Assessment of diffuse pollution load resulting from the implementation of mining operations in the Lageado Grande Watershed, RS, Brazil.

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Abstract

This study aimed to assess the diffuse pollution in the Lageado Grande watershed, located in the city of São Martinho da Serra - RS. The watershed land-use is mainly characterized by agricultural activities and the extraction of gemstones. The quality of runoff water was analyzed and results showed that the mining operations resulted in increased conductivity, turbidity and solids content. Recorded event mean concentrations (EMC) of the samples analysed were: TS 479.4 mg/l, TSS 320.6 mg/l, TDS 160.5 mg/l, VSS 112.6 mg/l, FSS 209.1 mg/l and 64.7 NTU. Statistical analysis were used to determine the relationships between flow rate and water quality parameters. Higher surface runoff and rainfall values result in increases in the concentration of these parameters. The study also investigated the existence of first flush produced by surface runoff in the quality of water of this watershed. First flush volume was estimated using total suspended solid loads. Although mining operations in São Martinho da Serra are recent, results indicate they are having a detrimental effect on the quality of water in this watershed and control measures of the diffuse pollution in the Lageado Grande Watershed are needed. A containment basin is proposed to reduce sediments from mine drainage.

Keywords: diffuse pollution; first flush; containment basin

1. Introduction

Mining could be sources of water pollution. The water resource is essential to development to mining activities, through by washing the mined product or like component of reject dam (VON SPERLING, 1998).

In case of gemstones extraction the waste removed compared to very small quantities gemstones extracted is very high when compared other bulk or massive mineral such ore, copper, industrial or building materials (KAMBANI, 2003).

Previous researches have studied the diffuse pollutions of urban surface runoff (DE, LUCA; MILANO and IDE, 1991; GUPTA and SAUL, 1996; DELETIC, 1998; BERTRAND-KRAJEWSKI, CHEBBO and SAGET, 1998; LEE and BANG, 2000 and KIM, YUR and KIM, 2006). The pollution from gemstone mining haven't explored yet.

This study aimed to assess the diffuse pollution load in the Lageado Grande watershed, a sub-basin of Ibicuí-Mirim river. The watershed is located in the city of São Martinho da Serra – RS, between 53°52'46" and 53°57'14" in the west longitude and 29°30'16" through 29°35'04" in the south latitude. The watershed area spreads over 33.19 km2, and the land-use is mainly characterized by agricultural activities and the extraction of gemstones (amethyst and agatas).

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2. Materials and methods

The water samples were collected in dry weather and during rainfall events to establish runoff pollutant loads, from December 2004 to January 2006. The quality of runoff water was analyzed using the following parameters: pH, conductivity (EC), turbidity (NTU), total solids (TS), total suspended solids (TSS), total dissolved solids (TDS), fixed suspended solids (FSS), volatile suspended solids (VSS), concentration of aluminium (Al), calcium (Ca), copper (Cu), chromium (Cr), iron (Fe), magnesium (Mg), manganese (Mn), sodium (Na) and zinc (Zn) ions.

3. Results and discussion

Table 1 gives the EMCs of parameters analyzed. Results showed that the mining operations resulted in increased conductivity, turbidity and solids content. Wet weather EMCs showed higher values when compared with dry weather, indicating that the runoff flow affects the quality of the water in the receiving body.

Table 1: Event mean concentrations of monitored stormwater runoff.

Parameters	EMC				Dry Weather			
	Mean (mg/L)	Standard Deviation	Minimum	Maximum	Mean (mg/L)	Standard Deviation	Minimum	Maximum
EC (μS/cm)	91.16	36.32	54.39	157.58	85.79	27.20	85.79	152.30
pH	7.01	0.18	6.59	7.30	7.30	0.12	7.30	7.49
TS (mg/L)	479.37	256.11	211.83	1124.86	236.15	193.48	236.15	651.50
TSS (mg/L)	320.60	181.89	123.02	784.26	144.02	162.62	144.02	464.20
TSD(mg/L)	160.51	76.80	88.81	340.52	92.14	44.36	92.14	187.30
VSS (mg/L)	112.57	59.96	50.77	275.47	50.38	61.93	50.38	183.40
FSS (mg/L)	209.12	127.43	72.25	522.66	93.64	101.59	93.64	280.80
Turb.(NTU)	64.68	38.86	26.90	180.02	22.42	11.78	22.42	42.39
Al (mg/L)	0.473	0.127	0.335	0.597	0.983	0.527	0.983	1.800
Ca (mg/L)	5.877	1.174	4.700	7.012	6.480	1.274	6.480	8.000
Cu (mg/L)	0.018	0.012	0.004	0.032	0.013	0.009	0.013	0.024
Cr (mg/L)	0.006	0.009	0.000	0.019	0.003	0.004	0.003	0.010
Fe (mg/L)	0.338	0.106	0.243	0.482	0.660	0.329	0.660	1.000
Mg (mg/L)	1.477	0.100	1.337	1.550	1.640	0.313	1.640	2.100
Mn (mg/L)	0.009	0.008	0.004	0.021	0.006	0.002	0.006	0.009
Na (mg/L)	2.612	0.158	2.451	2.821	2.680	0.192	2.680	3.000
Zn (mg/L)	0.018	0.008	0.010	0.027	1.308	2.580	1.308	5.900

The relationships between the flow rate and water quality concentrations were analyzed (table 2) by employing correlation analysis, in which the relationships between parameters were represented by their corresponding Pearson correlation coefficients. Higher runoff and rainfall values result in increases in the concentration of these parameters. In addition, a significant correlation was observed between solids content and turbidity values. The table 3 shows the pollutant load discharged during rainfall events for the mainly parameters. This study also investigated the first flush load. Gupta and Saul (1996) define first flush as that part of the storm upto the maximum divergence between the dimensionless cumulative percentage of pollutants and the cumulative percentage of flows plotted vs. the cumulative percentage of time. This relation allows the engineer to design the detention storage necessary to capture a given percent of suspended solids.

Table 2: Pearson coefficients from the analysis between water quality constituents

	Vol	Rain	TS	TSS	TSD	VSS	FSS	Turbidity
Vol	1.000	0.884	0.762	0.782	0.685	0.855	0.742	0.888
Rain	0.884	1.000	0.597	0.616	0.515	0.714	0.569	0.805
TS	0.762	0.597	1.000	0.997	0.973	0.954	0.997	0.844
TSS	0.782	0.616	0.997	1.000	0.952	0.970	0.994	0.851
TSD	0.685	0.515	0.973	0.952	1.000	0.881	0.966	0.781
VSS	0.855	0.714	0.954	0.970	0.881	1.000	0.939	0.898
FSS	0.742	0.569	0.997	0.994	0.966	0.939	1.000	0.820
Turbidity	0.888	0.805	0.844	0.851	0.781	0.898	0.820	1.000

Rain = Total rainfall, Vol = Discharged volume.

Table 3: Total discharged loads of monitored stormwater runoff

Event	TS (ton/d)	TSS (ton/d)	TSD (ton/d)	VSS (ton/d)	FSS (ton/d)	ADWP (days)	I (mm/h)	Rain (mm)	Vol (m^3)
05/07/16	6.63	6.64	0.95	2.62	2.98	1	1.78	20.30	1297
05/08/21	23.22	14.48	8.74	3.52	10.96	1	4.27	19.06	3249
05/08/23	33.77	21.51	15.35	7.36	14.15	1	2.36	21.23	85002
05/09/10	212.05	140.87	71.07	49.04	91.94	6	4.69	33.64	77496
05/09/24	252.07	182.67	69.39	69.71	112.97	9	5.63	54.91	294179
05/10/04	1375.00	957.20	417.71	333.23	642.11	1	5.00	102.53	1051780
05/10/13	31.93	20.95	10.98	9.51	11.45	5	3.83	19.15	8300
05/10/14	133.33	88.50	44.83	33.50	54.99	1	3.98	38.24	242456
05/10/21	5.80	3.77	2.03	1.80	1.97	4	2.68	16.51	61809
05/11/06	9.40	6.65	2.75	2.13	4.53	15	2.14	24.21	33083
05/11/24	8.64	5.09	3.56	2.05	3.04	19	8.33	30.56	9953
06/01/08	6.24	3.92	2.32	1.72	2.20	7	23.38	52.60	5270
06/01/12	25.36	15.77	9.59	5.35	10.42	2	33.06	41.32	19824
Mean	163.34	112.92	50.71	40.12	74.13	-	-	-	-

ADWP=antecedent dry weather period, I=rainfaill intensity

Previous studies have proposed equations to calculate the volume necessary to control diffuse pollutions of urban surface runoff (Schueler 1987, apud Tomaz 2006; Tucci (2000) e Kim, Yur e Kim, 2006). This research suggest the following equation to calculate the volume necessary to containment basin to reduce sediments from mine drainage:

$$Vd=(P/1000)*R*A$$

where: Vd is a detention basin volume (m^3), P is precipitation (mm), R = coefficient that depends on the area of soil displayed (mines), A = watershed area (m^2)

Admiting the first flush as runoff equivalent to the first 25mm of precipitation depth (Schueler 1987, apud Tomaz 2006), was calculated the containment basin volume. The figure 1 shows the cumulative mass of TSS vs. cumulative volume of the most important rainfall event. Figure 2 shows cumulative discharge volume vs. the cumulative discharge mass, where runoff of 25mm precipitation is equivalent to about 60% of the TSS loads. Therefore, installing a containment basin near would help reduce sediments from mine drainage entering into the receiving body.

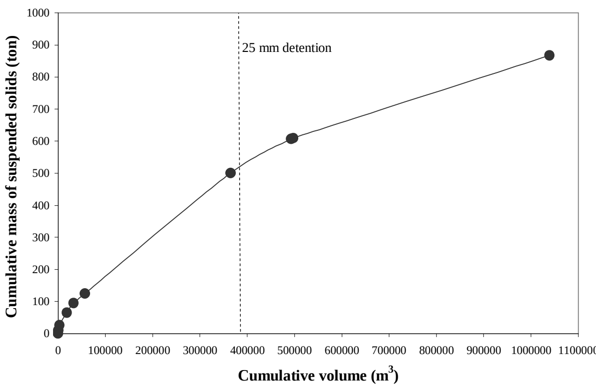

Fig. 1. Cumulative mass of TSS vs. cumulative volume of 05/10/04 event.

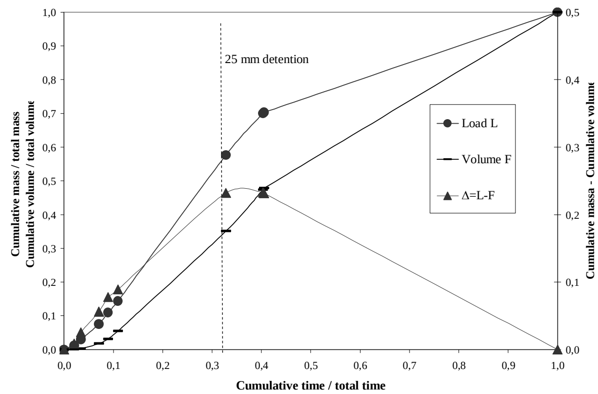

Fig. 2. Cumulative discharge volume vs. the cumulative discharge mass of 05/10/04 event.

4. Conclusions

This study aimed to assess the diffuse pollution in the Lageado Grande watershed, The watershed area spreads over 33.12 km^2 and its land-use is mainly characterized by agricultural activities and the extraction of gemstones. Although mining operations are recent, results indicate they are having a detrimental effect on the quality of water in this watershed and control measures of the diffuse pollution load are needed. A containment basin, whose essential design elements are discussed, is proposed to reduce sediments from mine drainage.

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