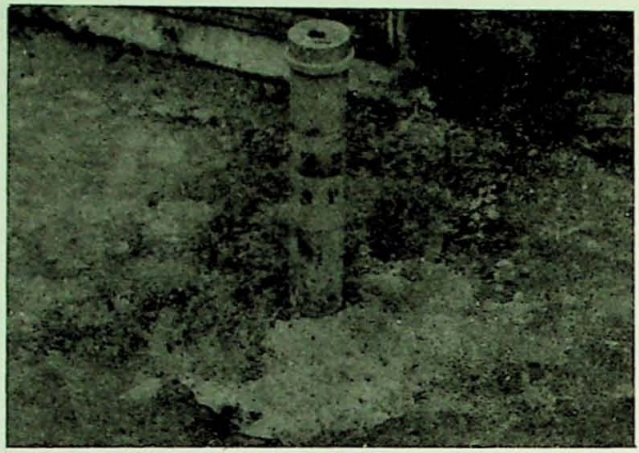

Figure 2 - APiezometer installed in the Areia Branca cemetery

SAMPLES AND METHODS

A total of 67 samples were collected through 36 piezometers and analysed between january and december of 1989. Of these samples, 29 were from the Vila Formosa cemetery, 11 from the Vila Nova Cachoeirinha cemetery and 27 from the Areia Branca cemetery.

The samples were collected with the help of a metallic collector tube, washed and desinfected before each sampling, and were stored in 5 liter plastic flasks, non-toxic and sterile, in accordance with the "Standard Methods for the Examination of Water and Wastewater" (APHA, 1985).

Chosen for this study were microorganisms indicators of fecal contamination of one pathogenous, bacterial degradators of organic material, and standard measure count of aerobic and anaerobic bacteria.

The samples were submitted to the following bacteriological tests:

A) Multiple Tube Technique for determination of:
   - total coliforms (CT)*
   - fecal coliforms (CF)*
   - fecal streptococci (SF)*
   - sulfite reducer clostridia (CSR)**
   - proteolitic bacterias (PROT) (Lennette, 1974)

B) Standard measure count of heterotrophic aerobic (CPH 1) and anaerobic bacterias (CPH 2)*

C) Salmonella study **

D) Coliphages study (Isbsiter et al., 1983)

E) Lipolitic bacteria study (LIPO)***

* - Standard Methods for the Examination of Water and Wastewater (16th ed., APHA, 1985)
** - Standard Techniques CETESB - NT-08 (1978)
*** - Compendium of Methods for the Microbiological Examination of Foods (2nd ed., APHA, 1976)

RESULTS AND DISCUSSION

The encountered results concerning the index of fecal contamination (with the exception of the coliphages) and of organisms used as indicators of the presence of organic material, show that the hygienic and sanitary conditions of the studied waters are considered unsatisfactory (Table 1).

Table 1 - Maximum, minimum and geometric midia valours of different bacteriological indicators from the three cemeteries

	CAB			CVF			CVNC		
indic.	max.	min.	M.G.	max.	min.	M.G.	max.	min.	M.G.
CT	1600	2	58	1600	2	14	1600	27	163
CF	1600	2	5	300	2	3	7	2	2
SF	1600	2	55	1600	2	8	1600	2	8
CSR	1600	2	21	240	2	14	27	2	7
PROT	1600_5	23	431	1600_4	2	268	9000_3	220	1018
CPH 1	$81x10^5$	700	14699	$71x10^4$	200	9018	$53x10^3$	2800	10821
CPH 2	$38x10^4$	2	4049	1200	130	675	$16x10^4$	440	16383
LIPO	$12x10^5$	80	6433	1500	75	2520	$36x10^3$	160	3942

CAB - Areia Branca cemetery
CVF - Vila Formosa cemetery
CVNC- Vila Nova Cachoeirinha cemetery

In the correlation study between the various piezometers, significant correspondence was observed between the three indicators of fecal contamination, as well as between the standard measure count of the heterotrophic aerobic and anaerobic bacterias and count of lipolitic bacteria (Table 2).

Table 2 - Matrix correlation between studied indicators, considering total data of the three cemeteries.

	CT	CF	SF	CSR	PROT	CPH1	CPH2
CF	0.387**						
SF	0.527*	0.288***					
CSR	0.323**	0.807*	0.335**				
PROT	0.063	-0.060	0.102	-0.070			
CPH1	-0.038	-0.038	0.016	0.086	0.046		
CPH2	-0.099	-0.083	0.148	0.056	0.002	0.295***	
LIPO	-0.052	-0.014	0.038	0.119	0.007	0.789*	0.698*

*p 0.001 ** p 0.01 *** p 0.02

In the comparison of the bacteriological results in relation to the three cemeteries, it was verified that the proteolitic bacterias and the heterotrophic anaerobic bacterias were in a greater number at the Vila Nova Cachoeirinha cemetery. On the other hand, the number of the heterotrophic aerobic and lipolitic bacterias were in greater number at the Areia Branca cemetery (Figure3) . This is probably due to the lithologic differences and depth to water table in the area of these cemeteries.

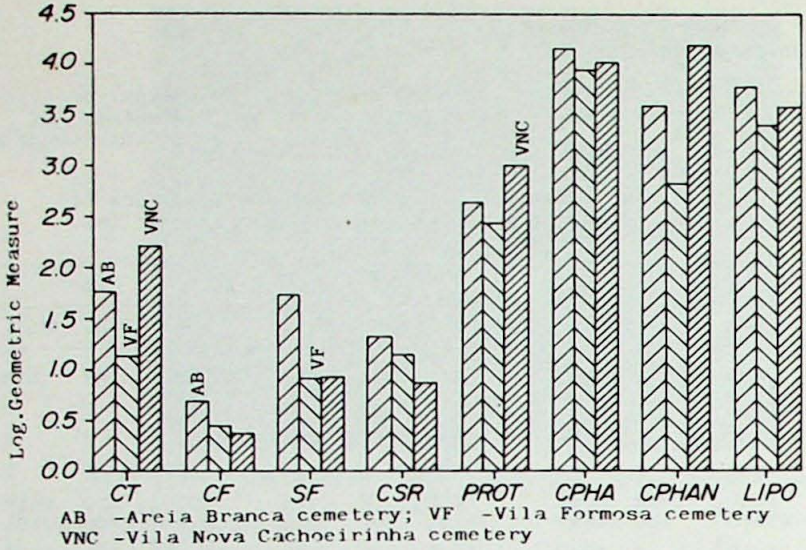

Figure 3 - Bacteriological data

From the analysis in the Table 1, it is shown that the Vila Formosa cemetery had the lowest levels of total coliforms, fecal streptococci, proteolitic bacteria, standard measure count of aerobic and anaerobic bacterias, as well as lipolitic bacteria. This could indicate that the lithology present in this cemetery acts as a natural filter, retaining the microorganisms and organic material.

The proteolitic and lipolitic bacterias are related to the process of decomposition of animal and vegetal organic material. Studys done in clean wells revealed that these types of microorganisms are encountered in low quantities or are absent. As higher levels of these bacterias were detected in the water table of the three cemeteries, they probably are derived from the process of decomposition, during with occurs a great proliferation of microorganisms. It is also worth mentioning that the water samples collected at the three cemeteries had a nauseating smell, which can be an indicator of contamination by corpses.

The detection of fecal streptococci and sulfite reducer clostridia in the majority of the samples, and the absence of fecal coliforms in many of the samples, appears to show that these two bacterias should be more elevated for the evaluation of groundwater from the sanitary point of view, which is in accordance with the results encountered by Alhjjar et al. (1988).

Concerning Salmonella, this pathogenous was detected in only one piezometer in the Vila Formosa cemetery. To show the risk of the presence of patogenic microorganisms in groundwaters, there has also been utilized a study of this type, in which bacterias responsable for typhoid fever and gastro-intestinal infections were encountered.

As for coliphages, which are a virus that are parasitic to bacterias of the coliform group, and can be utilized as indirect indicators of the presence of patogenic microorganisms, no were detected in the samples of water collected from the three cemeteries. This can result from the fact that these virus can be more easily fixed to soil particles than the bacterias, and, consequently, are not carried to the water table.

CONCLUSION

Cemeteries are a potential risk to groundwater which can transform into a real risk in the implantation of these constructions does not obey the previous geologic and hydrogeological studies.

From the bacteriologic point of view, the higienic and sanitaries conditions of the waters of the water table in the cemeteries of Vila Formosa, Vila Nova Cachoeirinha and Areia Branca were considered unsatisfactory. Therefore, the three cemeteries a real risk for these waters.

The study revealed that the bacteriologic quality of the groundwaters depend on the soil type and the depth to the water table.

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