WATER QUALITY OF THE RURAL PROPERTIES SITUATED IN CORREGO RICO WATERSHED, JABOTICABAL – SP

(QUALIDADE DA ÁGUA EM PROPRIEDADES RURAIS SITUADAS NA BACIA HIDROGRÁFICA DO CÓRREGO RICO, JABOTICABAL – SP)

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SUMMARY

Water is an important vehicle for transmitting diseases, thus rural populations with no access to public sanitation are more susceptible to consumption of contaminated water. So the objective was to characterize the quality of water consumed in farms located in the region of Jaboticabal-SP during both rainy and dry periods. Human and animal drinking water, as well as irrigation water samples were collected from 29 farms. *Escherichia coli*, mesophilic heterotrophs, nitrate and turbidity were determined for the water samples. Under current Brazilian legislation, supply and drinking water were the most contaminated. About half of the farms had water unfit for human consumption, mainly due to the presence of *Escherichia coli*. There was no difference in contamination levels between the rainy and dry seasons.

KEY-WORDS: *Escherichia coli.* Rural properties. Public health. Water quality.

RESUMO

A água é um importante veículo de transmissão de doenças, dessa forma, populações, como da zona rural, que não possuem acesso ao saneamento público estão mais susceptíveis ao consumo de água contaminada. Sendo assim, o objetivo desse trabalho foi caracterizar a qualidade de água consumida em propriedades rurais situadas na região de Jaboticabal-SP durante os períodos de chuva e seca. Foram visitadas 29 propriedades rurais e colhidas amostras da água de consumo humano e animal e água usada na irrigação, nas amostras foram analisadas presença de *Escherichia coli*, populações de microrganismos mesófilos heterotróficos, turbidez e concentração de nitrato. De acordo com a legislação brasileira, verificou-se que os pontos de maior comprometimento devido à contaminação da água foram a fonte de abastecimento e consumo humano, aproximadamente metade das propriedades apresentaram água imprópria para o consumo humano principalmente devido à presença de *Escherichia coli*. Não foi verificada diferença nos níveis de contaminação entre os períodos de chuva e estiagem.

PALAVRAS-CHAVE: *Escherichia coli.* Propriedades rurais. Qualidade de água. Saúde pública.

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INTRODUCTION

Since water is the most important natural resource in the world, its use for human consumption poses a significant health risk for society due to transmission of pathogens and other harmful substances (GERMANO & GERMANO, 2001).

Waterborne diseases and infections related to poor sanitation are important contributors to the outbreak of diseases and death worldwide (PRÜSS & HAVELLAR, 2001; SOBSEY, 2006). They are also responsible for the high mortality rate of individuals with low resistance, especially the elderly and children under 5 years old (OPS, 2000). These diseases, as well as its consequences on the population health, have economic costs resulting from patient treatment and the loss of working days (ELIMELEC, 2006; KARANIS, 2006).

In the United States, from 1991 to 1998, there were 230 reported waterborne outbreaks, affecting approximately 443,000 people (CRAUN et al., 2002). Still in the USA, a report identified the occurrence of 31 outbreaks of waterborne diseases in 19 states that affected 1,020 people and caused seven deaths (BLACKBURN et al., 2004).

In the United Kingdom, it has been found that 100% and 63% of the wells and springs, respectively, were not within the microbiological standards required for drinking water (FEWTRELL & GODFREE, 1998). On land properties in northeastern São Paulo, it has been verified that 90% from the samples of water used in milk production were also not within the microbiological standards required for potable water (AMARAL et al., 1995).

In the tropics, water contamination increases during the rain season, there are many evidences that the high rainfall rate and its runoff are significant events that contribute to increase the risk of waterborne disease epidemics (CURRIERO et al., 2001; NAUMOVA, 2006).

Given that the rural population is more prone to the consumption of contaminated water due to poor access to public sanitation, the objective of this study was to evaluate the water quality of several rural properties located in the watershed of Córrego Rico em Jaboticabal, SP.

MATERIAL AND METHODS

The area of the study is linked to the Watershed Committee of Mogi Guaçu River, and part of the Córrego Rico watershed (from the springs of Tijuco and Rico in Monte Alto to their confluence in Jaboticabal – SP). Water samples were collected from 29 farms randomly chosen, during the rain and dry seasons.

The sampling points were at water supply (well or spring), human and animal consumption points and water used for irrigation, when that was the case. A total of 164 samples were analyzed, and for each period 29 samples of the supply water, 29 samples of drinking water, 5 samples of water used to irrigate vegetables that can be eaten raw and 10 samples of water used for watering animals. Microbiological analysis was performed to determine the most probable number (MPN) of *Escherichia coli* in 100 mL of water (chromogen/fluorogenic hydrolysable substrate method) and mesophilic heterotrophic microorganisms (using the standard plate count) and the results were expressed as colony forming units (CFU) (APHA, 1992). In addition to the microbiological analysis, turbidity (APHA, 1992) was measured using the Turbidimeter Hach Model 2100 A, the results were expressed as Nephelometric Turbidity Unit (NTU), and nitrate concentration was determined by the cadmium reduction method using the Spectrophotometer DR 2010 and the results were expressed as milligrams per liter (HACH, 1991).

Water quality standard adopted was defined by Portaria N^{o}518, Ministério da Saúde on 25/03/2004 for water fit for human consumption (BRASIL, 2004), and resolution n^{o} 357 by Conselho Nacional do Meio Ambiente (CONAMA), on 17/03/2005, for water used to irrigate vegetables that can be eaten raw and for watering animals (BRASIL, 2005). The different quality standards for the water are shown in Table 1.

The analysis ANOVA was performed to check for significant differences between the rain and dry season, when the assumptions of normality and homoscedasticity were met. When the assumptions were not met, we used the nonparametric Kruskal-Wallis.

RESULTS

Approximately 50% of the samples were not within the standards for drinking water, due to the presence of *Escherichia coli* during both periods, rain and dry seasons. The heterotrophic mesophilic microorganism populations were also above the standards required for drinking water (Table 2).

The presence of *E. coli* in drinking water occurred especially because of contamination at the source, 10 farms during the rain and dry season had both, the supply and drinking water points, already contaminated. However, the contamination does not always happen at the supply source, it may occur also during the course of the water to the point of human consumption as seen in four and two farms, during the rain and dry seasons, respectively (Table 3).

The maximum turbidity value allowed is 5 NTU (BRASIL, 2004). From all the analyzed samples, only three were outside the standard range according to the current legislation, all three supply water. Farm number 6 had 33.7 and 41.0 NTU during rain and dry periods, respectively, while farm number 28 had 11.9 NTU during the dry season.

Nitrate concentrations of all water samples were within the standards required by the current legislation (below10 $mg.L^{-1}$) (BRASIL, 2004).

Table 1. Water quality standards for water used for different purposes

	Water use		
	Drinking water	**Vegetable irrigation water**	**Watering animals**
Legislation source	Portaria 518 Ministério da Saúde	CONAMA 357 Resolution	CONAMA 357 Resolution
Water classification	-	1	3
Maximum value allowed			
Escherichia coli (MPN.100 mL^{-1})	Absent	200	1.000
Mesophilic microorganisms (CFU)	500	-	-
Turbidity (NTU)	5	40	100
Nitrate - $N\text{-}NO_3$ ($mg.L^{-1}$)	10	10	10

Table 2 – Number and percentage of farms whose water samples were not within the required microbiological standards for drinking water established by decree 518/04 of Ministério da Saúde (BRASIL, 2004).

	Escherichia coli*		**Mesophilic****	
	Rain	Dry	Rain	Dry
Supply source	15 (51.7%)	14 (48.3%)	3 (10.3%)	5 (17.2%)
Human consumption	14 (48.3%)	11 (37.9%)	3 (10.3%)	4 (13.8%)

Microbiological standard: *Absent in 100 mL, ** Maximum 500 CFU.mL^{-1}

Table 3 – Number of farms that had water contaminated with *Escherichia coli* determined in 100 mL samples of supply water, drinking water and in both sampling points.

Sampling points	**Number of farms**	
	Rainy	**Dry**
Supply	5	5
Human consumption	4	2
Supply and human consumption	10	9

Table 4 – Analysis results for irrigation water of vegetables that can be eaten raw.

Farms	***E. coli*** (MPN.100mL^{-1})		**Turbidity** (NTU)		**Nitrate** (mg.L^{-1})	
	Rainy	**Dry**	**Rainy**	**Dry**	**Rainy**	**Dry**
3	200.0	191.0	7.62	5.9	7.9	3.1
8	107.1	31.0	**63.9**	22.3	2.3	2.1
24	0.0	0.0	0.3	0.9	3.6	1.2
27	0.0	0.0	0.9	0.4	2.8	2.2
29	**305.0**	195.6	0.9	0.5	4.4	3.3

Numbers in bold face are above the standards allowed by Resolution 357 from 2005, CONAMA (BRASIL, 2005).

Table 5 – Analysis results for water used for watering animals of the properties that raised animals.

Farms	***E. coli*** (MPN.100mL^{-1})		**Turbidity** (UNT)		**Nitrate** (mg.L^{-1})	
	rainy	**dry**	**rainy**	**dry**	**Rainy**	**dry**
1	410.0	20.0	48.0	61.0	0.9	2.1
4	3.1	0.0	0.4	0.2	3.4	2.2
5	13.4	0.0	0.9	1.2	3.4	2.1
7	0.0	17.3	0.5	0.6	2.7	1.2
13	6.2	121.0	0.3	7.6	3.9	1.4
16	609.0	**1.100.0**	18.2	12.0	1.2	2.1
23	45.0	13.2	0.4	0.9	0.8	2.1
25	254.0	0.0	7.9	6.4	3.4	1.4
27	0.0	0.0	0.3	0.3	2.5	2.6
28	23.3	16.1	0.7	0.2	3.1	1.3

Numbers in bold face are above the standards allowed by Resolution 357 from 2005, CONAMA (BRASIL, 2005).

Of the 29 farms visited, only 5 used water to irrigate vegetables that can be eaten raw. One farm had irrigation water with population of *E. coli* greater than that allowed by law, and another farm had irrigation water turbidity higher than that allowed by the legislation during the rain period (BRASIL, 2005) (Table 4).

Only ten farms raised animals and the quality of the water used for watering animals was within the standards required by law, with the exception of farm 15 that had 1100 MPN.100mL^{-1} of *E. coli* during dry season (Table 5).

The statistical test ANOVA was used to determine significant differences for nitrate concentration of drinking water samples between the rainy and dry periods. For the other variables, the non-parametrical Kruskal-Wallis test was used. Only turbidity was significantly different between periods, drinking water turbidity was significantly higher during the rain season (p=0.03).

DISCUSSION

This study showed that according to the Brazilian legislation, a higher degree of contamination was observed especially in supply water and drinking water. Several studies report the vulnerability of rural properties regarding water quality (QUEIROZ et al., 2002; ROCHA et al., 2006; SOTO et al., 2006), the risk of outbreaks of waterborne diseases is even higher in the rural areas, especially due to bacterial contamination of the water, which is often captured in old wells, improperly sealed and close to pollution sources such as, cesspits and grazing animals (AMARAL et al., 2003).

The bacterium *Escherichia coli* is considered the most specific indicator of fecal contamination (BAUDISOVA, 1997; DAWSON & SARTORY, 2000). Although the digestive system of endothermic animals is considered to be its natural habitat, this bacterium is able to survive and multiply in tropical ecosystems due to high nutrient concentrations, as well as soil, water and air high temperatures (WINFIELD & GROISMAN, 2003). Also it has been observed that these microorganisms are transported by surface and underground water between livestock farms (YATES & OUYANG, 1992; WALKER & STEDINGER, 1999). This study showed that fecal contamination of water is a significant problem in rural properties located in the watershed of Córrego Rico, Jaboticabal, SP, since approximately half of the sampled properties had *E. coli* in the supply and drinking water.

However, the absence of *E. coli* does not mean that there are no other pathogens present in the water (VASCONCELLOS et al., 2006), the presence of mesophilic heterotrophic bacteria in also an indicator of the bacteriological quality of the water (TRYLAND & FIKSDAL, 1998) and it should also be considered that water with high number of mesophilic microorganisms may be contaminated by bacteria of the underestimated coliform group (LECHEVALLIER & MCFETERS, 1985). In this study, one and two farms during the rain and dry seasons, respectively, had water considered unfit for consumption due to presence of mesophilic heterotrophic microorganisms, even though no *E. coli* was detected in the samples.

Another parameter related to the occurrence of waterborne diseases and also suggested as water quality indicator is turbidity (PAYMENT & HUNTER, 2001). A relationship has been reported between turbidity index and rates of hospital admission for gastrointestinal diseases among the elderly in Philadelphia, USA, during 1992-1993 (SCHWARTZ et al., 2000). In this study, turbidity disqualified three supply water samples and one sample of water used for irrigation. Thus showing that the analysis of multiple variables is important for assessing the quality of drinking water, for in spite of *E. coli* contamination in approximately half of the samples of drinking water, the good turbidity level may lead the population to neglect proper treatment for believing that the water is fit for consumption.

In addition to microbiological contamination, water can also be polluted with chemical products. Among the inorganic products that are health hazards, nitrate is the most widespread and problematic, due to its high mobility and stability in aerobic groundwater systems (FOSTER & HIRATA, 1993). Agricultural activities are the most important sources of groundwater contamination by nitrate, since it is largely used in fertilizers and the trend of livestock intensification (SPALDING & EXNER, 1993).

Although the samples of this study did not present nitrate concentrations above the limit stipulated by the legislation, levels above 3.0 $mg.L^{-1}$ indicate contamination by anthropogenic activity (BOUCHARD & WILLIAM, 1992). Water samples are classified according to nitrate levels as follows: clean (0-3 $mg.L^{-1}$), slightly polluted (3-6 $mg.L^{-1}$), polluted (6-10 $mg.L^{-1}$) and heavily polluted (>10 $mg.L^{-1}$) (LIU et al., 2005).

In this study, seven water samples (4 from the rain and 3 from the dry seasons) had nitrate concentrations between 3 and 6 $mg.L^{-1}$, while three samples (2 from the rain and 1 from dry seasons) were classified as polluted due nitrate concentrations between 6 and 10 $mg.L^{-1}$ (Figure 1).

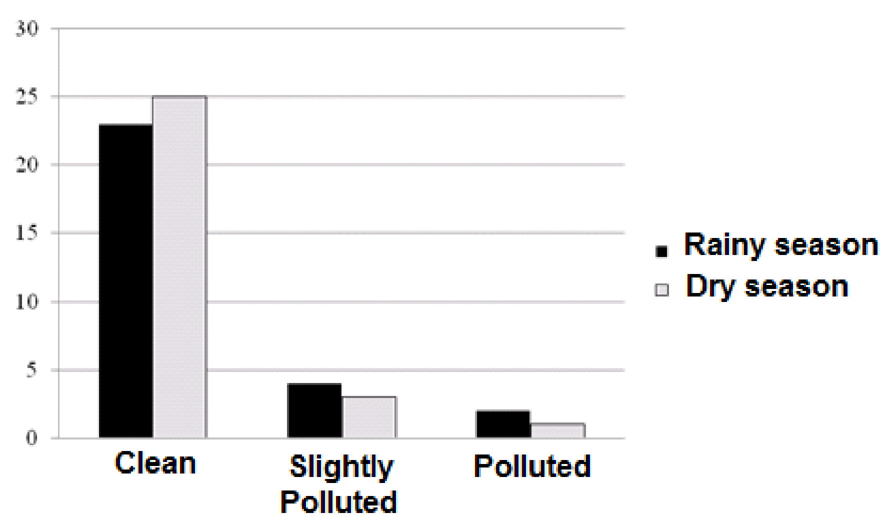

Figure 1 – Classification of drinking water samples according to their nitrate concentration (Liu et al., 2005).

The nitrate consumption through drinking water is associated with two adverse health effects, the appearance of methemoglobinemia, especially in children, and potential formation of carcinogenic nitrosamines and nitrosamides (BOUCHARD & WILLIAM, 1992). In addition to this, it should be noted that a study in the USA reported an association between spontaneous abortion and women who consumed water from wells contaminated by nitrate (GRANT et al., 1996).

This study demonstrated that according to the different uses of water and their quality standards, a high number of supply and drinking water samples did not fit the standards required by the current legislation. Meanwhile, among the samples of water used for vegetable irrigation and watering animals, only a small number was not fit. This is due to different standards that are required for the different uses, but since irrigation of vegetables and animal watering are an important route for the transmission of diseases, the evaluation of the water quality for such purposes should not be overlooked.

A study in Istanbul, Turkey, reported that surface water was the main cause of excess nutrients in water reservoirs (BAYKAL et al., 2000), other studies have found that cattle grazing areas nearby springs can act as sources of fecal pollution, since these microorganisms are washed away with rainfall (FISHER et al., 2000; SERVAIS et al., 2007). However, since there was no effect of rain or drought on the contamination levels of the water samples, a factor that could explain the water contamination in both periods is either the bad quality of the water supplying sources or the presence of a constant source of pollution, such as, the inflow of waste water sewage into the supply water source, thus increasing fecal pollution indicators that affect both surface and underground water (FERNANDEZ-MOLINA, 2004).

CONCLUSION

According to current legislation, the highest number of contaminated samples were of supply and drinking water, which were unfit for consumption due to the presence of *Escherichia coli*. Water quality was not affected by rain or drought, probably due to improper storage or maintenance of water supplies, or a constant source of contamination such as septic tanks nearby. Given that consumption of contaminated water poses a serious threat for public health, it is necessary to develop prevention strategies to inform the population about measures to preserve the supply water sources, proper disposal and/or treatment of wastewater and residues, as well as close monitoring of the water quality.

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REFERENCES

AMARAL, L. A.; NADER FILHO, A.; ROSSI JÚNIOR, O. D.; FERREIRA, F. L. A. & BARROS, L. S. S. Água de consumo humano como fator de risco à saúde em propriedades rurais. **Revista de Saúde Pública**, v.37, p.510-514, 2003.

AMARAL, L. A.; NADER FILHO, A.; ROSSI JÙNIOR, O. D.; PENHA, L. H. C. Características microbiológicas da água utilizada no processo obtenção do leite. **Pesquisa Veterinária Brasileira**, v.15, n.2/3, p.85-88, 1995.

AMERICAN PUBLIC HEALTH ASSOCIATION, **Standard methods for the examination of water and wastewater**, ed. 18th New York, 1992.

BAUDISOVA D. Evaluation of *E.coli* as the main indicator of fecal pollution. **Water Science and Technology,** v.35, n.11/12, p.333-356, 1997.

BAYKAL, B. B.; TANIK, A.; GONENC, I. E. Water quality in drinking water reservoirs of a Megacity, Istanbul. **Environmental Management**, v.26, n.6, p.607–614, 2000.

BLACKBURN, B. G.; CRAUN, G. F.; YODER, J. S.; HILL, V.; RCALDERON, R. L.; CHEN, N.; LEE, S. H.; LEVY, D. A.; BEACH, M. J. Surveillance for Waterborne-Disease Outbreaks Associated with Drinking Water - United States, 2001—2002. **Morbility and Mortality Weekely Report**, v.53, n.8, p.23-45, 2004.

BOUCHARD, D. C.; WILLIAM S. M. K.. Nitrate contamination of groundwater; sources and potential health effects. **Journal of the American Water Works Association,** v. 84, n.9, p.85-90, 1992.

BRASIL. MINISTÉRIO DA SAÚDE. Portaria n^{o} 518 de de 25/03/2004..Normas e padrões potabilidade da água para consumo humano. **Publicada no Diário Oficial da União**, 2004.

BRASIL. MINISTÉRIO DO MEIO AMBIENTE. Resolução n^{o} 357 de 17/03/2005. Dispõe sobre a classificação dos corpos de água e diretrizes ambientais para o seu enquadramento, bem como estabelece as condições e padrões de lançamento de efluentes, e dá outras providências. **Publicada no Diário Oficial da União**, 2005.

CRAUN, G. F.; CALDERON, R. L.; NWACHUKU, N. Causes of waterborne outbreaks reported in the United States, 1991–98. In: **Drinking Water and**

Infectious Disease: Establishing the Link, ed. Hunter, P.R., Waite, M. and Ronchi, E. p.105–117. Boca Raton: CRC Press, 2002.

CURRIERO, F. C.; PATZ, J. A.; ROSE, J. B.; LELE, S. The Association between extreme precipitation and waterborne disease outbreaks. **American Journal of Public Health**, v.91, n.8, p.1194-1199, 2001.

DAWSON, D. J.; SARTORY, D. P. Microbiological safety of water. **British Medical Bulletin**, v.56, n.1, p.74-83, 2000.

ELIMELEC, M. The global challenge for adequate and safe water. **Journal of Water Supply: Research and Technology-AQUA**, v.55, n.1, p.3-10, 2006.

FERNANDEZ-MOLINA, M. C.; ALVAREZ, A.; ESPIGARES, M. Presence of hepatitis A virus in water and its relationship with indicators of fecal contamination. **Water, Air, and Soil Pollution**, v.159, n.1, p.197–208, 2004.

FEWTRELL, L.; KAY, D.; GODFREE, A. The microbiological quality of private water supplies. **Journal Ciwen**, v.12, p.98-100, 1998.

FISHER, D. S.; STEINER J. L.; ENDALE D. M.; STUEDEMANN J. A.; SCHOMBERG H. H.; FRANZLUEBBERS A. J.; WILKINSON S. R. The relationship of land use practices to surface water quality in the Upper Oconee Watershed of Georgia. **Forest Ecology and Management**, v.128, n.1/2, p.39-48, 2000.

FOSTER, S. & HIRATA, R. C. A. **Determinación del riesgo de contaminación de aguas subterráneas. Una metodología basada em datos existentes**. Lima: CEPIS, OPS/OMS. 2ªed. 1993.

GERMANO P. M. L.; GERMANO M. I. S. A água: um problema de segurança nacional. **Revista Higiene Alimentar**, v.15, n.90/91, p.15-18, 2001.

GRANT, W.; STEELE, G.; ISIORHO, S. A. Spontaneous abortions possilbly related to ingestion of nitrate-contaminated well water, Indiana 1991-1994. **Morbility and Mortality Weekely Report**, v.45, n.26, p.569-572, 1996.

HACH COMPANY. **DR 2000 Spectrophotometer Handbook**. Procedures Section II, p.301-302, 1991.

KARANIS, P. A review of an emerging waterborne medical important parasitic protozoan. **Japanese Journal of Protozoology**, v.39, n.1, p.5-19, 2006.

LECHEVALLIER, M. W.; MCFETERS, G. A. Interations between heterotrophic plate count bacteria and coliforms organisms. **Applied and Environmental Microbiology,** v.49, n.5, p.1338-1341, 1985.

LIU, G. D, WU, W. L., ZHANG, J. Regional differentiation of non-point source of pollution of agriculture derived nitrate nitrogen in groundwater in northern China. **Agriculture, Ecosystems and Environment**, v.107, p.211-220, 2005.

NAUMOVA, E. N. Mistery of seasonality: Getting the rhythm of nature. **Journal of Public Health Policy**, v.27, p.2-12, 2006.

OPS - ORGANIZACIÓN PANAMERICANA DE LA SALUD. **La salud y el ambiente en el desarrollo sostenible**. Washington, D.C., p.283, 2000.

PAYMENT, P.; HUNTER, P. R., editors. Endemic and epidemic infectious intestinal disease and its relationship to drinking water. In: **Water Quality: Guidelines, Standards and Health,** ed. Fewtrell, L. and Bartram, J. London: IWA Publishing, p.43-59, 2001.

PRÜSS, A.; HAVELAAR, A. The global burden of disease study and applications in water, sanitation and hygiene. In: **Water Quality: Guidelines, Standards and Health** ed. Fewtrell, L. and Bartram, J. London: IWA Publishing; p.43–59, 2001.

QUEIROZ, M. F., CARDOSO, M. C. S.; SANTANA, E. M.; GOMES, A. B.; RIQUE, S. M. N.; LOPES, C. M. A qualidade da água de consumo humano e as doenças diarréicas agudas no Município do Cabo de Santo Agostinho, PE. **Revista Brasileira de Epidemiologia** Suplemento Especial: 456, 2002.

ROCHA, C. M. B. M.; RODRIGUES, L. S.; COSTA, C. C.; OLIVEIRA, P. R.; SILVA, I. J.; JESUS, E. F. M.; ROLIM, R. Avaliação da qualidade de água e percepção higiênico-sanitária na área rural de Lavras, Minas Gerais, Brasil, 1999-2000. **Cadernos de Saúde Pública**, v.22, n.9, p.1967-1978, 2006.

SCHWARTZ, J.; LEVIN, R.; GOLDSTEIN, R. Drinking water turbidity and gastrointestinal illness in the elderly of Philadelphia. **Journal of Epidemiology & Community Health**, v.54, n.1, p.45-51, 2000.

SERVAIS, P.; GARCIA-ARMISEN, T.; GEORGE, I.; BILLEN, G. Fecal bacteria in the rivers of the Seine drainage network (France): Sources, fate and modelling. **Science of the Total Environment,** v.375, n.1/3, p.152–167, 2007.

SOBSEY, M. D. Drinking water and health research: a look to the future in the United States and globally. **Journal of Water and Health**, v.4, suppl.1, p.17-21, 2006.

SOTO, F. R. M.; FONSECA, Y. S. K.; RISSETO, M. R., AZEVEDO, S. S.; ARINI, M. L. B.; MOURA, C. R. V.; MARCHETTE, D. S. Monitoramento da qualidade de água de poços rasos de escolas públicas da zona rural do município de Ibiúna/SP: parâmetros microbiológicos, físico-químicos e fatores de risco ambiental. **Revista Instituto Adolfo Lutz**, v.65, n.2, p.106-111, 2006.

SPALDING, R. F.; EXNER, M. E. Occurrence of nitrate in groundwater— a review. **Journal of Environmental Quality**, v.22, n.3, p.392–402, 1993.

TRYLAND, I.; FIKSDAL, L. Rapid enzymatic detection of heterotrofic activity of environmental bacteria. **Water Science and Technology**, v.38, n.12, p.95-101, 1998.

VASCONCELLOS, F. C. S.; IGANCI, J. R. V.; RIBEIRO, G. A. Qualidade microbiológica da água do Rio São Lourenço, São Lourenço do Sul, Rio Grande do Sul. **Arquivos do Instituto Biológico**, v.73, n.2, p.177-181, 2006.

WALKER, F. R.; STEDINGER, J. R. Fate and transport model of Cryptosporidium. **Journal of Environmental Engineering**-ASCE, v.125, p.325-333, 1999.

WINFIELD, M. D.; GROISMAN, E. A. Role of Nonhost Environments in the Lifestyles of *Salmonella* and *Escherichia coli*. **Applied and Environmental Microbiology**, v.69, n.7, p.3687–3694, 2003.

YATES, M. V.; OUYANG, Y. Virtus, a model of virus transport in unsaturated soils. **Applied and Environmental Microbiology**, v.58, n.5, p.1609-1616, 1992.