THE INFLUENCE OF SAMPLING FREQUENCY AT THE QUANTIFICATION OF POLLUTANT LOADS IN THE DESCOBERTO RIVER – DISTRITO FEDERAL, BRAZIL

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INTRODUCTION

River basin water quality monitoring systems, essential activity for the water management, involves lots of variables to be evaluated in the sense of allocating operational and financial resources that makes it an optimized project. Some researches, however, are developed to establish the minimal networks for monitoring watersheds that turns viable it implementation, even in small basins.

Design water quality network monitoring involves three major activities: selection of the water quality indicators; allocation of the sample's points; and the frequency of sampling activity. The first step is well known, whereas the followings have been done based on the knowledge of the watershed and by try and error. These need to be more studied to make it systemize.

To point out the step of choosing the frequency of the sampling activity, this paper aims to verify the influence of some sample's frequencies for the quantification of the pollutant loads in the Descoberto River Watershed, Federal District - Brazil, regarding the objective of subsidizing the sample's frequency definition in ungaged basins.

The Descoberto River Watershed is an area of assorted land use as well as conservation practices, with increasing development in recent years. This watershed is also the main water supply source for the Federal District and, consequently, there is a strong interest on the impact assessment of increasing human activities over the river water quality.

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The comparison of different strategies of sampling frequency, established by the Water and Wastewater Company and the refined frequency of this study at the Descoberto River Watershed, shows its influence for the river pollutants quantification.

WATERSHED LOCATION AND DESCRIPTION

The Descoberto River Watershed is predominantly an upland rural watershed of 1,200Km^2, located in the western Federal District (Figure 1).

Figure 1 – The localization of the Descoberto River Watershed.

The Descoberto river begins at the junction of the Barrocão and Capão da Onça streams. After 15Km and the contribution of tributaries, there's a dam that makes the Descoberto Lake. This is the main source of water supply of the capital of Brazil. Downstream the lake, the Melchior River flows into the Descoberto River. The Melchior is the receptor of all the wastewater, without treatment (at the time of this research) of two main urban areas at the watershed – Taguatinga and Ceilândia – estimated on 600 mil inhabitants).

Downstream this point, the Melchior River receives the effluents of treated wastewater of Samambaia (another urban area).

Following the Descoberto river, it goes into the Corumbá River, which is an hydroelectric source: Corumbá IV, and pointed on by the government as the main future water supply source for the Federal District.

According to Köppen classification, the climate of the Federal District is classified as **A**, between the tropical of savannah and temperate. It is characterized by two seasons a raining and hot one, which is from october to march, and a dry and cool, from april to september. Average annual precipitation is about 1,600mm; and the temperature varies around 18 and 28^{O}C, whereas the relative umidity is 70% at the raining station and 15% at the dry one. The land surface elevations in the watershed range from approximately 900 and 1,300m above mean sea level.

AVAILABLE DATA AND FREQUENCY PRE-DEFINITION FOR THE DESCOBERTO WATERSHED

The definition of the sampling frequency is an activity that depends upon the objective of the program, the resources (technical and financial), the characteristics of the watershed, the variability of the pollutants, and others.

The temporal variability of the water quality has been recently focused like the main factor in the definition of the sampling frequency. This consideration, however, deserves a previous knowledge of the variables, for a period of time, that turns difficult the adoption of this methodology at the ungaged basins.

According to Sanders *et al.* (1994), considering the normal distribution for the values of water quality, and a year of monitoring, the number of samples can be defined by the following equation:

$$n = \left(\frac{Z_{\alpha/2} * \sigma}{Erro} \right)^2$$

where : $Z_{\alpha/2}$ – tabled value of the normal distribution;

σ - standard deviation;

Error – error admissible.

Applying this equation, and at the data collected by the Water and Wastewater Company, the annual number of samples required at the exit of the Descoberto Reservoir was about <u>fifteen *per* year</u>.

Soares *et al.* (2001) adopted the theory of Pomoroy and Orlob (1967) and defined some equation to define the sampling frequency based on the slope of the basin. Considering that methodology, the annual number of samples at the exit of the Descoberto Reservoir was <u>seven *per* year</u>. The expression used for this determination was:

$$\text{Number of samples} = 0{,}9855 * \text{area}^{0{,}3289} \quad \text{(equation defined for slope of } 0{,}0095\text{m/m).}$$

These two methodologies shows how big can be the variation of frequencies adopted for the same study case, depending upon the considerations done by the designer of the network monitoring system. For the first one, the Pomeroy and Orlob (1965), modified by Soares (2001), the number of samples is too small compared with the statistic methodology. In fact the Pormeroy and Orlob methodology is quiet simplistic, with only two index of the watershed considered – area and slope. The statistic methodology, on the other hand, proposes a large amount of samples, which could turn unavailable the implementation of the water quality monitoring program.

The desirable situation to apply the existent methodologies is to have minimal knowledge of the temporal variability, this is acquired analyzing the results critically, looking for the optimum sampling frequency, based on the objective of the monitoring program.

METODOLOGY

The pollutant loads variation is more perceived at the raining station, due the drainage in the watershed and the mixed of the benthonic cover, sediments and particulate material. The adoption of a smaller frequency as sampling strategy can better show the real scenario of the water quality all over the time, but the cost of this is the limited factor. In terms of quantification of pollutant loads, the question is what it means, the lose of information, when the frequency is bimonthly, monthly, six times *per* year or three times *per* year, for example.

To accomplish the objective of this study, it was considered three frequencies of evaluation: monthly, six times a year and three times *per* year, and compared with the bimonthly strategy. Some river's sections have been chosen and two pollutant loads analyzed – BOD and Total Phosphorus.

Daily streamflow data, measured by stream gauges at the four existing sampling locations, were taken from March 2003 to March 2004. Despite the data collection routine, additional composite samples have been taken during various storm events from November 2003 to February 2004 at the four sampling locations. Considering the limitations and purposes of this paper, it will be shown the results of only one location: the exit of the Descoberto Reservoir.

RESULTS

By the analysis of the graphics shown at the figure 02, it can be concluded that for the dry period the load of BOD is about 70 ton, whereas the same pollutant at the raining period is 80 tons, as can be observed at the figure 03. This difference can be explained by the drainage in the watershed.

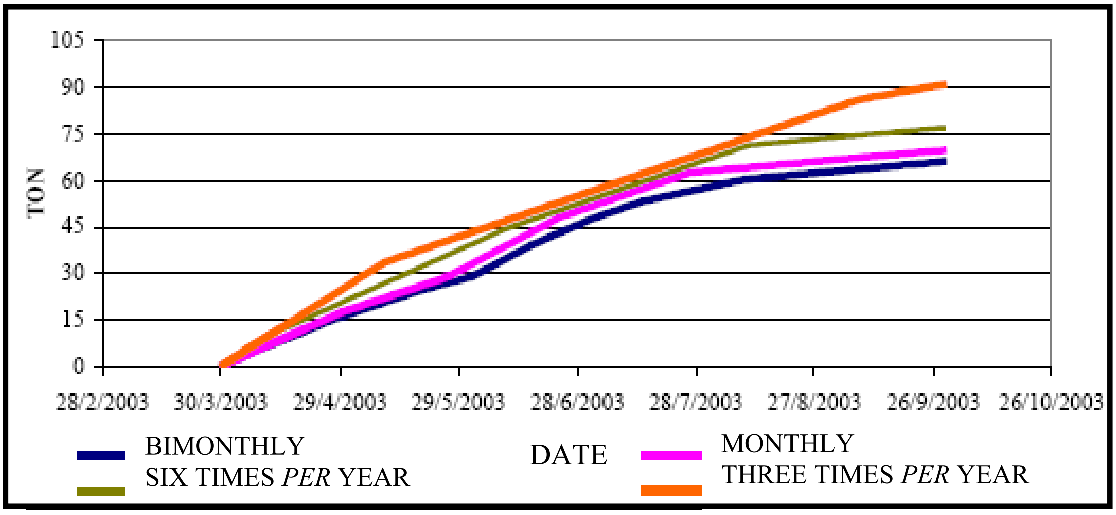

Figure 02 – Load of BOD during the dry period, at the exit of the Descoberto Reservatory.

The influence of the sample strategy, in terms of frequency, in this case, isn't significant at the dry period, however, at the raining period, due the load carried by the runoff, there are important variation between the six or three times *per* year, in comparison of the bimonthly or monthly frequency of sampling.

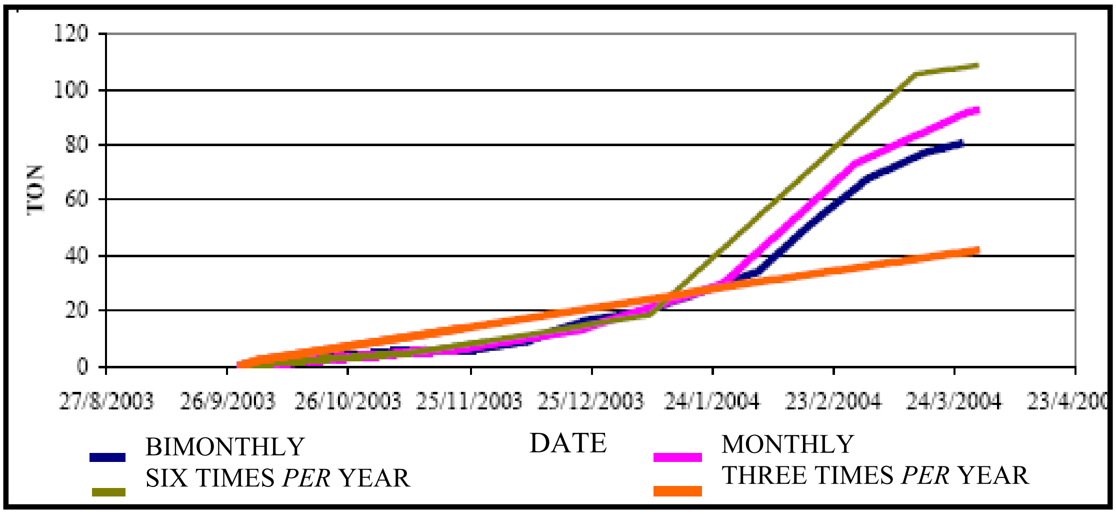

Figure 03 – Load of BOD during the raining period, at the exit of the Descoberto Reservatory.

Considering the phosphorus load for this section, for the dry period the values are small, approaching 0,004 ton a day. At the raining period, it grows due to the runoff contribution.

For the dry period, the quantification of phosphorus has been less affected by the frequency when it is considered the monthly or six times *per* year strategies. For the three times *per* year frequency, the prediction was bad in comparison with the bimonthly prediction. (See figures 04 and 05)

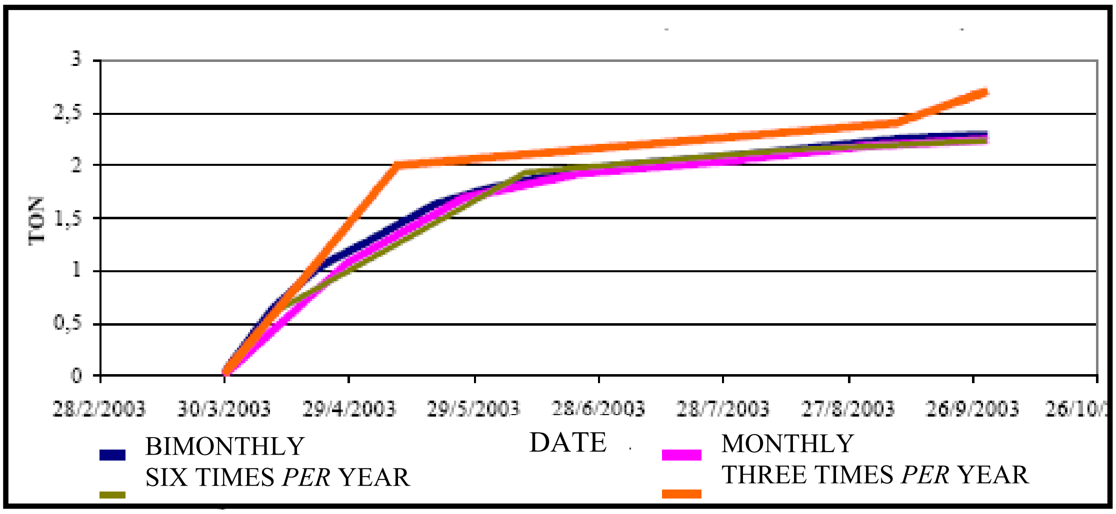

Figure 04 – Load of phosphorus during the dry period, at the exit of the Descoberto Reservatory.

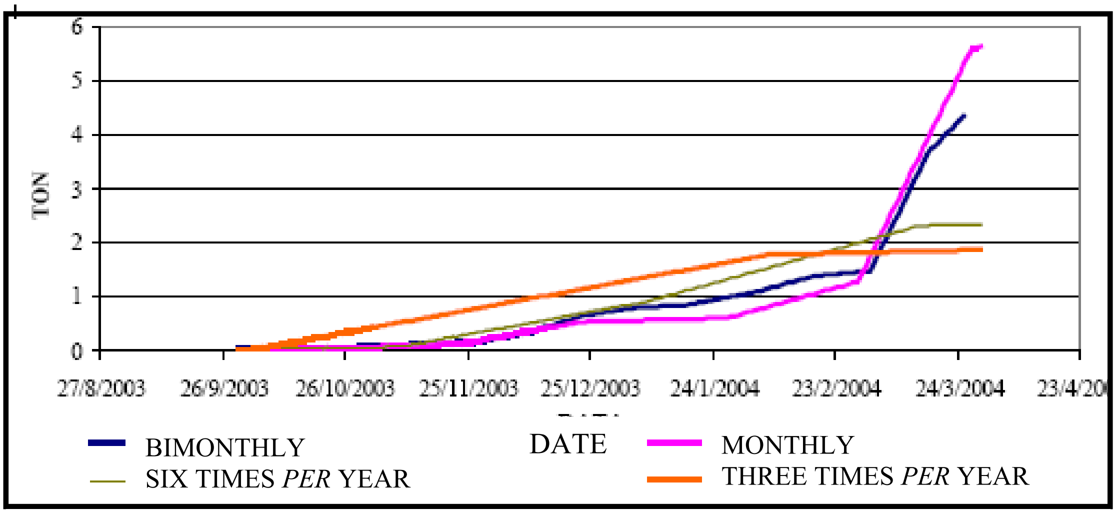

Figure 05 – Load of phosphorus during the raining period, at the exit of the Descoberto Reservatory.

CONCLUSIONS

The stage of definition of sampling frequency is of great interest in terms of exploratory studies in the field of water quality network monitoring system. As it involves costs that should be considered at the decision making process. However, the experience shows that fixed frequencies of sampling are generally adopted. Depending on the intention of the study, the consideration of supplemental samples at flood flow periods is efficient.

In the case of study presented in this paper, the basin of the Descoberto River, had been analyzed by the fixed frequencies of sampling - biweekly, monthly, bimonthly and three times *per year*, and composite samples have been taken during various storm events during the raining period – from November 2003 until Feburary 2004, for load estimation and survey of pollutants. As result, it was gotten that, for dry periods, the bimonthly fixed frequency is efficient, while that at the rainy periods the indication is of the monthly fixed frequency.

It is also important to point out that the definition of the sampling frequency of a water quality network is a complex activity and that there isn't any universal standard methodology for this activity. The tool statistics is efficient when the historical series are known. For basins without historical series, the methodology of Pomeroy and Orlob (1968) can be an initial indication. The knowledge of the designer on the mechanisms of behavior of the basin, as well as the clear definition of the objectives of the project, is the main factors for the determination of a good strategy of sampling.

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