FECAL POLLUTION DYNAMICS OF CORREGO RICO STREAM AND SUPPLY WATER OF JABOTICABAL CITY- SP

DINÂMICA DA POLUIÇÃO FECAL NAS ÁGUAS DO CÓRREGO RICO, MANANCIAL DE ABASTECIMENTO DA CIDADE DE JABOTICABAL-SP

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SUMMARY

The quality of the supply water source is of great importance to surface water treatment systems, since any kind of treatment failure may send contaminated water that can be harmful to consumer health. The present work aims to monitor fecal pollution dynamics of water from the Corrego Rico stream, as well as from the supply source of Jaboticabal city, SP, during 24 hours. Water samples were collected every 2 hours, during 24 hours and the following variables were determined: Most Probable Numbers of total coliforms, *Escherichia coli* and sulfite reducing Clostridia, as well as ammonia concentrations during the rainy and dry seasons. It was concluded that during some of the periods, the water from Corrego Rico stream cannot undergo conventional water treatment and be supplied to the population. The incident rains, mainly during the evening, brought water contamination level above the limit allowed for its class. This microbiological contamination may pose a health threat to the population. The results of this study can help to devise a strategy to improve the quality of the water supplied to the population and to prevent waterborne diseases

KEY-WORDS: Water. Ammonia. Fecal pollution indicators. Supply water.

RESUMO

A qualidade da água in natura é de grande importância nos sistemas de tratamento de águas superficiais, pois uma vez que haja falhas no tratamento pode haver o risco de produzir água contaminada tornando-se prejudicial à saúde dos consumidores. O objetivo do presente trabalho foi conhecer a dinâmica da poluição fecal, durante 24 horas, na água do manancial de abastecimento público da cidade de Jaboticabal, SP. Para isso foram colhidas amostras da água do manancial, com intervalos de 2 horas, durante 24 horas, e foram determinados os Números Mais Prováveis de coliformes totais, *Escherichia coli* e clostrídios sulfito redutores e as concentrações de amônia nos períodos de chuva e estiagem. Conclui-se que em alguns períodos a água do Córrego Rico não poderia ser utilizada para o abastecimento da população por tratamento convencional, pois com as incidentes chuvas, principalmente no período vespertino, o córrego apresenta contaminação microbiológica acima do limite para sua classe e pode representar risco à saude da população. Os resultados obtidos podem nortear ações visando promover a qualidade da água fornecida à população no sentido de prevenir as enfermidades de veiculação hídrica.

PALAVRAS-CHAVE: Água. Amônia. Indicadores de poluição fecal. Manancial de abastecimento

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Submitted: 11/04/2012 Accepted: 23/08/2012

INTRODUCTION

In France, in the middle of the eighteenth century, public health practices were focused on environmental control. There was concern about the accumulation and circulation of water and air, and in certain places, with the disposal of wastewater and the situation of water supplies in the cities (FOUCAULT, 1990; FABRE, 1993).

A historical analysis of the use of water resources shows that from the 70s, problems such as lack of sanitation, water supply and industrial pollution worsened due to fast economic development and industrialization. Progress and fast development led to an increase of waterborne diseases, thus becoming necessary to start monitoring the quality of the water supplied to the population and animals, in order to detect poor quality water and monitor the pathogens that may be present in the water.

In Brazil, animal farming is essentially a rural activity that takes place especially where there is easy access to water for watering. Therefore, animal waste ends up transported, directly or indirectly, to the water sources a fact that contributes massively to water pollution. For this reason, studies of water quality indicators to monitor water sources are increasingly more common and are important tools to evaluate the sanitary condition of the water body.

This work was conducted in the hydrographic basin of Corrego Rico stream, a tributary of Mogi-Guaçu River, responsible for supplying 70% of the water to the city of Jaboticabal, SP, and has suffered environmental impact resulting from its disorderly occupation (LOPES et al., 2003). This basin is a member of the Unidade de Gerenciamento de Recursos Hídricos do Rio Mogi-Guaçu (UGRHI-9), the economic-ecological compartment called Médio Mogi Inferior, with an approximate area of 1,465,300 ha.

According to Köeppen, climate in the area is Aw type, mesothermal climate with dry winters, where average temperature in the warmest month is higher than 22 ºC and in the coldest is below 18 ºC. Average annual rainfall and relative humidity are 1,425 mm and approximately 71%, respectively. Rainy season lasts from October to March and the dry season from April to September (ESTAÇÃO AGROCLIMATOLÓGICA, 2009).

The present study aimed to determine the dynamics of bacterial population by determining the following parameters, MPN of *Escherichia coli*, enterococci and sulphite-reducing clostridia and ammonia levels during a 24 hour period, in the water from Corrego Rico Stream and supply water of the city of Jaboticabal-SP, during the rainy and dry seasons.

MATERIAL AND METHODS

Initial sampling was performed during rainy and dry seasons, in order to determine the best week day to carry out the sampling. It was established that fecal pollution was worse on Mondays and therefore, sampling should take place on this week day.

Samples were collected in sterilized wide-mouth glass jars closed by a screw plastic cap. The 250 mL jars were sterilized in autoclave and opened only at the time of sampling. The water was collected from a faucet in the supply water source in the Water Treatment Station, every two hours during 24 hours, totaling 12 samples daily. Samples were collected in five replicates during rainy and dry seasons, totaling 60 samples per period.

Each bottle was duly tagged with sampling local and time. Samples were transported to the laboratory in isothermal boxes filled with ice.

The Most Probable Number (MPN) of sulphite reducing clostridia was determined by the culture method norm 1-1986 (ISO, 1986) adapted by Gesche et al. (2003). The results were expressed as MPN of sulphite reducing clostridia per 100 mL of sample. For the total coliforms, *Escherichia coli* and enterococci were determined by the chromogenic substrate method, according to APHA (2012), the results were expressed as MPN. 100 mL^{-1}. Ammonia concentration was determined by the method described by HACH, (1996), and the results were expressed as mg $N\text{-}NH_3.L^{-1}$.

Average MPN of clostridia, enterococci and *Escherichia coli* were log x transformed. Subsequently, these means and mean ammonia levels were submitted to analysis of variance ANOVA and compared by Tukey test at 1% to 5% significance using the software SAS (Statistical Analysis System) (DER & EVERITT, 2006).

RESULTS AND DISCUSSION

The area of Corrego Rico basin, in Jaboticabal, is surrounded by rural properties that disposed of their waste water in the stream with little or no treatment whatsoever in the period of the visits, between August 2007 and March 2008. The animal farms in the area raise cattle, poultry and pigs, and the latter is a major contributor to water pollution in the area (LOPES et al. 2008).

Total coliforms and *Escherichia coli*, as well as enterococci and sulphite reducing clostridia are groups of bacteria that indicate water contamination by either domestic sewage or animal waste; while the first group suggests recent contamination (VARNAM & SUTHERLAND,. 1994), and the second, remote (SANTANA et al. 2003).

Figures 1 and 2 show the bacterial population present in the stream water. It can be seen that at times, the bacterial populations are above the limit set by the Ministério do Meio Ambiente, CONAMA - Resolution nº 357, from March 17, 2005(BRASIL, 2005). This result corroborates the data reported by Lopes et al. (2003), who has previously pointed out the disposal of waste water in the stream. It is observed that the highest loads of sulphite reducing clostridia, *Escherichia coli* and enterococci occurred respectively,

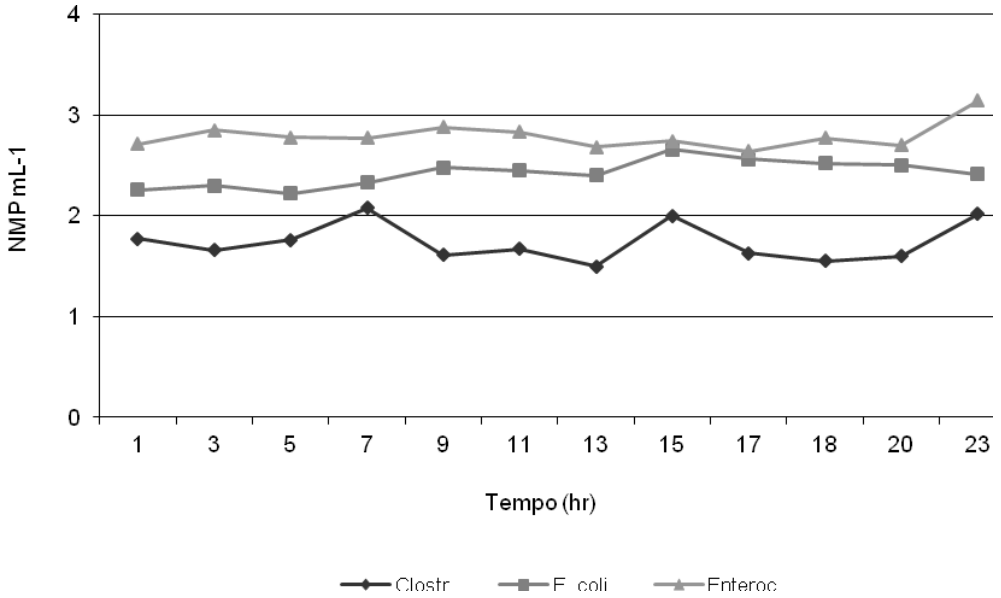

Figure 1 - Most Probable Number (log10) of the indicators: sulphite reducing clostridia (Clostr.), *Escherichia coli* (*E. coli*) and enterococci (Enteroc.) per 100 mL of Corrego Rico water in the dry season (September-October 2007) .

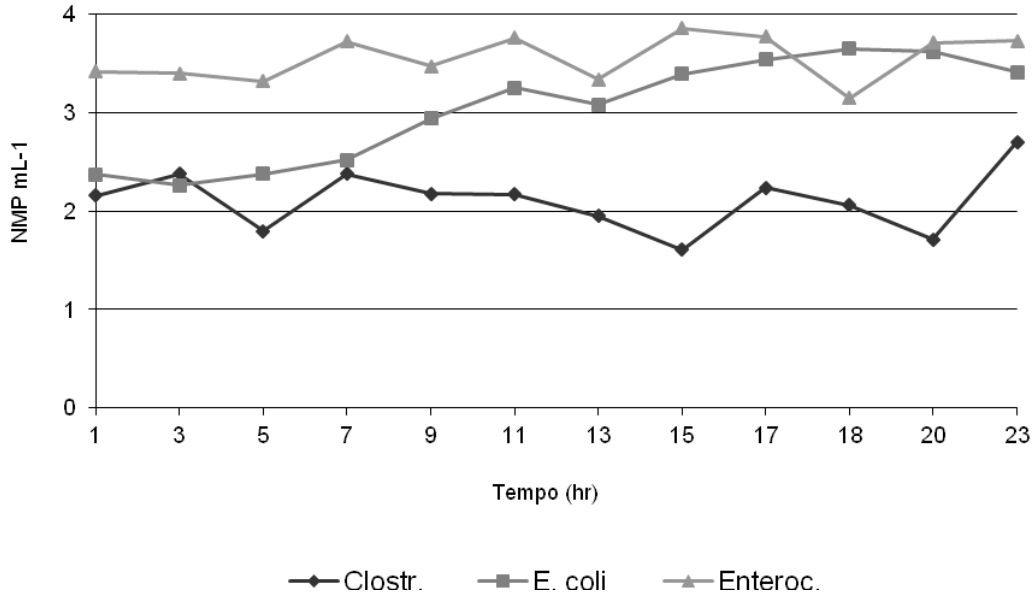

Figure 2 - Most Probable Number (log10) of indicators: sulphite reducing clostridia (Clostr.), *Escherichia coli* (*E. coli*) and Enterococcus (Enteroc.) per 100 mL of Corrego Rico water during the rainy season (February-March 2008) .

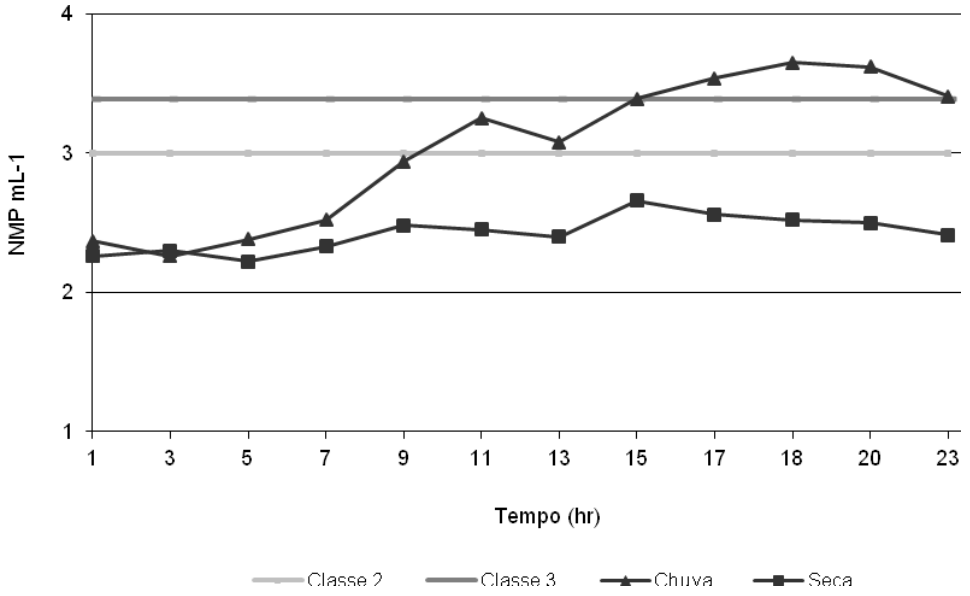

Figure 3 - Population (log10) of *Escherichia coli* over time during the rainy and dry seasons, and the legal limit for *Escherichia coli* for water classes 2 and 3 (BRAZIL, 2005).

at 7 a.m., 3 p.m. and 11 p.m. during the dry season (Figure 1).

Water analysis results indicated the presence of fecal matter and confirmed the release of wastewater in the studied basin. This can be observed by the dynamics of the indicators, *Escherichia coli* and enterococci showing recent contamination, and sulphite reducing clostridia showing remote contamination of the water body. The presence of both remote and recent indicators of fecal pollution leads us to conclude that there is a constant contamination of the studied water body.

Francy & Helsel (2000) confirmed this dynamics and the presence of indicators as means of assessing the quality of water systems in the United States.

Figure 3 shows that *Escherichia coli,* during the rainy period, exceeds the limit of 1000 NMP mL^{-1} (upper limit of Class 2), to over 4000 NMP mL^{-1} (upper limit Class 3) (BRASIL, 2005), which makes the water from the stream unfit for consumption when treated conventionally. This fact can be explained by the greater flow of runoff water from the rain carrying organic and solid matter, thus causing physical, chemical and microbiological imbalance in the studied stream.

Water supply sources close to urban areas are more polluted because they permeate through a critical context that disrupts the harmony between development and the conditions offered by the environment.

The pollution caused by non-point sources was not recognized until late 60s. However, it is estimated that about half of the pollution load that enters a basin comes from diffuse sources. Diffuse pollution in caused primarily by surface outflow, leaching and flow of macropores, which in turn are related to soil properties such as porosity and infiltration. The main problem of a diffuse pollution source, as observed in the studied watershed, is to control it.

Similarly to Nogueira et al. (2003), in this study we also observed the influence of rainfall on the percentage of water samples positive for coliform. In the rainy season, positive results for fecal and total coliforms increased.

According to Yagow & Shanholtz (2008), pollution by diffuse loads is the main cause of degradation of surface water bodies in the USA, and 72% of the total pollution load originates from agricultural activities. About 40% of the rivers, estuaries and lakes that have already adequate control of point source pollution are still unfit for fishing and recreational activities due solely to diffuse pollution load (USEPA, 2002).

Brazil does not have a lot of experience dealing with diffuse pollution sources. There are some national studies investigating how this pollution is generated and how the pollution loads impact water quality and

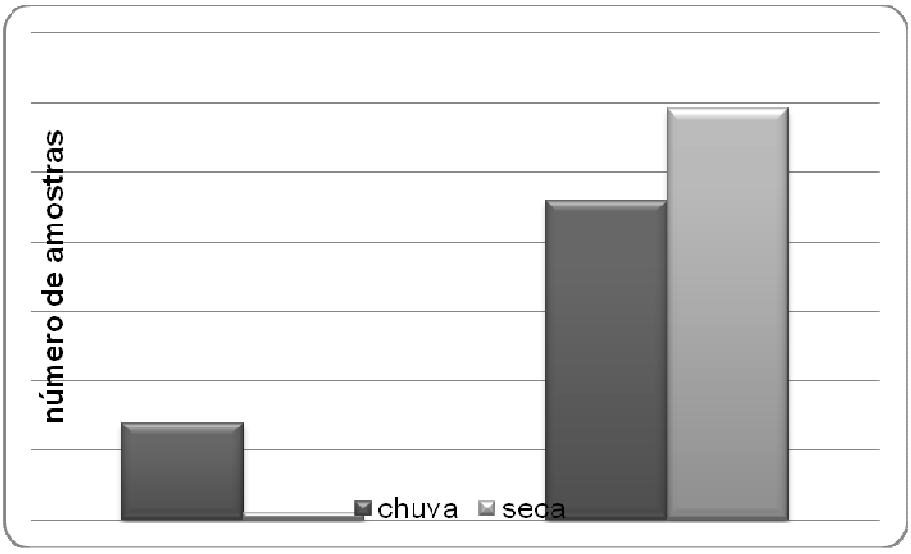

Figure 4 - Number of water samples with Escherichia coli populations within and outside the standard recommeded by Resolution 357/05 (BRAZIL, 2005), during rainy and dry seasons.

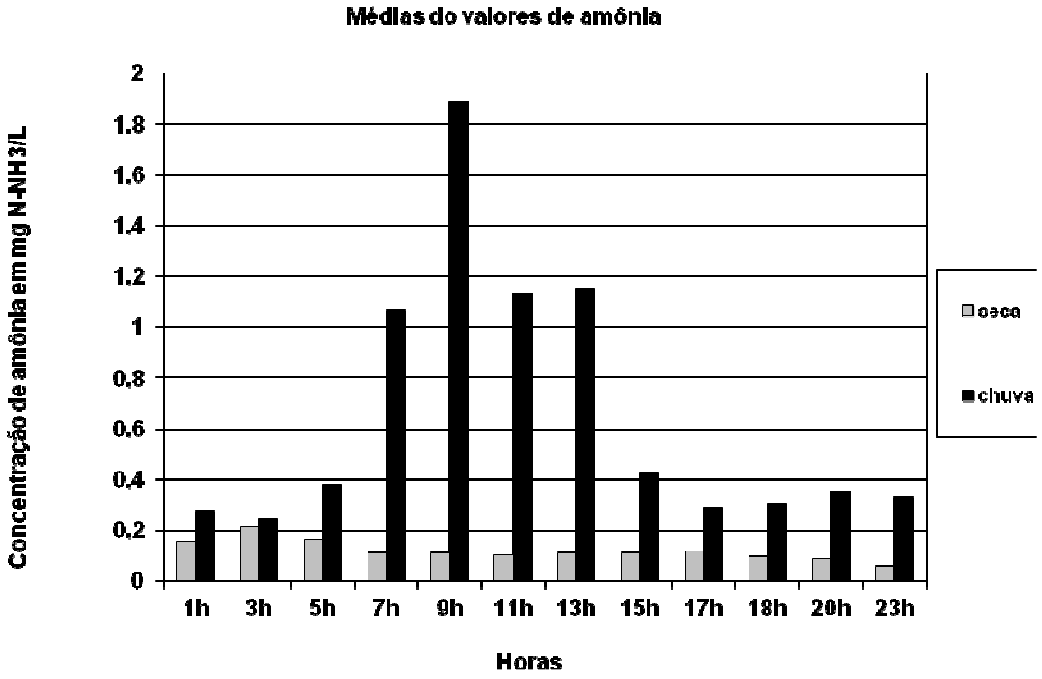

Figura 5 - Médias dos valores das concentrações de amônia no período de seca e chuvas na água do Córrego Rico no período das chuvas (fevereiro a março de 2008).

Table 1 - Comparison of mean indicators of fecal pollution according to Tukey test, during the rainy and dry periods.

	Seca	Chuva
Escherichia coli	5,5 a	6,0 b
Clostrídios	3,55 a	5,2 b
Enterococos	6,0 a	7,2 b
Amônia	0,11 a	0,45 b

* Means followed by the same letters in rows and columns do not differ by Tukey test.

human health (DALCANALE, 2001; EIGER, 1993; MARTINS, 1988; PRIME ENGENHARIA, 1998).

The fecal matter from animal farms that is washed out to the Corrego Rico stream by the surface runoff brings with it pathogenic bacteria, which may be present in the intestinal microbiota of the animals and were shed in the feces that can be harmful to human health.

Figure 4 shows that during the rainy season, 14 of 60 samples, that is, 23% had *Escherichia coli* levels above the maximum allowed by Resolution 357/05 (BRASIL, 2005) for Class 2 water; therefore, the microbiological water quality of the stream deteriorated. On the other hand, during the dry season only 1.7% of the samples, that is, one out of 60 samples had *E. coli* level above that recommended for Class 3 water by the same resolution. Thus, the stream water was apt for human consumption after undergoing the municipal treatment.

From the 14 samples that were out of the recommend standards, eight had *E. coli* levels above that allowed for consumption after either conventional or advanced treatment, that is, higher than 4,000 thermotolerant fecal coliforms per 100 mL of sample, which is worrisome because the city of Jaboticabal has only conventional water treatment.

As described by Lopes et al. (2008), 60.9% of the rural properties in the Corrego Rico watershed are considered small, between 0 and 50 hectares. Of these, 79% discard animal waste to the environment, which is consistent with the results found in this study, since the increased number of fecal coliform and ammonia level suggest recent contamination of the stream during the rainy season when surface runoff contributes to bring more waste to the stream.

In the Corrego Rico watershed, the aforementioned authors reported that only 22% of the farms preserve and plant riparian vegetation, 82% use pesticides regularly, 23% use the stream water for watering animals and 8% use this water to clean animal facilities (LOPES et al., 2008). Facts that contribute to depreciation of the water quality, since without protection of riparian areas, surface runoff towards the creek is higher and there is still a greater input of organic matter from animal waste, which is evidenced by increase of recent contamination by *Escherichia coli* and ammonia, present in the waste that end up in the water of Corrego Rico.

Figure 5 shows that ammonia levels are always higher in the rainy season, with peak times due to the heavy rainfall in the period along with diffuse pollution sources, which contribute further to the pollution of the watershed. However, the levels were always within the standard recommended by Resolution 357/05(BRASIL, 2005), which sets the maximum of 3.7mg/L N, for pH $\leq$ 7.5 and 2.0mg/L N, for 7.5 < pH $\leq$ 8.0.

Statistical analysis showed no significant difference among the MPN means of enterococci, *Escherichia coli*, clostridia and ammonia compared at different times in the same period; however, the differences were significant between rainy and dry seasons (Table 1).

This result is consistent with Amaral (2001) who stated that it is important to conduct microbiological analysis during both rainy and dry seasons in order to determine water quality, since during the rainy season; surface runoff contributes more to change water quality.

In a study conducted in Mexico, Gonzalez et al. (1982) concluded that the presence of fecal coliforms in the water samples from supply sources and households were directly related to rainfall, due to human and animal waste leaching, which has also been seen in this study.

CONCLUSION

Escherichia coli population, an indicator used for microbiological classification of water bodies, displayed during the rainy season, values above the recommended level for Class 3 water, making the stream water unfit for consumption by conventional treatment, in some periods of the day, during this season.

The presence of fecal pollution indicators (*Escherichia coli*, enterococci and sulfite reducing

clostridia) demonstrates that the studied watershed is constantly contaminated by the releasing of fecal material, either human or animal.

During the rainy season, the water of Corrego Rico displayed higher levels of bacterial indicators of fecal pollution and ammonia levels, which indicates the importance of surface runoff contamination in the studied watershed.

ACKNOWLEDGMENTS

Thanks are due to Fundação de Amparo à Pesquisa do Estado de São Paulo-FAPESP- for the financial support.

REFERENCES

AMARAL, L. A. **A água como fator de risco para saúde humana e animal em propriedades leiteiras situadas na região Nordeste do Estado de São Paulo.** Tese de livre-docência. Faculdade de Ciências Agrárias e Veterinária "Júlio de Mesquita Filho". FCAV/Unesp, Jaboticabal, 2001

APHA. **American Public Health Association**. Standard methods for the examination of water and wastewater, AWWA, 22th, 2012.

BRASIL. Conselho Nacional do Meio Ambiente. Resolução nº357 de 17 de março de 2005. Dispõe sobre a classificação dos corpos de água e diretrizes ambientais para seu enquadramento, bem como estabelece as condições e padrões de lançamento de efluentes e dá outras providências. **Diário Oficial da União**, Brasília, v.1, n.53, p.58-63, Seção 1, 18 mar. 2005.

DALCANALE, F. **Simulação de cargas difusas em bacias rurais**. São Paulo: Escola Politécnica, Universidade de São Paulo. Dissertação de Mestrado (Mestrado em Engenharia), 2001.

DER, G.; EVERITT, B. S. **A handbook of statistical analysis using SAS.** ed.2, p.360, 2006.

EIGER, S**. Aplicação do Modelo BIDIM ao Reservatório do Rio Grande**: relatório final – manual de descrição do modelo. São Paulo: Editado, 1993.

ESTAÇÃO AGROCLIMATOLÓGICA. **Resenha Meteorológica do Período 1971 – 2000**. Disponível em: <http://www.exatas.fcav.unesp.br/estacao/est_resanha.htm>. Acesso em: 24 fev. 2009.

FABRE, G. La notion de contagion au du sida, ou comment interfèrent logiques sociales et catégories médicales. **Sciences Sociales et Santé,** Paris, v.11, n.1, p.5–32, mar, 1993.

FOUCAULT, M. **Microfísica do poder.** Rio de Janeiro: Graal, 1990. 174p.

FRANCY, D. D.; HELSEL, R. N. Ocurrence and Distribution of Microbiological Indicators in Groundwater and Stream Water. **Water Environmental,** v.72, n.1, p.152-161, 2000.

GESCHE, E.; VALLEJOS, M. V.; SAEZ, T. M. Eficiencia de Anaerobios sulfito-reductores como indicadores de calidad sanitaria de agua. **Archivos de Medicina Veterinária**, n.1, v.35, 2003.

GONZALEZ, R. G.; TAYLOR, M. L.; ALFARO, G. Estudo bacteriano del agua de consumo en una comunidad Mexicana**. Boletin de la Oficina Sanitaria Panamericana**, v.93, n.2, p.127-140, 1982.

HACH COMPANY MANUAL. Dr/2000 Spectrophotometer instrument manual for use software version 3. Loveland, p.58, 1996.

ISO. International Standard Organization. **ISO 6461/1 water quality**: Clostridia Geneva, Switzerland, 1986.

LOPES, L. G.; AMARAL, L. A.; HOJAIJ, A.; COSTA JÚNIOR, L. L.; PALLA, V. L. Estudo do uso do solo e condições ambientais da microbacia hidrográfica do Córrego Rico**. FAZU em Revista** (Uberaba), v.1, p.16-24, 2008.

LOPES, L. G.; COSTA, J. L. L.; ITALIANO, L.W.; HOJAIJ, A.; ZANETTI, F. G. M. L.; MARQUES, J. A. S. Monitoramento da Qualidade da Água na Bacia Hidrográfica do Córrego Rico (Jaboticabal - SP). In: ASSEMBLEIA NACIONAL DA ASSEMAE, 33, 2003. Santo André**. Saneamento Inclusão Social**. Jaboticabal: Assemae, 2003.

MARTINS, R. H. **Carga difusa em ambientes urbanos: A bacia representativa do Córrego do Mandaqui.** São Paulo: Escola Politécnica, Universidade de São Paulo 1988. 207p.. Tese (Doutorado em Engenharia), 1988.

NOGUEIRA, G.; NAKAMURA, C.V.; TOGNIM, M.C.B.; ABREU FILHO, B.A.; DIAS FILHO, B.P. Microbiological quality of drinking water of urban and rural communities, Brazil. **Revista de Saúde Pública.** São Paulo. v.37, n.2, 2003.

PRIME ENGENHARIA. **Avaliação da poluição por fontes difusas afluente ao reservatório Guarapiranga – relatório síntese**. São Paulo. PRIME Engenharia, p.46, 1998.

SANTANA, A.S.; SILVA, S.C.F.L.; FARINI, I.O.; AMARAL, C.H.R. Qualidade microbiológica de águas minerais. **Ciencia e Tecnologia de Alimentos**, v.23, p.190-194, 2003.

USEPA, 2002. **Flow calibration tutorial**. Disponível em: <www.epa.gov/waterscience/ftp/basins/training/tutorial/storm.htm>. Acesso em: 07 jul. 2008.

VARNAN, A.H. & SUTHERLAND,J.P. Bebidas: tecnologia, química e microbiologia. Acribia. Zaragoza, 1994.487p.

YAGOW, G.; SHANHOLTZ, V. Procedures for indexing monthly NPS pollution loads form agricultural and urban fringe watersheds. In: WATERSHED 96. Disponível em: <www.epa.gov/owow/watershed/Proceed/yagow.htmL >. Acesso em: 07 jul. 2008.