Monitoring of diffuse pollution in an urban catchment in Brazil

D. J. Carvalho [1*], M. E. L. Costa [1] & S. Koide [1]

1 Department of Civil and Environmental Engineering, University of Brasilia, Brasília-DF, Brazil.

**Corresponding author email: d.junqueirac@gmail.com*

Highlights

- Flood events lead to high concentrations and loads of TSS in the Riacho Fundo stream.
- EMC was suitable to indicate pollutant loads and can have influence of the antecedent dry days, but it may not be related to flood duration, peak flow or some of the rainfall characteristics.

Introduction

Rivers are directly affected by the phenomenon of diffuse pollution, which is associated to the transport of pollutants present on the surface by stormwater. This phenomenon can be considered episodic and is related to several weather variables, the land uses and management-based factors, hence its monitoring is very complex (Ferrier et al., 2005). However, despite the difficulties, it is very important to understand how both, point and diffuse pollution loadings, act in the rivers' water quality (Varekar et al.,2015) and therefore continuous monitoring efforts along the year are necessary.

The Riacho Fundo catchment is a highly urbanized area that drains to the Paranoá lake, located in Brasília, Federal District, central Brazil. It is known that this catchment highly contributes to the lake's silting zones increase, being an important source of sediment due to its urban characteristics (Franz et al., 2014). Also, high nutrient loads were found in urban stormwaters in the catchment, showing that other pollutants are being discharged into Paranoá lake by the Riacho Fundo catchment (Tsuji et al., 2019).

Since the Paranoá lake has a history of eutrophication and has been experiencing a decrease in its surface area due to sediments, studies on the water quality of the streams that discharge into it are needed. Thus, this study aims to assess the Riacho Fundo Stream water quality during rainfall events to estimate the diffuse pollution loads carried by this stream.

Methodology

The Riacho Fundo catchment has a total of 213 km² drainage area, a large part of which is urbanized, and its main watercourse is the Riacho Fundo Stream, that has 13.2 km of length. The region's average annual rainfall is 1,500 mm, concentrated in the rainy season that begins in October and lasts until April.

Rainfall monitoring was carried out from October 2019 to February 2020 through 16 rain gauges installed within the catchment. A flow and water quality monitoring station was installed in a section of the Riacho Fundo stream near the catchment outlet and operated during the same period. Figure 1 shows the location of the area of study, the rainfall monitoring points and the monitoring station for flow and water quality.

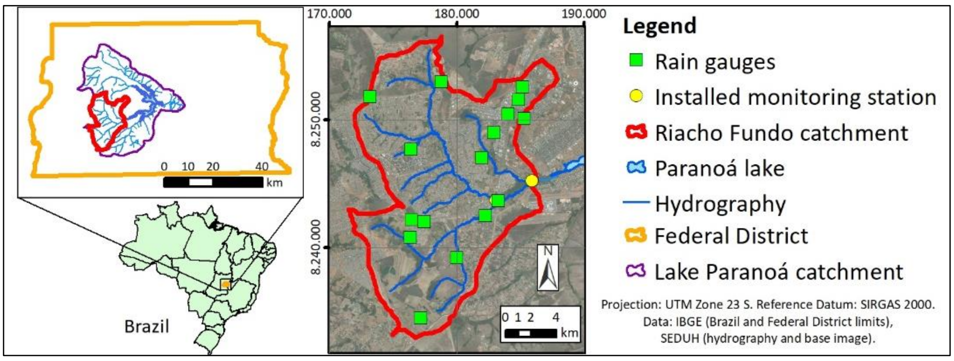

Figure 1. Locations of the Riacho Fundo catchment, rain gauges and flow and water quality monitoring station.

A pressure transducer level logger was used to register the stream water level every 10 minutes. The flow was measured using an acoustic doppler profiler during a few flood events to create a rating curve. Water samples were collected at uniform intervals by a programmable autosampler activated by a level sensor. The samples were analyzed with the methodologies present in the Standard Methods for the Examination of Water and Wastewater (APHA, 1998) and the water quality parameters measured were total solids (TS), total suspended solids (TSS), turbidity, conductivity, pH, chemical oxygen demand (COD), nitrate, nitrite, total phosphorus and reactive phosphorus.

With the resulting samples' concentrations and the respective flows, the pollutant loads can be represented by a number of indicators. In this study, the Event Mean Concentration (EMC) was used to indicate the total pollutant load of TSS discharged in each monitored event. EMC can be considered a concise indicator that allows comparisons between events of different rainfall intensities and antecedent dry periods (Righetto et al., 2017). Equation 1 shows the calculation for the EMC indicator.

$$EMC = \frac{\sum_i^n (Qi.Ci).\Delta t}{\sum_i^n Qi.\Delta t}$$ **(Equation 1)**

EMC: Event Mean Concentration (mg/L);
Q: flow rate (m^3/s);
C: pollutant concentration (mg/L);
Δt: time interval.

Results and discussion

A set of water samples considered representative for the flood event was collected for 10 events, which are going to be referred to as monitored events. In these events, the sample collection occurred during the whole flood or at least until its peak. This abstract focused on TSS concentrations, that were measured by gravimetric determination, filtering the samples using 47 mm diameter and 0,7 µm particle retention glass fiber prefilter and drying the prefilters at 105°C for at least 24 hours.

For flow estimation, it was used a rating curve developed with data from flow measurement campaigns in the monitoring station in the Riacho Fundo stream. Two equations needed to be adjusted for the rating curve due to the geometry of the section, since at a certain level the stream reaches its flood plain. For every sample a flow value was associated by matching the sampling time to the nearest flow level record.

The maximum total accumulated rainfall depth measured by one of the 16 rain gauges for a monitored event was 68.2 mm, which occurred for the event on 02/24/2020, but the highest intensity for one event found was 63.7 mm/h on 01/10/2020. It was observed that the rainfall records can vary a lot between rain gauges. In addition, it should be noted that 3 of the rain gauges operated by the UnB crew experienced some operational problems, failing to register data for a period of time. Consequently, each event's rainfall was evaluated considering the rain gauges that were operating normally. Table 1 shows the 10 monitored events along some of their flood and rainfall characteristics and the calculated TSS EMC.

Table 1. Events' rainfall and flood characteristics and EMCs for [TSS] for the monitored events on the Riacho Fundo catchment, Brasília, Brazil.

Date	Mean rainfall intensity (mm/h)	Mean rainfall duration (min)	Mean antecedent dry days	Flood duration (h)	Peak Flow (m^3/s)	Samples collected	[TSS] EMC (mg/L)
11/07/2019	11.9	91	0.6	11	20.21	31	807.94
12/05/2019	2.2	575	0.6	10.8	20.77	19	1261.02
12/18/2019	7.3	91	2.4	7.3	15.20	15	991.67
12/22/2019	7.9	13	2.0	6.3	10.69	7	899.35
12/23/2019	8.4	95	1.5	8.7	18.30	24	1362.53
01/10/2020	11.3	3	0.1	7.2	11.90	12	1056.10
01/23/2020	1.3	462	0.4	14	8.84	7	413.19
01/30/2020	3.4	28	0.8	6.2	9.04	9	177.67
02/23/2020	3.7	50	0.8	8.3	11.57	9	111.44
02/24/2020	5.6	375	0.3	17.8	69.40	41	1336.38

It was noticed that the event with lower EMC was not the one with lower peak flow or flood duration, neither the event with highest EMC matched the one with highest peak flow. The event on 02/23/2020 had higher duration and peak flow than the 12/22/2019 one for instance, although it presented the lowest TSS EMC of all events. In the other hand, the small peak flow events that occurred in January also presented lower EMCs.

Rainfall characteristics such as mean intensity and duration did not seem to be related to the EMC value. The event with highest TSS EMC had rainfall duration and intensity far from the lowest or the highest. However, events with more antecedent dry days presented higher EMCs than others with similar peak flows and flood duration, what can indicate an influence of this parameter.

Figures 2 and 3 illustrate the variation of flow (Q) and TSS concentration in hydrographs and pollutograms for the events with highest (12/23/2019) and lowest (02/23/2020) total suspended solids EMC.

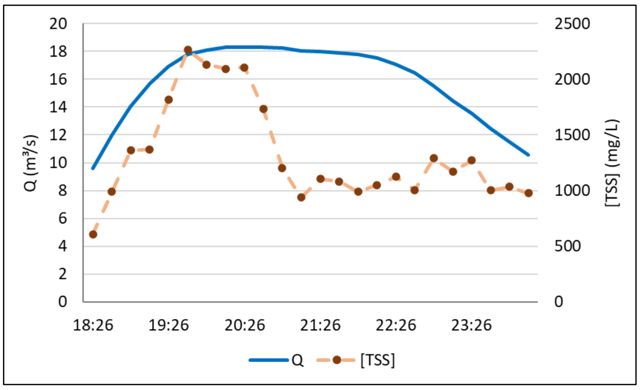

Figure 1. Hydrograph and [TSS] pollutogram for event on 12/23/2019.

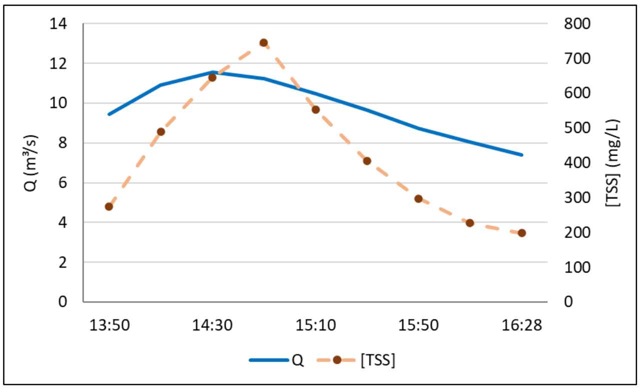

Figure 2. Hydrograph and [TSS] pollutogram for event on 02/23/2020.

The peak of TSS concentration occurs on the first half of the event in both cases, as well as the peak flow. The event on 12/23/2019 presents a flow value close to the peak for a longer time, but the same trend is not observed in the TSS concentration, that reduces shortly after the peak. On 02/23/2020 event however, the peak of TSS concentration occurs after the peak flow.

Conclusions and future work

The responses in streams' water quality due to diffuse pollution loads are variable, depending on a lot of factors, such as the rainfall distribution and the catchment characteristics as well. Flood duration, peak flow and some rainfall characteristics are not necessarily related to higher or lower values of EMCs. The number of antecedent dry days can be a factor that contributes to higher TSS EMC. Despite that, it was observed that high concentrations of total suspended solids are present in the Riacho Fundo Stream in flood events.

Future work includes applying computer modelling to the Riacho Fundo catchment in order to estimate the total load that arrives at Paranoá lake through it and get a better understanding of the extent of its contribution to the total lake pollution, aiming the proposal of solutions to improve the lake water quality.

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