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THE ISSUE OF QUALITY OF STORMWATER: ANALYSIS OF DIFFUSE LOADS IN BRASILIA, DISTRITO FEDERAL, BRAZIL

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ABSTRACT: The water quality in water bodies can be affected during rainy seasons due to contribution of stormwater contaminated by diffuse pollutant loads from runoff generated by precipitation events carries the pollutants, accumulated during dry periods. Therefore, it was aimed in this study to evaluate the pollution loads from stormwater in countries like Brazil, where domestic sewage have a separated collection network and stormwater are discharged directly into water bodies without any treatment. Hydrology data (rain and flow) and to water quality data (Suspended Solids, Organic Matter - COD, nutrients - nitrogen and phosphorus) were collected during two rainy seasons (2012 – 2014) in Brasília, Brazil, with defined rainy and dry seasons, and mean rainfall of about 1500mm (Inmet, 2010). After two years monitoring stormwater in two small urban watershed which discharged in the Paranoá Lake, it was observed that the pollution of urban waters is related to the rainfall intensity, the number of days between their occurrence and spatial distribution and also varying according to the use and occupation of land in the urban watershed, which vary significantly, even in small areas. Highest loads were observed during the more intense events, reaching, levels in the range of the existing wastewater treatment plant loads like in the extreme event of November 2012 in which the loads reached values of 31.44kg/day/ha of SS, 36.89kg/day/ha of COD and 3kg/day/ha of nutrients. It can be noted that the problems and inconveniences caused by the floods goes beyond the level of the water or flooding, because their final destination pollute the water resources of the cities. Thus, in places where these loads are significant like in the studied area is important to adopt sustainable techniques in order to reduce diffuse pollution and the effects of urbanization on the hydrological processes and water quality.

Key Words: diffuse pollutant, urban watershed, monitoring

1. INTRODUCTION

Brazil is one of the most affected countries by floods in the world. From 1960 to 2008, 94 disasters were recorded with 5,720 deaths and more than 15 million people affected (ANA, 2014). Among the main factors responsible for the increase of natural disasters is the population growth, and the urban disordering. Developing countries, in respect of urban drainage, have unsolved quantitative impacts while the water quality impacts have not been identified (Tucci, 2006). This case is applied to Brazil, including the Brazilian capital, Brasilia.

The impacts on water quality on the receiving water body are severe and cause aesthetic changes, sediment deposits, depletion of dissolved oxygen concentration, contamination by pathogenic organisms, eutrophication damage due to the presence of toxic organisms (Porto,1995).

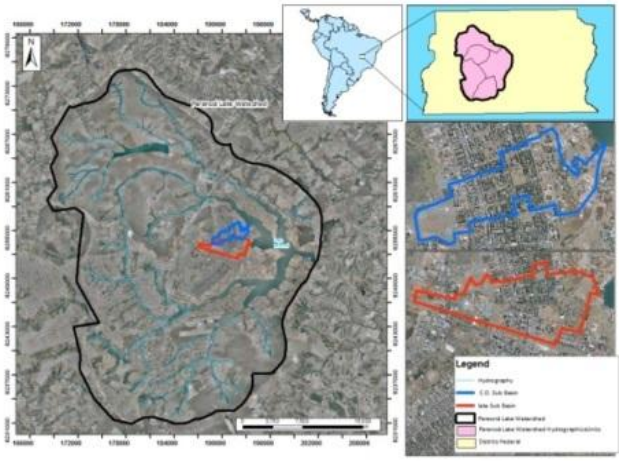
The study was carried out in Brasília, in the Central region of Brazil, where climate can be classified as Tropical Savanna, with two well defined seasons: a dry season, when a great pollutant accumulation in the soil surface occur and a wet season, with an average rainfall of 1500mm, which promotes washoff and carrying of pollutants to the water bodies (Ferrante *et al.*, 2001).

Knowing the temporal distribution of pollutant concentration along the rainfall event is not as important as knowing the total load of pollutants discharged into the receiving water body, so that the damage caused can be mesured. In Australia, urban stormwater in coastal waters were contributing negatively influencing Pacific reefs (Poustie et al., 2011). Since Singapore was harming pollutants the choice of a bay as a possible source, Wong (2011).

This research aimed to evaluate the water quality of storm water, analyzing the pollutants loads caused by diffuse pollution in urban water system in Brasilia, Brazil. This city, like the majority of Brazilian cities, uses the domestic sewage that have a separated collection network and storm water are discharged directly into water bodies without any treatment.

2. MATERIALS AND METHODS

This research happened in two small urban watersheds of Lake Paranoá, C.O. and Iate (Figure 1). They were monitored throughout the rainy season during 2012-2013 and 2013-2014. Both areas are occupied by urban development; however, with different characteristics regarding land use: in the C.O. area, residential and local commercial use is dominant, whereas in the Iate area there are mainly commercial buildings and some building developments.



Characteristics	C.O. basin	Iate basin
Area	5.43sq. km	8.9 sq. km
Length	15.3 km	16.9 km
Slope	2.84%	4.05%
Drainage Network Section	2.2 x 2.2 m	3 x 3 m
Land Use		
Paved Areas	13.5%	15%
Green Areas	45%	30%
Built Areas	41.5%	55%

Figure 1. Map and Characteristics of the Study Area.

Brasilia, like Brazil, in general, did not have data on the diffuse loads. Even being a city that has 100% coverage of water supply and 93% of 100% collection and treatment (Caesb, 2013) in which we use tertiary treatment in WWP in order to remove this nutrient. The adoption of this technology was due to concern for the receiving water body, Lago Paranoá, which will be used as a source of supply.

Seeking the quality of Lake Paranoá, diffuse loads were monitored in order to ascertain the extent of pollution caused by storm water drainage, transportation to serious environmental problems. Therefore, monitoring was planning Performed about flow, rain and water quality in both catchments (Figure 2 and Figure 3). It was installed flow meters (2), and samplers (2), which measures each five minutes in the outfall, whereas the rain gage (7) were distributed along the area.

Figure 2. Drainage Network in the C.O. basin, outfall detail.

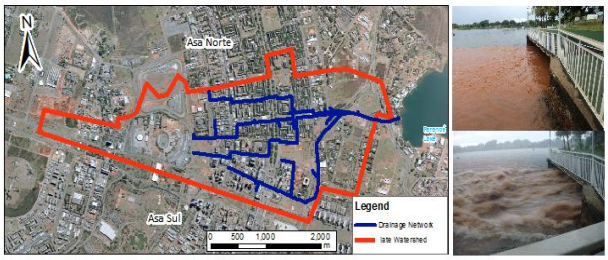


Figure 3. Drainage Network in the Iate basin, outfall detail.

In the studied period, 200 runoff events were recorded by the level loggers and water samples were collected during 63 events, amounting 816 samples. Physical and chemical water quality variables were measured to quantify the pollutant concentration: COD, nutrients (nitrate, nitrite, ammonia and phosphorous), solids (total, suspended and dissolved), turbidity and conductivity.

The water quality data were calculated by means of diffuse loads of pollutants discharged into Lake Paranoá the two drainage galleries for each event, whether extreme or not, ie, whether or not causing floods along the basin. The rates were scaled kg / ha / day, using Equation 1 in order to measure the pollutants that dock in the water body.

$$\boldsymbol{Load = \overline{Flow} x \overline{Concentration}} \qquad \text{Equation 1}$$

3. RESULTS

The results were divided by sub-basin and year of monitoring, which are shown loads of total phosphorus (Pt), Nitrogen (N, sum of all nitrogen nitrite, nitrate and ammonia), suspended solids (SS) and organic matter (COD).

In the CO sub-basin pollution loads are quite high, as seen in Figure 4. It was possible to collect data during the event on 11/19/12, whose return period was equivalent to 72 years, which caused extensive damage in the studied basin. Thanks to the intensity and duration of events, 133,77kg/ha/day were recorded SS, 39.83kg/ha/day of COD, 0.284 kg/ha/day and Pt 1.62 kg/ha/day N.

These data are shown in Figure 4. Peaks refer to the before mentioned events, surpassed in the amount of SS launched out in the event 11/17/12, whose intensity was 5.4 mm/h for 240 min. It is noticed that there is initially a greater discharge of pollutant loads, caused by soil washing after the dry season. It is also evident that extreme events despite having a lower frequency are responsible for large diffuse pollution reaching Lake Paranoá.

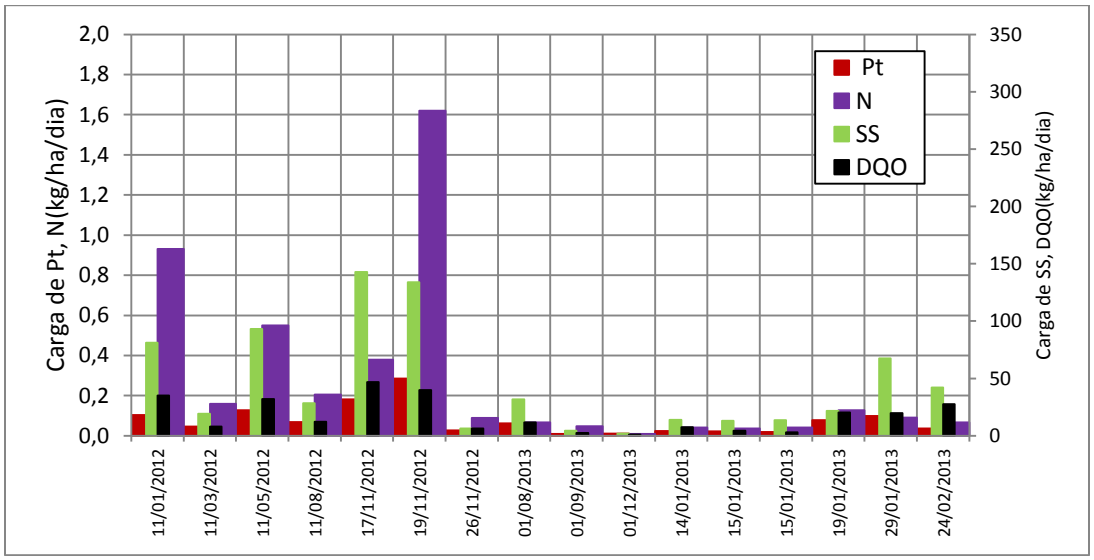


Figure 4..Pollutant Loads at CO basin during the monitoring 2012-2013.

With these data it was possible to determine the incidence of sewage releases in the drainage gallery, observed by the analysis of the concentration of N, Pt and COD (Figure 5 a Figure 7). In these graphs it is evident that there is an incessant source, and the observed parameters, it is possible to state that it corresponds to domestic sewage. As for the data of N, we realize that there is a reduction of the peaks of the beginning of the rainy season, which can be attributed to the washing of pollutants at the beginning of the rainy season, due to accumulation in the use and occupation of the dry season.

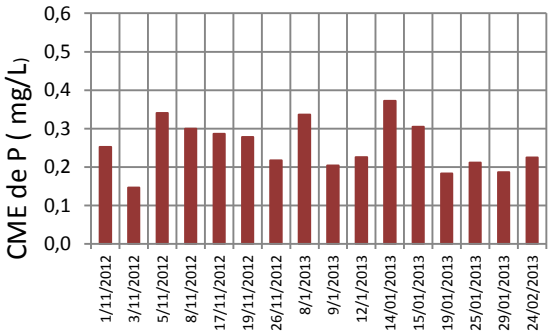


Figure 5. CME Pt at CO.

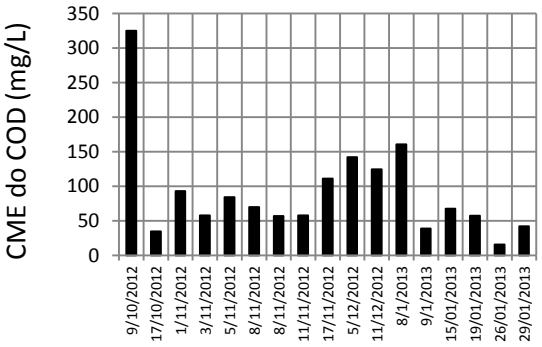


Figure 6. CME of COD at CO.

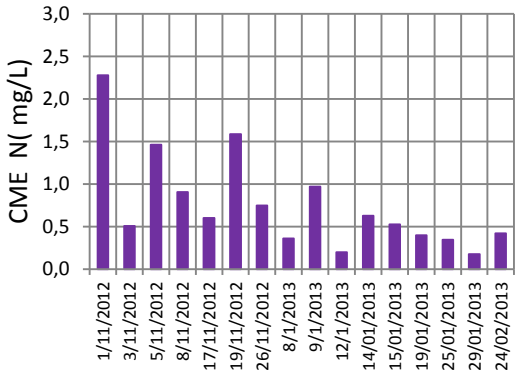


Figure 7. CME N at CO.

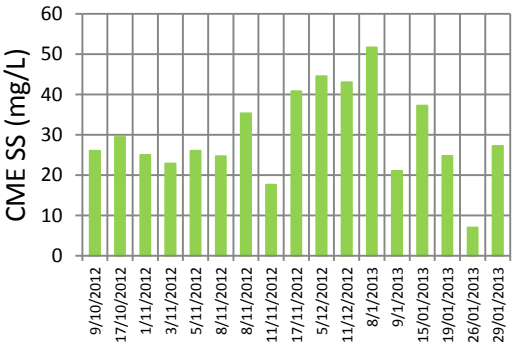


Figure 8. CME SS at CO.

With no less importance, the events decrease time to return, discharge significant loads of pollutants, as shown in Figure 8, in which event all have less than 1 between 2013 and 2014. These data the maximum values corresponding to SS 214 kg/ha/day 0.145 N kg/ha/day 33.8 kg COD/ha/day Pt and 0.209 kg / ha / day.

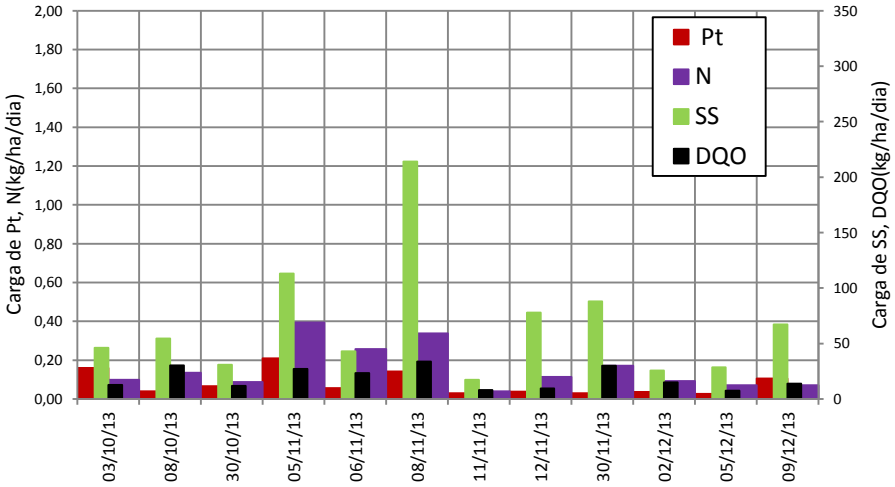


Figure 9.Pollutant Loads at C.O. basin during the monitoring 2013-2014.

Analyzing the data collected in the sub Iate Basin, one realizes that the diffuse loads are higher in all four types of pollutants analyzed, compared with the CO sub-basin. The use and occupation of the soil of this basin is similar, but during the monitoring it was observed the presence of several buildings, which explains the high rate of SS, 112.66 kg/ha/day average and maximum 314.43 kg/ha/day value close to the maximum shown in CO (Figure 9).

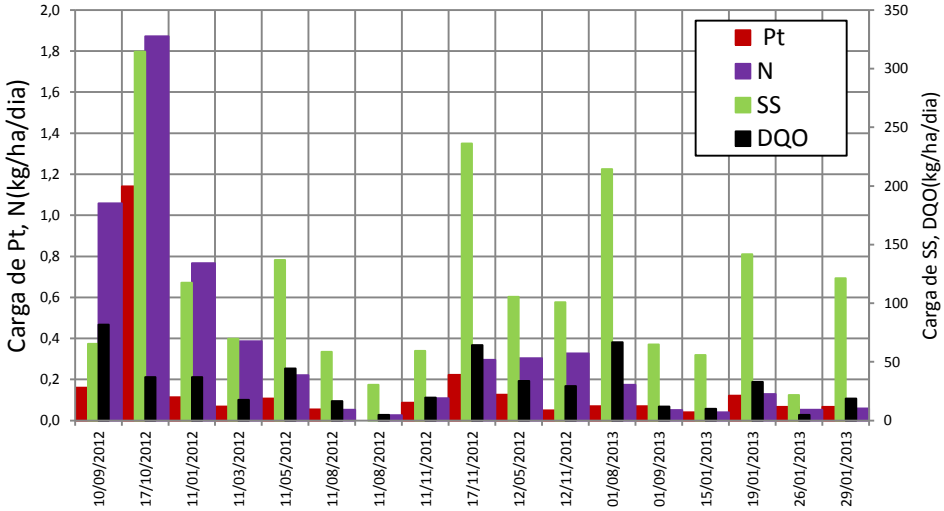


Figure 10.Pollutant Loads at Iate basin during the monitoring 2012-2013.

It was noticed a change in the monthly distribution of rainfall between the years analyzed, as can be seen in Figure 11, which consequently influences the discharge of diffuse loads on Lake Paranoá. The precipitation in the hydrological year 2012/2013 rain concentrated in the months of November and

January, while the following year, the rainiest months are December and March, in the latter there was no monitoring of water quality.

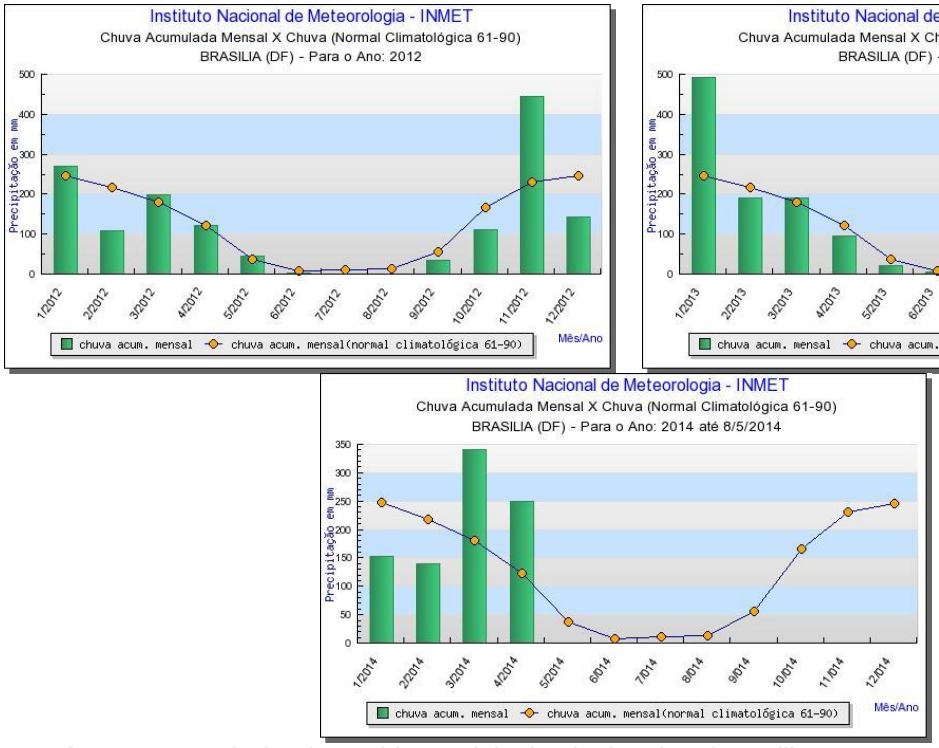


Figure 11. Analysis of monthly precipitation in the city of Brasilia, compared to historical average.

This difference in precipitation can be seen in the graph of diffuse charges of iate under the second year of monitoring basin. Loads of SS remain significant, and Maximum value measured was 181.7 kg/ ha/day. The amount of N load can be verified with high values until early December, which can be considered the end of the washing of the streets of this period, because this month showed more intense and with a greater volume of rainfall rains. The average rate of COD was 22.9 kg/ha/day, while the Pt was 0.055 kg/ha/day.

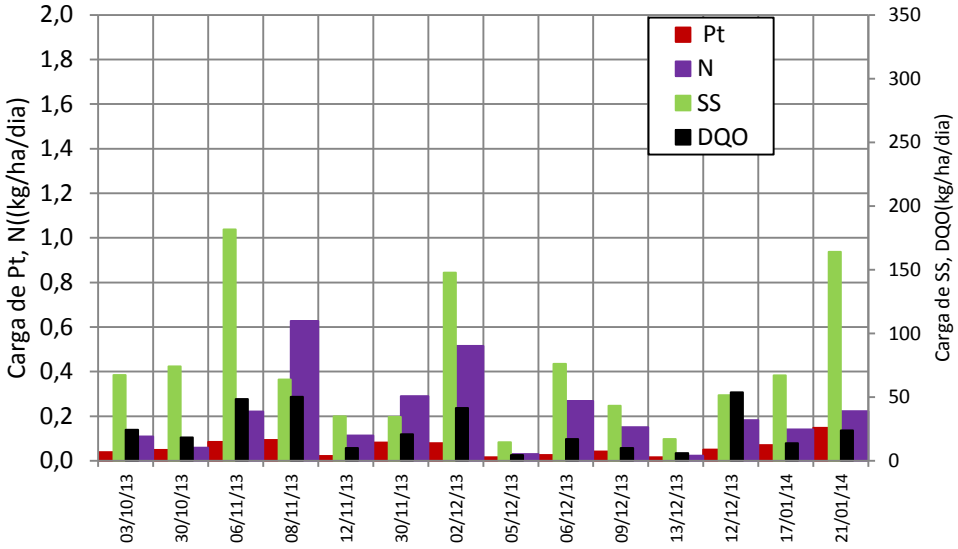


Figure 12.Pollutant Loads at Iate basin during the monitoring 2013-2014.

The data were also compared with the Wastewater Treatment Plant nearest the studied basins, the North WWTP, which has the capacity to treat an average flow of 479.39 l/ s and serve a population of about 260,000 inhabitants, the average concentration of the parameter are shown in Table 1 (Caesb, 2012).

Table 1. Comparison data of diffuse pollutant and WWTT. Caesb (2012)

Parameters Concentration	Waste Water	Waste Water Treatment	CO	Iate
COD	312,5	25,6	47,6	56,6
SS	200	10	167,1	171,3
PT	5,6	0,2	0,2	0,14

In this comparison we see that the discharge of CO basin corresponds to 100% of PT and 186% of COD, comparing with the wastewater treated. Already Iate basin 70%Pt, and 221% of COD. This value are very high, however the flow at WWTT is permanent, while in urban drainage is not. Nevertheless, there are more than 100 similar to those, which are reaching this pollution in the Lake.

Therefore, it is possible to observed that the urbanization increases the runoff flows due to soil not permeable and is responsible for significant part of pollutant loads that are carried by the rainwater and reach the water bodies.

4. CONCLUSION

A major data set was collected during the rainy season (2012-2014) and it was identified that Paranoá Lake was receiving a very poor quality of water from the drainage system. This study allowed us to confirm phenomena like the irregular entries of sewage in the network, the concentrations pollutants are influenced by many processes like number of the previous days without raining, spatiality of rain and land use.

It is observed that during the monitoring period loads of sediment (SS) in the Iate basin were high even in the events of less magnitude, which may be associated to activities in the construction area that were developed in the study area.

The information in this paper will be helpful in selecting better strategy for controlling the quality of stormwater runoff in the areas with prolonged rainy and dry seasons, where occurred the accumulate of pollutants loads. The monitoring process has being maintained to choose the best solution about this diffuse pollution.

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