

Diffuse Pollution in the Drainage System at Two Urban Catchments

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Abstract – The objective was to evaluate the water pollutant load and the litter transmitted by the urban drainage net of two catchments located in Santa Maria – RS - Brazil. Cancela catchment has an area of 4.95km² with 56% of urban area. Alto da Colina catchment has an area of 1.90 km² with 22.3% of urban area. The water quality characteristics were assessed through the following parameters: biochemical oxygen demand (BOD), thermotolerant coliforms and total suspended solids (TSS). The litter was assessed through its quantification in weight and volume. The results indicate that Cancela catchment presents diffusive and litter loads higher than Alto da Colina catchment, which shows the degradation process associated to each studied area characteristics as its size and mainly the land use. Both areas presented an elevated degradation process due to the human activities such as the urbanization development, the sewer spilling and the litter release on the receiving bodies.

Keywords: Urban drainage, first flush, litter

INTRODUCTION

Over the last decades, the increasing in the urbanization process has been changing the environmental conditions, decreasing the population and the water resources life quality. Due to this decrease, there is the necessity of identifying the factors that influence the environmental quality. The water quality and the litter transmitted by the urban drainage net are among these factors.

The urban drainage nets are responsible by the transportation of considerable pollutant loads. This pollution is presented in a diversified form and depends on the following factors: land use, population density, seasons, topography, geology and the rainfall frequency and intensity.

According to Novotny (1999) the urban increase in the development countries leads to the big centers sprouting, which are the places with the major problems regarding the diffuse pollution.

Considering the temporal distribution of this pollutant load, studies present that the first part of the storm runoff is the most polluted, which is known as the first flush phenomenon. Many investigations about the nature and existence of the first flush were accomplished to identify the variability of the factors that influence the first flush phenomenon (Gupta & Saul, 1996, Lee et al., 2002, Paz, 2004).

The urbanization process is connected to the increase in the litter yielding, this material cause damages to the environmental when it is not adequately managed and becomes one of the major problems faced by the community.

The quantification of the pollutant load transmitted through the storm runoff becomes important when considering the urbanization impacts investigation, once the pollutant load and the runoff volume increase considerably when a catchment is urbanized.

The objective of this paper is to evaluate diffuse load transmitted by the urban drainage net. Two catchments were studied, which were located in Santa Maria – RS - Brazil. The obtained results were compared and a prognosis was obtained regarding the intervenient factors, such as: rainfall, land use, the area physical characteristics and event antecedent dry weather period.

DESCRIPTION OF THE STUDIED AREAS

This work analyzed two Brazilian urban catchments located in Santa Maria – RS. In the Cancela catchment studies of water quality and solid residues were developed, from January to December, 2004. In the Alto da Colina catchment, the water quality data were obtained by Paz, 2004 and the litter data were monitored during the same period of Cancela catchment.

The Cancela catchment presents an area of 495 ha where 56% is urbanized and from this, 35% is constituted of impervious surfaces, with predominance of residential and commercial areas. Alto da Colina catchment presents an area of 190 ha, where 22% is urbanized and from this, 12% is constituted of impervious surfaces, in the agricultural area (78%) predominate native field and culture of soy alternating with periods of pasture. The Figure 1 indicates the studied areas.

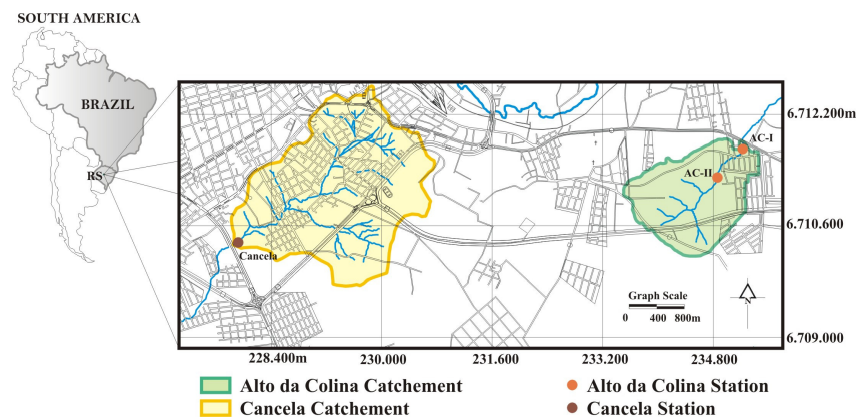


Figure 1 – Geographic localization of the studied catchments in Santa Maria - RS -Brazil.

WATER QUALITY ANALYSIS

The water samples were obtained during dry and wet weather periods, absence and existence of rainfall, respectively.

Dry weather period samples were obtained manually at the center of the sampling section. The wet weather period samples were accomplished manually and through the ascension and descent level samplers, ALS and DLS, respectively (Umezawa, 1979). These samplers allowed to monitor the water quality variation during the flood wave crossing at nightly events or at the ones when the manually monitoring was not possible.

Figure 2 presents an illustration of the automatic level samplers installed at the sampling section.

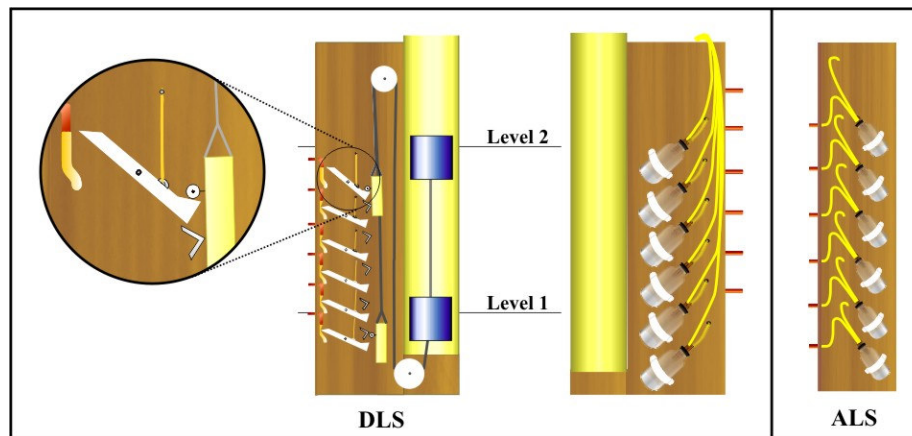


Figure 2 – Illustrative picture of the automatic level samplers used in the study

To obtain a complete assessment of the water quality characteristics during the flood wave crossing, initial/final points were used to all the analyzed events, it was assumed the dry weather period water quality characteristics from the days closest to the event, previous/posterior.

To the diffuse load estimation, the pollutant mass of the events occurred during the monitored period were summed and divided by this time period interval, resulting on the pollutant load transmitted by storm drainage system in the studying area. In this calculation the water body base load was obtained to each time interval and reduced from the total measured load.

The pollutant loads were obtained through the multiplication of the water quality characteristic, in question, for runoff in the considered instant. The load values were accumulated during all precipitation event. In this calculation the water body base load ($\text{Flow}_{\text{base}} * \text{Concentration}_{\text{base}}$) was obtained to each time interval and reduced from the total measured load.

The following water quality parameters were analyzed: total suspended solids (TSS), biochemical oxygen demand (BOD), Thermotolerant coliforms (TC). Table 1 presents the diffuse load to BOD, TC and TSS found at both catchments in function of their contributing areas.

Table 1: Storm runoff diffuse load in function of the catchments areas

Parameter	Catchment diffuse load		
	Cancela	AC-I	AC-II
BOD (kg/ha/year)	75	30	24
TC (organisms/ha/year)	6.5×10^{11}	5.4×10^{11}	2.0×10^{10}
TSS (kg/ha/year)	1686	1859	2253

Comparing the load values in function of the areas, it was found out that Cancela catchment presented higher diffuse load than Alto da Colina catchment, for BOD and thermotolerant coliforms, characteristic of urban areas. However, the TSS values were higher at Alto da Colina catchment, mainly at AC-II station, which is placed in rural area. It can be explained due to the soil management at the agricultural area.

The main observed factors that differenced their storm runoff quality were: the land use, the catchment size and the soil surface impermeabilization process.

The pollutant mass presented a tendency of increasing with such rainfall characteristics: mean intensity, total rainfall and storm runoff volume. There was no observed correlation between the transported pollutant mass and the event antecedent dry weather period. (Brites, 2005)

Estimation of the First Flush

The methodology described by Gupta & Saul (1996) was applied to the first flush evaluation. According to the authors the first flush may be define as the event portion up to the point of maximum divergence between the dimensionless cumulative percentage of pollutant mass and the cumulative percentage of volume plotted against the cumulative percentage of time.

Curves M(V) were elaborated. It became possible an adimensional analysis enable to compare events with characteristics and localization different. Through this graphical analysis, it is observed all position of curve in relation to 45° line, indicating the distribution of the pollutants during the event.

The figures 3, 4 and 5 show the curves M(V) of events register in Cancela Catchment for the parameters BOD, thermotolerant coliforms and TSS, respectively.

BOD, TC and TSS showed these curves M(V) had slope greater than 45°, in the majority of events. It indicated that the pollutant load was not distributed uniformly during the runoff.

In the Cancela catchment, the first flush effect presents variations regarding its incidence among the events and parameters, showing the phenomenon variability. According to Paz (2004), Alto da Colina catchment presented little susceptible to the first flush incidence, according to Gupta & Saul (1996) methodology.

The events that presented the first flush were analyzed separately, seeking to identify the one that generated the higher pollutant load and transported volume up to the instant when the load achieved its maximum value. This verification becomes important when it is required to

retain the runoff to control the pollutant load release into the water body. This study showed that if the first 6.000 m³ of the runoff volume was retained, approximately 75% of the BOD load would be treated, avoiding higher degradation of the water body.

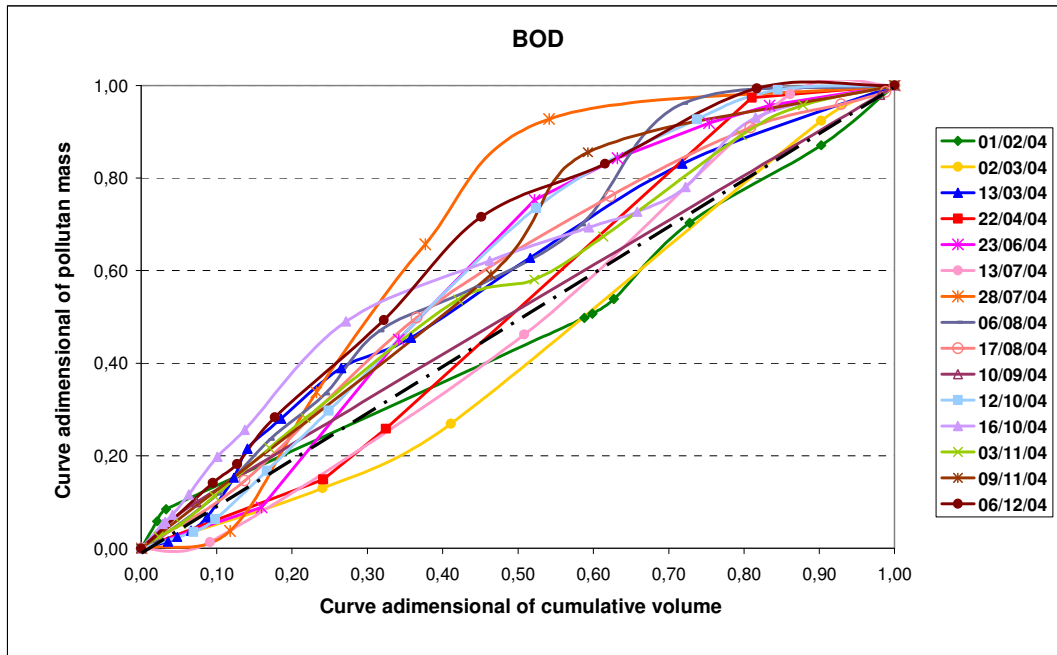


Figure 3 – Curves M(V) for BOD in Cancela Catchment

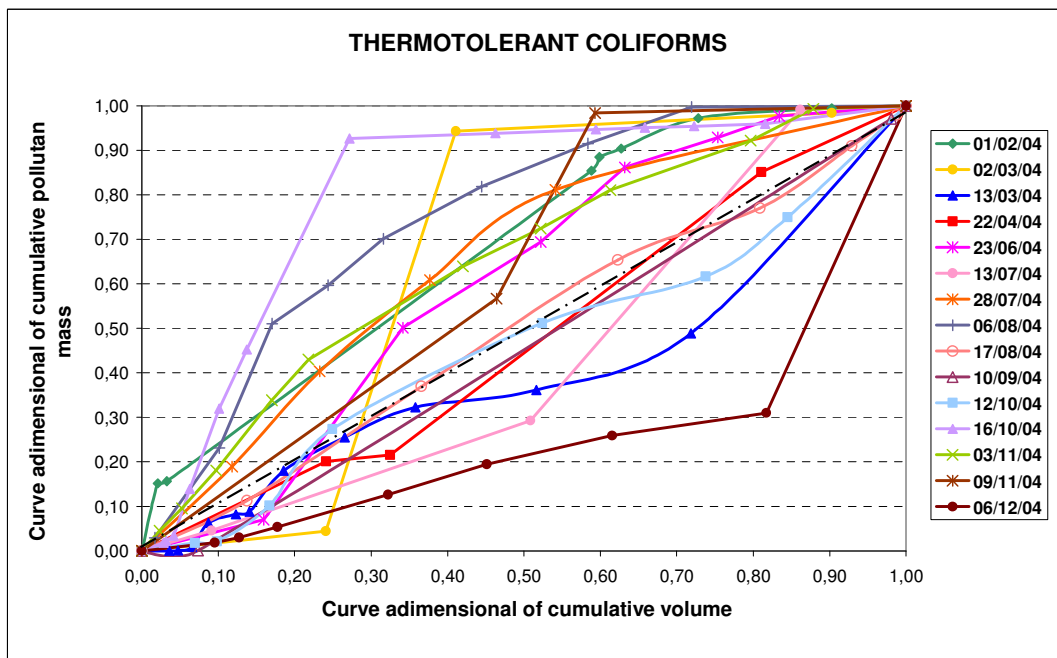


Figure 4 – Curves M(V) for thermotolerant coliforms in Cancela Catchment

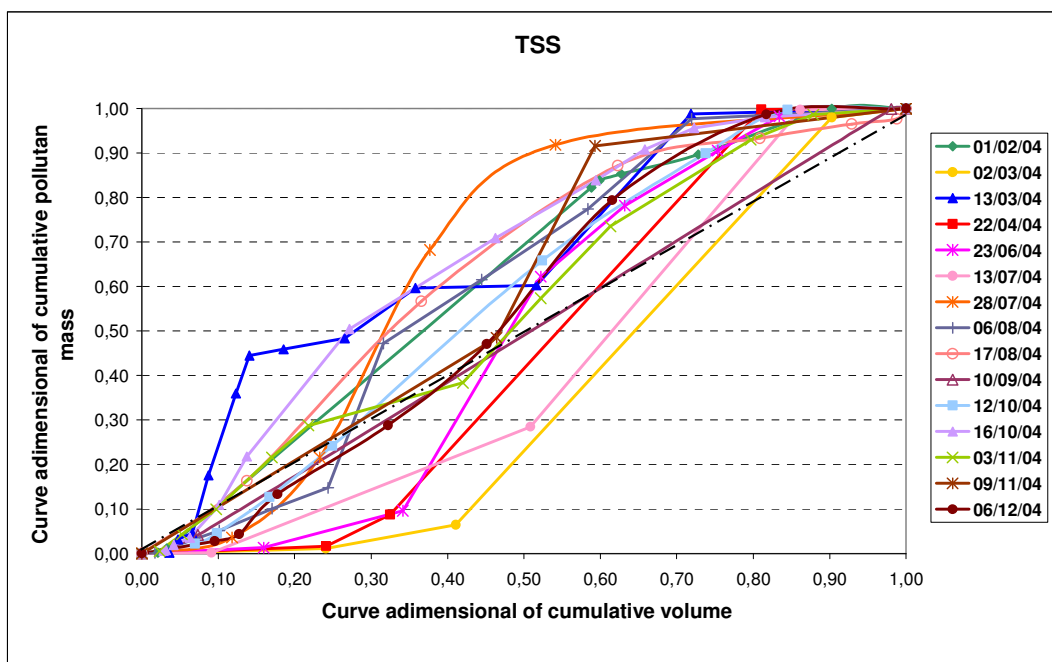


Figure 5 – Curves M(V) for TSS in Cancela Catchment

LITTER ANALYSIS

The litter collections were accomplished at Cancela and Alto da Colina catchments from April to December 2004, after each rainfall event.

To the material retention collector nets made of steel wire with 70 mm mesh were implemented transversally to the river axis allowing the retention and the analysis of the major transported litter.

Figures 6-A e 6-B present the collector nets with the retained material after a rainfall event at Cancela and Alto da Colina monitoring stations, respectively.



Figure 6 – Collector nets with the retained material after a rainfall event at Alto da Colina (A) and Cancela (B) stations

After each rainfall event the litter retained on the nets was accumulated for some time on the water banks to allow the exceeding water runoff avoiding the samples additional of weight

due to the material moisture. The material was classified according its composition and then was quantified in weight and volume.

The organic matter was compounded of rest of food, vegetation (leaves, branches, barks, roots), processed wood and dead animals. The inorganic matter was compounded of plastic (shopping bags, bottles, containers, milk bags), metals (foil, brass, number plates), glass (bottles, cups, lamps), Styrofoam and others (old clothing, documents, cardboard, toy, tire).

Table 2 indicates the litter load transported in each catchment in function of their areas. The table indicates the organic matter, OM, inorganic matter, IM, and the total load of the quantified material.

Table 2: Litter contribution in function of the studied catchments areas

Catchment	OM kg/ha/year	IM kg/ha/year	Total kg/ha/year
Cancela	6.9	1.5	8.4
AC	2.3	0.9	3.2

It is observed that Cancela catchment presented higher litter pollutant load than Alto da Colina, mainly considering the organic matter, which is explained by the high vegetation cover existent at Cancela water bank. At Alto da Colina this characteristic was not observed.

Kim et al. (2004) had found load of inorganic matter, for event, between 1,2 - 15,6 kg/ha. The litter was collected in bags connected directly to the draining conduits, in an area with high impermeability. The values found for Alto da Colina and Cancela catchments had been 0,45 and kg/ha, respectively. The different values are explained by the characteristics of each area.

Cancela catchment presented litter composition of 71.5% organic matter, 14.7% plastic, 0.4% metal, 4.9% styrofoam, 0.7% glass and 7.8% others from the total quantified volume. Alto da Colina catchment presented litter composition of 62.9% organic matter, 29% plastic, 1.3% metal, 1.1% styrofoam, 0.8% glass and 5% others. The differences found between the catchments are related to each area characteristics.

It was observed that the composition of solid residues in the two basins was similar to the found for Gamtron (1992), apud Allison et al. (1998), where the organic matter was the material most abundant, constituting 71% of the total, followed for plastic, glass, metals and papers.

The litter transportation presented an increasing tendency with the runoff volume and with the total rainfall in both analyzed catchments. The volume transported during the events did not present correlation with the event antecedent dry weather period. (Brites, 2005)

CONCLUSIONS

This paper aimed to evaluate the water pollutant and the litter loads transported by the urban storm runoff in two catchments located in Santa Maria – RS – Brazil. The obtained results were compared and the intervenient factors were predicted, altering such variables: rainfall, land use, physical characteristics of the area and the event antecedent dry weather period.

Cancela catchment presented higher diffuse load than Alto da Colina catchment, for characteristic parameters of urban areas, BOD and TC. Alto da Colina catchment presented higher diffuse load for TSS, characteristic parameters of rural areas, due to the soil management at the agricultural area.

Cancela catchment presented more susceptible to the first flush incidence than Alto da Colina catchment. At Cancela catchment 70% of the analyzed events presented 73.5% of the total load during the event transported in 32% of the total runoff volume.

In the two catchments, the litter load presented relation with the characteristics of each area.

The studied catchments present water quality degradation process due to the human activities as the population and urbanization development, sewer spilling and litter release into the water receptor bodies.

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