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Scientific paper

Seasonality influence on water quality parameters of Lavapés River and tributaries

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Abstract

This study was conducted in Botucatu, São Paulo, Brazil, and had as objective to assess the influence of seasonality on the water quality and flow of the Lavapés River and its tributaries. It were analyzed three physic-chemical parameters of water, namely electrical conductivity (μS cm^{-1}), pH and temperature (ºC). The measurement was performed on two occasions: being the first in September 2011, during the dry season, and the second in December of the same year, during the rainy season. The results showed a positive correlation between the rainy period, electric conductivity and pH, however, for the physical parameter of temperature there was no significant correlation. It is concluded that the seasonality, represented in this study by the transition between rainy and dry season significantly influence the physic-chemical parameters of the rivers and streams waters, since that, the onset of the rains leads to important alterations in the landscape, as the increase of surface runoff and flow in the water courses.

Keywords: rainfall, runoff, soil leaching and ions input.

Influência da sazonalidade na qualidade da água do rio Lavapés e afluentes

Resumo

O presente trabalho foi realizado no município de Botucatu, São Paulo, Brasil, e teve o objetivo de avaliar a influência da sazonalidade na qualidade da água e na vazão do rio Lavapés e afluentes. Foram analisados três parâmetros físico-químicos da água, a saber: a condutividade elétrica (μS cm^{-1}), o pH e a temperatura (ºC). As medições foram realizadas em duas oportunidades, sendo a primeira em Setembro de 2011 durante a época seca e, a segunda, em Dezembro do mesmo ano durante a época chuvosa. Os resultados mostraram uma correlação positiva entre a ocorrência de chuvas, condutividade elétrica e pH, no entanto, para o parâmetro físico temperatura, não houve correlação significativa. Conclui-se que a sazonalidade, representada neste trabalho pela transição entre as épocas seca e chuvosa, pode influenciar significativamente os parâmetros físico-químicos da água de rios e córregos, uma vez que, o início das chuvas, provoca importantes alterações na paisagem, como o aumento do deflúvio superficial e o incremento de vazão nos cursos d'água.

Palavras chave: precipitação, escoamento superficial, lixiviação e aporte de íons.

Influencia de la estacionalidad en la calidad del agua del río Lavapés y afluentes

Resumen

El presente trabajo se realizó en Botucatu, São Paulo, Brasil, con el objetivo de evaluar la influencia de la estacionalidad en la calidad del agua y del caudal del arroyo Lavapés y afluentes. Se analizó tres parámetros físico-químicos del agua, siendo, la conductividad eléctrica (μS cm^{-1}), pH y la temperatura (°C). Las mediciones se realizaron en dos ocasiones, la primera en septiembre de 2011 durante la estación seca y la segunda en diciembre del mismo año, durante la temporada de lluvias. Los resultados mostraron una correlación positiva entre la ocurrencia de las precipitaciones, la conductividad y el pH, sin embargo, para el parámetro físico temperatura no hubo ninguna correlación significativa. Se concluye que la estacionalidad, representada en este trabajo por la transición entre la época seca y lluviosa, puede influir significativamente en los parámetros físico-químicos del agua de los ríos y arroyos, ya que el inicio de las lluvias, causa grandes cambios en el paisaje, como aumento de la escorrentía y del flujo de los cursos de agua.

Palabras clave: precipitación; escorrentía; lixiviación; contribución de iones.

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Introduction

The availability and water quality are indicators of human development in a region; therefore, this are related with the economical, social, cultural and environmental development of a community, with positive or negative reflexes in the life quality, as lack of water, disease proliferation, with losses to the health of the involved communities.

The Lavapés River, main water body which composes the watershed of the Lavapés, in the city of Botucatu, has its headwaters within the municipality boundaries, and its mouth in the Barra Bonita dam, Tietê River (VALENTE et al., 1997).

Through the historical process of urban development of the city, the pressure over the Lavapés River, with the dispose of domestic sewage, water of industrial use, diffuse pollution and destruction of the riparian vegetation constituted some of the important factors which contributed for the actual situation of degradation which characterizes the same.

The inadequate use of soil and water has provided an increase of the degraded areas and altered the quality of the water available in all world regions (RODRIGUES, 2001).

The water quality is a term which that do not restricts to determination of the purity of the same, but to its desired characteristics for its diverse uses. Both the physic-chemical characteristics as for the biological ones of the water can be altered. In most of the cases, this alteration is caused by the pollution, which can have many origins. Alterations in the aquatic system conduct to economical losses for the regions, which goes from the reduction of fishing to the increase of expanses with water treatment (LIMA, 2007).

The search for ways for the rational management of water considering quantity, quality and distribution are urgent (RICHTER and NETTO, 1991). This urgency also is necessary as for the comprehension that which water body is associated to a basin, i. e. to an area naturally defined and shared, where must occur the protection of its natural resources, from which life is dependent. Despite the increase in consciousness and the creation of the Water Basin Committees, Consortiums, Non Governmental Organizations and of the studies done by different universities, nothing is definitive before the complexity which involves the management of water basins (NAYME, 2008).

The use of water quality indicators consists in the use of variables which are in correlation with the alteration that occurred in the micro basin, being these of anthropogenic or of natural origin (TOLEDO, 2002). Each lotic system posses its own characteristics, what makes difficult to establish one single variable as an standard indicator for any water system. In this sense, the search in field work consists in the obtainment of water quality indexes which briefly and objectively reflect the changes, with emphasis for the human interventions, as the agricultural, urban and industrial use (COUILLARD and LEFEBVRE, 1985).

The water quality is basically defined through the analysis of physic-chemical and microbiological parameters, being normally analyzed through laboratory tests. Some physic-chemical parameters as electric conductivity, hydrogen potential (pH) and temperature, are of easier measurement and correspond to good indicators of alterations in the water resources.

The water temperature plays an important role in the aquatic species control, and can be considered one of the most important characteristics to ensure the survivor and reproduction of these species. The variation range of this parameter must be between 0 and 30 ºC (CETESB, 2006).

The pH influences the natural aquatic ecosystems due to its effects in the physiology of many species. To preserve the aquatic life, the ideal pH must vary between 6 and 9 (ESTEVES, 1998). In its turn, the electric conductivity parameter indicate the existence of ions dissolved in water, which can represent the possible existence of pollution sources. (ZUIN et al., 2009).

As the rain is the main regulator agent of water courses, it is expected that it is also may be an important variable to be considered in studies involving the water quality of rivers and tributaries (SILVA et al., 2008).

In this context, the present study was performed with the objective of assessing the seasonality influence, represented by the transition between the dry and rainy season, in the water quality of the Lavapés River and its main tributaries.

Materials and Methods

The studies were done in the hydrographic micro basin of the Lavapés River in the municipality of Botucatu, São Paulo, Brazil. This micro basin drains great part of the municipality and receives high quantity of domestic and agricultural effluents. Due this, the quality of water from the Lavapés River and the streams of the micro basin is significantly compromised.

The local weather is predominantly classified according to the Köppen system as of Cfa type - hot and humid temperate climate (mesothermal), with annual average temperature of 20.3 ºC, average temperature of the hottest month superior to 22 ºC and average index of annual rainfall of 1428 mm (CUNHA and MARTINS, 2008).

With the use of geoprocessing techniques, were distributed six points of water collect in the Lavapés watershed (Figure 1).

It were analyzed three of the main variables which guide the physicochemical parameters, according to Company of Technology of Environmental Sanitation - CETESB (2006), and in accordance with the Resolution of the National Council of Environment (CONAMA) 357/2005 and other studies. The variables analyzed were defined as follows:

The electrical conductivity is the measure of water's ability to conduct electrical current whose values are expressed in micro Siemens per centimeter (µS cm^{-1}). It is role of the concentration of ions present in the water which can conduct this electric current, but is value, besides depending of the temperature, also differs to each ion (ESTEVES, 1998).

The physic-chemical parameters analyzed (electrical conductivity, pH and temperature) were measured at the time of collection with the aid of a digital meter. Three measurements were made for each parameter and subsequently considered only their respective average value.

After the calibration of the digital meter with the solution of potassium chloride 0,01 mol L^{-1} (1413 µS cm^{-1}), this was used to perform the measurements on the field.

The measurement of the watercourses flow was done with the assistance of a digital Flow Probe gaging, which was submerse and kept at a distance of approximately 20 cm of the river bed (flow measurement at ford). Thus, the speed and the water level were measured in different points of the normal bed of the river, as well as distance between each point and the margin.

Given these data, it was generated a model of the cross section of the river (figure 2) with the areas of influence of the vertical measures which, allied with the profile of velocities of water, allowed the estimation of flows for all watercourses studied.

The area of each spillway was obtained through the different highs of the water, where were generated polygons. The different areas of the generated polygons were denominated of A1, A2, A3 and A4. For the flow calculations was used the sum of these area, denominated of total area. (TA).

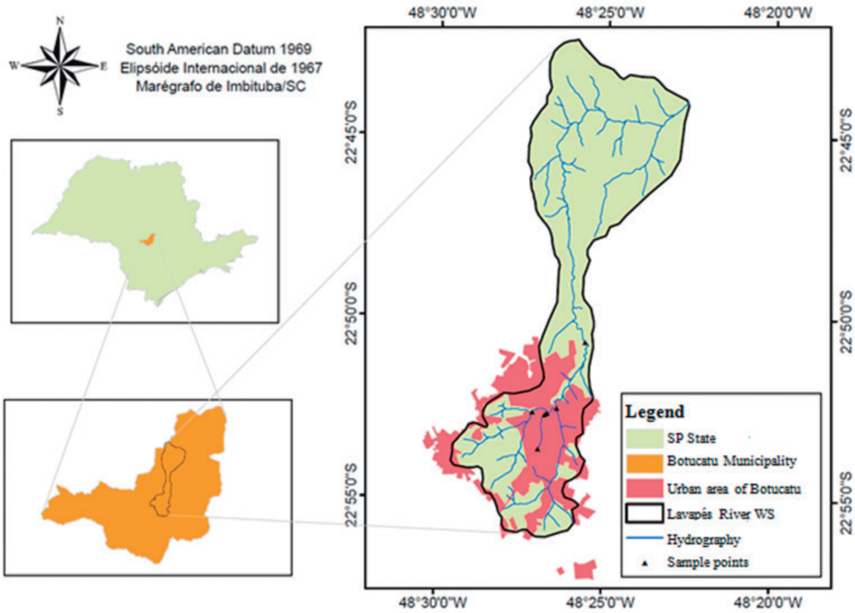

Figure 1. Localization of study area.

Table 1. Localization of points of sampling.

Points of sampling	Latitude	Longitude
Tanquinho headspring (NT)	-22°53'38''	-48°26'24"
Tanquinho mouth (FT)	-22°52'42"	-48°26'24"
Água Fria headspring (NAF)	-22°52'38"	-48°27'00"
Água Fria mouth(FAF)	-22°52'40"	-48°26'24"
Tanquinho/Água Fria intersection (TAF)	-22°52'31"	-48°26'24"
Lavapés "incubator" (LI)	-22°50'41"	-48°25'12"

* *Horizontal Datum: WGS 84.*

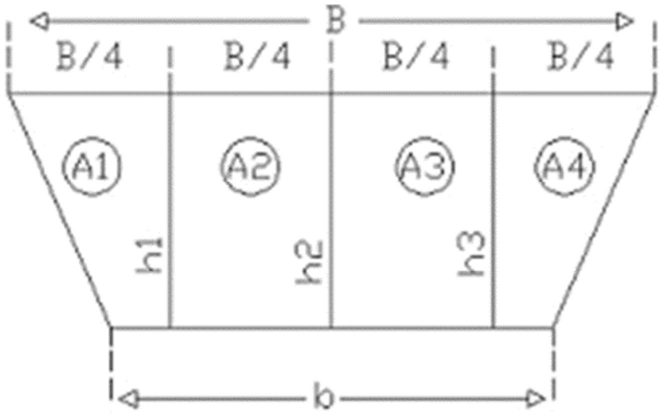

Figure 2. Scheme of the dimensions of a canal, where: h=height; B - larger base of the trapezoid, b = minor base of the trapezium, A1, A2, A3 and A4 = area of each section.

With these two variables: spillway area (A) and water velocity (V) was possible to obtain the flow of the water flux drained per unit of time in (L s^{-1} and m^3 s^{-1}), it was calculated the flow (Q) of each water course, in the moment of sample collection, according with the equation: Being: Q = Flow (L s^{-1} or m^3 s^{-1}); A = sectional area of the channel (cm^2 or m^2); V = water velocity (cm s^{-1} or m s^{-1}).

All this procedures of data collection for the flow calculation and sampling of the water courses were performed in two seasons, being the first after a prolonged period of dry and the other soon after a rainy period.

The procedures of data collection for the flow calculation and measurement of physic-chemical parameters at the sampling points were performed on two occasions, being the first during the dry season in September 2011 and the second during the rainy season in December of the same year.

Results and Discussion

In Figure 3, are presented the data referring to the average monthly precipitation in the municipality of Botucatu for the year of 2011, collected at the Meteorological Station of Lageado Experimental Farm - FCA / UNESP.

It is noted through Figure 3 that the rainy season extended from January to April, restarting in October and extending through December. Now, the dry season began in May and lasted until the month of September, which precipitation was of zero mm.

The accumulated rainfall in 2011 was 1892.98 mm, especially for the month of January which presented the highest average rainfall of the history of Botucatu, with 712.25 mm.

The values of the physic-chemical parameters analyzed, as well as the flow of each water course, referring to the dry (A) and rainy season (B), respectively in September and December of 2011, are presented in Table 2.

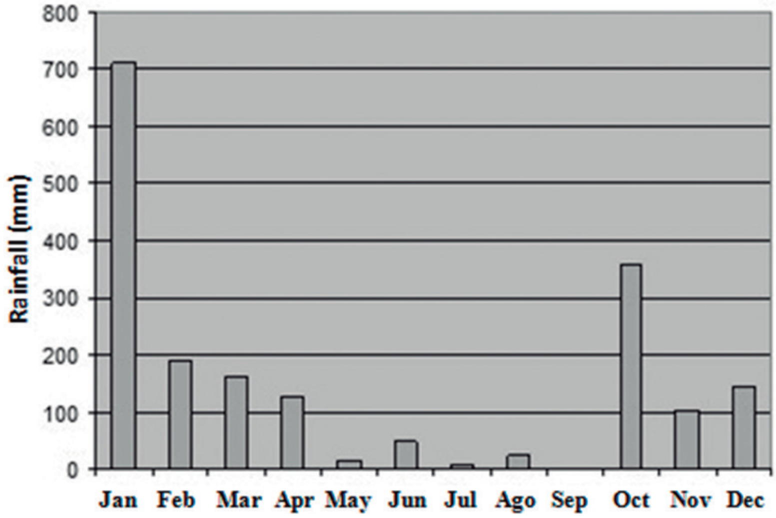

Figure 3. The average monthly precipitation in Botucatu, year of 2011.

Table 2. physic-chemical parameters of water and flow of the water courses in the dry and rainy seasons, respectively in September and December of 2011.

Parameters	Conductivity (μS cm⁻¹)		pH		Temperature (°C)		Flow (L s⁻¹)	
Pontos	A	B	A	B	A	B	A	B
1º NT	137.3	357.7	7.1	7.3	21.5	22.0	8.4	14.4
2º FT	124.3	226.7	7.3	7.6	20.3	21.6	31.4	37.4
3º NAF	90.3	118.7	6.7	7.1	21.2	21.0	153.9	193.1
4º FAF	97.3	117.0	7.0	7.1	20.4	20.9	217.5	252.3
5º T/AF	104.3	139.0	7.5	7.5	20.1	21.6	512.0	627.2
6º LI	96.0	135.7	7.8	7.9	22.2	21.1	564.4	784.0

Dry season (A), rainy season (B), 1º Tanquinho headspring (NT), Tanquinho mouth (TF), 3º Água Fria headspring (NAF), 4º Água Fria mouth (FAF), 5º Tanquinho/Água Fria intersection (T/AF), 6º Lavapés "incubator" (LI)

3.1. Analysis of Electrical Conductivity

The electrical conductivity of water is a measure of the capacity to conduct electrical current, being proportional to the concentration of dissociated ions in an aqueous system (ZUIN et al., 2009).

The water courses in the study receive a high amount of domestic sewage. Such sewage originates mostly from residences and is composed primarily of urine, feces, uneaten food, soap, detergents and washing water, containing a high amount of organic material, which contributes to the entry of ionic species into the water such as: calcium, magnesium, potassium, sodium, phosphates, carbonates, sulphates, chlorides, nitrates, nitrites, and ammonia, among others (GUIMARÃES and NOUR, 2001).

In the dry season, the collection point Tanquinho Headspring was the one with the highest values for electrical conductivity, with an average value of 137.3 $\mu Scm^{-1}cm^{-1}$. On the other hand, the collection point Água Fria Headspring had the lowest average value, with 90.3 $\mu Scm^{-1}cm^{-1}$.

During the rainy season, the electrical conductivity increased significantly in all the sampled points. The sampling points in the Tanquinho stream were those that presented more alterations, being that the average values of conductivity achieved

357.7 μS cm at the sampling point of Tanquinho Headspring and to 226.7 μS cm^{-1} at the sampling point of Tanquinho Mouth.

This situation can be explained by the increased of surface runoff due to the onset of rains, combined with lack of vegetation on the margins of the rivers and streams. The absence of permanent preservation areas favors the supply of ions into the riverbed, since leaching of soils occurs without impediment, promoting the pollution of these water sources by agricultural and urban diffuse loads.

In general, the urban surface runoff contains all the pollutants that are deposited on the surface of the soil. When occurs rainfall, accumulated materials in ditches, culverts, etc., are carried by rainwater to the streams, constituting in a source of larger pollution as deficient is the sewage collection or street cleaning (LACERDA, 2004).

For this authors, now, the agricultural surface runoff, presents different characteristics. Its effects depends on the agricultural practices used in each region and time of the year in which is done the preparation of the soil for the sowing, the application of fertilizers, pesticides and the harvest .

Considering that in the present work were not done analyzes of the chemical compounds solubilized in the sampled water and which the studied rivers drain both agricultural and urban areas, was no possible to determine the real cause of the elevation in the registered values for the electric conductivity. However, this parameter showed directly related with the rainfall.

Differently from what occurred in this work, some authors have reported a decrease in electrical conductivity values due to higher entry of water into the system, resulting in dilution of the ionic compounds. (POMPÊO et al., 1997; MOSCHINI-CARLOS et al., 1999; MELO, 1995).

3.2. Analysis of Hidrogenionic Potential (pH)

According to ZUIN et al. (2009), the pH is an important parameter which, along with others, can provide signs of the pollution level, metabolism of communities or even so impacts on an aquatic ecosystem. Most of the continental water bodies present a pH ranging between 6 and 8, however, it can be found more acidic or alkaline environments (ESTEVES, 1998).

ESTEVES (*op. cit.*) states that in the majority of natural waters the pH is influenced by the concentration of H^+ originated of the dissociation of carbonic acid, which generates low values of pH, and from the reactions of carbonate and bicarbonate ions with the water molecule, which increase the values of pH to the alkaline range.

After the calibration of the digital meter with buffer solution, it was measured the pH of the field samples. During the dry season, the minimum average value was of 6.70 for the sampling point Água Fria Headspring and the maximum average value was of 7.77 for the point of sampling Lavapés Incubator.

In the measurements done in the rainy season, the values of pH increased in all sampling points, being that the minimum average value was of 7.07 for the sampling point Água Fria Mouth and the maximum average value was of 7.88 for the sampling point Lavapés Incubator.

According with CARVALHO et al. (2000), with the increase of the rains the pH tends to rise and approximate to neutrality, because occur greater dilution of the compounds and faster runoff, causing the decrease of the water acidity. As in the second measurement all the studied rivers presented greater pH in its waters, we conclude that this parameter presents direct relation with the occurrence of rains.

3.3 Analyzes of the temperature

The temperature determines several chemical, physical and biological processes which occur in an aquatic system. MATHEUS et al. (1995) states that the majority of animal and vegetal species has defined demands as for the maximum and minimal tolerated temperatures, being the variations of the water temperature part of the natural weather regime, influencing the metabolism of the aquatic communities, as primary productivity, respiration of the organisms and decomposition of the organic matter.

To CARVALHO et al (2000), there is a meaningful relation between the increase of water temperature and the electric conductivity, which can occur from the reactions triggered in the aquatic fauna in face of the temperature increase.

During the dry season, the minimum average value found was of 20.1 °C for the point of sampling Tanquinho/Água Fria Cross and the maximum average value obtained was in the point of sampling Lavapés Incubator with 22.2 °C. Now, in the rainy season, the minimum average value of temperature was found in the point od sampling Água Fria Mouth with 20.9 °C and the maximum average value found was in the point of sampling Tanquinho Mouth with 22.0 °C.

In four of the six points of sampling the values of temperature increased, and in the points of sampling Água Fria Mouth and Lavapés Incubator the temperatures decreased, having no meaningful correlation of the physical parameter of temperature with the pluviosity for the sampled points.

However, many authors observed that the temperature of the water during the rainy season is greater when compared with the dry season (DONADIO et al., 2005; OLIVEIRA et al., 2008; ZANINI, 2009).

Probably, the observed increase in the water temperature for these authors is the result of the increase in the average air temperature, which is greater in the summer. If this proposition is true, it would explain the occurred with the registered values for the physical parameter of temperature in this study, since in the week that was performed the measurements of the rainy season, the daily temperatures registered in the municipality of Botucatu were lower than the averages registered for this period.

3.4. Analyzes of the Flow

The flow is the result of a process of interaction between the rainfall and the physiographic conditions of the micro basin area. It is understood that the variation of the flow in the studied rivers, considering the dry and rainy seasons, is the result of the greater runoff by direct runoff, higher flux of base and of the direct rainfall in the channels, resulting in higher flows during the rainy season (TUCCI, 2009).

The increases in the flow of rivers in the rainy season were of: 6.0; 6.0; 49.8; 34.8; 115.2; e 218,6 (L s^{-1}), respectively in the measurement points Tanquinho Headspring and Mouth, Água Fria Headspring and Mouth, Tanquinho/Água Fria Cross and Lavapés Incubator.

It's noteworthy that the point Lavapés Incubator receives water from the other five studied points and from another tributaries not covered by the study, justifying the largest increase in flow between all studied rivers. It is also observed that beyond increase the flow, there is a slight increase of the electric conductivity and pH of the point 4º Água Fria Mouth (AFM) for the point 5º Tanquinho/Água Fria Cross (T/AF).

Conclusions

The analysis of the obtained results allows us to conclude that clearly exist a positive relation between the occurrence of rainfall, electric conductivity and pH, whereas that, for the physical parameter of temperature there was now meaningful correlation.

It is understood that the rain water is responsible for the leaching of the soil, with consequent entrainment of sediment, organic material, garbage and other materials directly to the river beds, resulting in higher supply of ions to the system and higher values of electrical conductivity.

The increase of flow in the water courses acts in the dilution of solubilized compounds, promoting a decrease of acidity and consequent increase in the values of pH in the water.

The water temperature is directly affected by the air temperature, which is greater in the summer. The occurrence of rains, analyzed alone, do not causes meaningful changes in the water temperature.

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