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Water Quality of Caí River, RS

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Abstract: Environmental quality is essential for the well-being of the population and is entirely related to the quality of ecosystems. Data indicate that the Caí River, located in the northeast region of the State of Rio Grande do Sul – Brazil, is the eighth most polluted river in the country. A large population concentration is notorious, with industries and streams draining large urbanized areas, interfering with water quality. Considering the characteristics of the river and human actions, the aim of this study/article is to present a scenario of the environmental quality of the river Caí. "In loco" visits were carried out on the river to know its course and thus define the water collection points. Collections were carried out monthly, from November 2017 to August 2018. The parameters analyzed were lead, copper, total coliforms, conductivity, total chromium, BOD_5, COD, fecal coliforms, iron, total phosphorus, manganese, mercury, nickel , DO, pH, sodium, total solids, turbidity and zinc. The water samples collected at different points of the river were classified according to CONAMA Resolution 357/2005. The results verified along the River confirm the data presented by the authors and are consistent with the visits made to the collection points, in which the appearance of the River is less attractive, with a predominance of dark coloring and in certain places with a strong sewage odor cloacal. Comparing the results with CONAMA Resolution 357/2005, the values meet the resolution.

Keywords: Anthropogenic Action, Environmental impact, Monitoring, Population Concentration, Water.

I. INTRODUCTION

Human activities have generated a large amount of waste that, as they mischaracterize the environment, are called environmental pollutants. For this reason, the consequences of this pollution, which affects both the air, water and soil, has been given special attention. The main activities responsible for environmental pollution, as they generate a large amount of waste released into the environment, result from urbanization, agriculture and the industrial sector (SILVA, 2013).

As a result of these activities, it has been observed an increase in the amount of effluents released into water resources, causing a reduction in water quality, which can then compromise the entire biota associated with this system. Among the substances present in household and industrial effluents and in the disposal of agricultural residues, toxic metals (Pb, Cu, Cr, Hg and Ni) stand out. These substances present in the effluent have harmful effects, even when in low concentrations, putting ecosystems at risk (PASSOS, 2016).

According to Passos (2016), surveys are carried out to quantify the percentage of pollution by toxic metals in hydrographic basins, gathering data on the environmental impact and its complex relationships with economic activities. The purposes are to determine levels and identify possible sources of pollution, as well as assign trends in behavioral changes in industrial structuring and in the implementation of pollution control technologies.

Processes for treating the state of deterioration of water resources must be instituted in urban centers. In general, it is observed that conventional treatment processes are not efficient in removing these pollutants. Therefore, there is an eminent need to study these phenomena and to constantly monitor the rivers where effluents are released. Monitoring is carried out to assess and classify the quality of river waters. These activities begin with field inspections and measurements, collection of samples at monitoring stations, carrying out laboratory tests, tabulation and interpretation of results (OLIVEIRA, 2015).

According to CETESB (2018), the information obtained through monitoring has enabled the knowledge of the main conditions of rivers and reservoirs, where the main objective is to assess the evolution of freshwater quality. In addition to the water quality indexes being useful to inform, in a synthetic and accessible way, the population about the quality of water resources, they are also fundamental in the decision-making process of public policies and in monitoring their effects.

In order to characterize the CaíRiver Hydrographic Basin, in Rio Grande do Sul, regarding the contribution of toxic and physicochemical metals in the dissolved fraction, monthly samplings were carried out in six locations, representative of the basin, with studies focused on possible points. anthropic interference.

II. METHODOLOGY

Study area

The Caí River Hydrographic Basin (BHRC) is located in the northeast region of the State of Rio Grande do Sul (Fig. 1), at geographic coordinates 29º06' and 30ºS, 50º24' and 51º40'W, has an area of 5,057.25 km² , corresponding to 1.79% of the state, located north of Porto Alegre, between the Brazilian plateau and the central depression. The watercourse has an extension of 285 km, covering 42 municipalities, serving an estimated population of 550,000 inhabitants, corresponding to 5% of the population of the State of Rio Grande do Sul, with around 25% living in rural and 75% of the urban area (SEMA, 2019). This region has approximately 85,000 km² (about 30% of the geographic area of the State of Rio Grande do Sul) and comprises about 70% of the population of the State of Rio Grande do Sul, featuring a considerable population concentration.

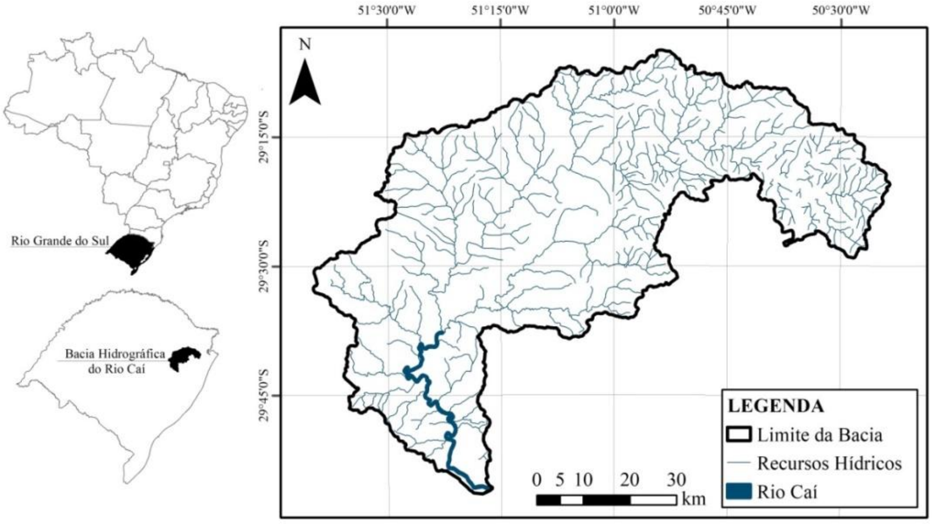

Figure 1 – Location of the Caí River Hydrographic Basin

In the Caí River Hydrographic Basin, 46% of GDP is generated by industrial activities, with emphasis on the leather-footwear, food and beverage, metal-mechanical and petrochemical industries, 31% by service activities and 23% by agricultural activities, with highlighting rice, vegetable and fruit crops and cattle, swine and poultry herds (PEDROLLO et al., 2011).

Toxic Metals

According to Oliveira (2015), urban and industrial effluents, intensive agriculture, cultivated pastures, agribusiness are among the main anthropogenic sources potentially causing changes in aquatic ecosystems. The concentration of toxic metals can generate information related to the degree of contamination of the aquatic ecosystem, as well as the period and location of the contaminating source.

Depending on the source, the sediment can represent an important source of pollutant due to the high diffuse flux of metals within the water column. It is also a deposit of contaminants for long periods, considered the main risk factor for water pollution (CAMACHO, 2012).

Toxic metal pollution has been shown to have adverse effects on ecosystems and the health of many organisms, from bacteria to plants, and even humans. The toxicity of metals depends on the chemical properties of the metal itself and the amount accumulated in specific tissues in the body. Metals such as Pb, Cu, Cr, Hg and Ni are known to severely affect human health (CAMACHO, 2012).

Land use and occupation

The use and occupation of land significantly alter the physicochemical and biological processes of natural systems (MENEZES et. al., 2016). Land use patterns have an important influence on water quality (surface and underground) and aquatic ecosystems within a river basin (ROTHWELL et al., 2010).

The consequences of disordered growth are the transport of large amounts of soil, organic matter, household and agricultural inputs to the bed of watercourses in the rainy season, significantly contributing to the increase in the concentration of solids and nutrients in water sources. Another type of contaminant that can be transported to the source bed is coliforms. The accumulation of these substances inevitably causes, from the entry into the food chain of aquatic species, the compromise of the entire ecosystem (SEBUSIANI, 2011).

According to DUPASA et al. (2015), the use and management of agricultural land has a strong influence on nutrient concentrations in water, also causing siltation. Thus, rivers are particularly vulnerable to transformations in ecosystems, since they integrate the landscape and their physicochemical characteristics reflect both the geological configuration they drain and the inputs from the surrounding basin (PICKETT et al., 2011).

Another aspect related to land use and occupation, which interferes with the ecosystem, is the replacement of the original vegetation in these regions by impermeable areas. Although the negative impacts of landscape transformations on water quality and aquatic ecosystems are well documented, the importance of urbanization and agriculture for water bodies remains a point to be discussed in order to predict the polluting potential of a given use and develop watershed management practices (KOÇER; SEVGILI, 2014).

Table 1presents the characterization of the areas of the 06 evaluated monitoring points.

Table 1 - Characteristics of the evaluated monitoring points

Point	Point Feature
01	The place presents a rural anthropogenic field, with low population density, predominance of rural properties. Featuring a bed mixed with rocks and sand.
02	The site has a dry native field and degraded field, it is used for the transposition of water for energy generation by CEEE and is responsible for 30% of the water in the Sinos Rivers. Water activities by the population.
03	The point ismarkedbybeing a valleyoflargeextensionsofforest, presenting a rural anthropogenicfield, withlowpopulationdensity. Locatedbetweenthemunicipalitiesof Canela and Gramado.
04	CORSAN's 02 watercollection point for thecityof Montenegro, presentsanthropicaction, receivesanorganicloadofswineproductiondischargedbytheMaratástream.
05	The riverreceivesthe Paulista streamthat runs alongsidethetreatmentpondsofthePetrochemicalComplex.
06	Place used for water activities by the population are companies, used for primary activities.

Data source

The water collections covered the period from November 2017 to August 2018, with sampling performed with triple repetition in each of them. They were carried out in the morning following the sampling procedures described in ABNT (1987).

The following parameters were analyzed in the Caí River water samples (APHA, 2012): lead, copper, total coliforms, conductivity, total chromium, BOD_5, COD, thermotolerant coliforms, iron, total phosphorus, manganese, mercury, nickel, OD, pH, sodium, total solids, turbidity and zinc. In tests in which the parameter result was lower than the detection limit, the detection limit value was considered as a reference value for the descriptive analysis. The data of the analyzed parameters were submitted to a descriptive analysis (mean, median and standard deviation calculations).

The results of the analyzed variables were compared with the Resolution of the National Council for the Environment (CONAMA) No. 357, of March 17, 2005 (BRASIL, 2005), which defines the acceptable levels of each variable in the water quality of water bodies aiming at its environmental preservation.

III. RESULTS AND DISCUSSION

In table 02, the parameters for evaluating the quality of the waters of the Caí River are presented.

Table 02 - Descriptive analysis of the evaluated parameters

Parameter	descriptivemeasure	Point					
		P1	P2	P3	P4	P5	P6
Lead ($mg.L^{-1}$)	mean	0,0141	0,0241	0,011	<0,0112	<0,0112	<0,0112
	median	0,0112	0,0112	0,0112	0,0112	0,0112	0,0112
	s.desviation	0,005	0,0224	0,0007	0	0	0
Copper ($mg.L^{-1}$)	mean	<0,013	<0,013	<0,013	0,013	0,013	0,014
	median	0,013	0,013	0,013	0,013	0,013	0,013
	s.desviation	0	0	0	0,001	0	0,028
Conductivity	mean	30,21	24,84	35,43	108,15	148,39	104,56

(µs.cm^{-1})	median	30,48	24,74	33,96	108,15	92,42	101,2
	s.desviation	3,58	1,71	5,67	25,14	111,14	30
chrome (mg.L^{-1})	mean	<0,182	<0,182	<0,182	<0,182	<0,182	<0,182
	median	0,182	0,182	0,182	0,182	0,182	0,182
	s.desviation	0	0	0	0	0	0
totalcoliforms(NMP/100 mL)	mean	2000	3933,3	2700	8250	33556,7	3543
	median	2000	3100	2700	8250	18000	3900
	s.desviation	1414,21	3426,85	2404	636,4	30474,7	2761,9
fecalcoliforms((NMP/100 mL)	mean	305	326,66	4433,3	1930	790	217
	median	304	300	4100	2300	790	100
	s.desviation	7,07	73,71	850,5	820,18	84,85	264,66
BOD_5 (mg O_2.L^{-1})	mean	5	<5	<5	<5	20	<5
	median	5	5	5	5	5	5
	s.desviation	0	0	0	0	25,98	0
COD (mg O_2.L^{-1})	mean	7,8	10,1	12,16	<3,1	15,71	78,43
	median	5,3	10,1	7,1	3,1	3,1	3,1
	s.desviation	6,33	7	12,4	0	21,85	130,48
Iron (mg.L^{-1})	mean	0,622	0,805	0,972	3,23	2,79	2,1
	median	0,67	0,73	0,955	3,08	2,72	2,204
	s.desviation	0,15	0,13	0,23	1,57	0,70	1,13
phosphorus(mg.L^{-1})	mean	0,062	0,05	0,175	0,204	0,28	0,102
	median	0,06	0,034	0,083	0,195	0,23	0,12
	s.desviation	0,05	0,04	0,16	0,12	0,19	0,07
Manganese (mg.L^{-1})	mean	<0,0431	0,101	<0,0431	0,194	0,105	0,103
	median	0,0431	0,065	0,0431	0,178	0,079	0,106
	s.desviation	0	0,08	0	0,12	0,05	0,06
Mercury (mg.L^{-1})	mean	0,025	0,025	0,025	0,022	0,024	0,023
	median	0,023	0,023	0,023	0,023	0,023	0,023
	s.desviation	0	0	0	0	0,01	0
Nickel (mg.L^{-1})	mean	<0,031	<0,031	<0,031	<0,031	<0,031	<0,031
	median	0,031	0,031	0,031	0,031	0,031	0,031
	s.desviation	0	0	0	0	0	0
Dissolvedoxygen (mg O_2.L^{-1})	mean	7,81	7,67	7,76	7,55	7,6	5,66
	median	8,3	7,93	7,6	7,7	7,01	5,85
	s.desviation	1,12	1,7	0,65	2,48	1,11	1,51
pH	mean	7,18	5,71	7,6	5,05	7,22	6,94
	median	7,32	6,96	7,32	6,49	7,32	6,93
	s.desviation	0,29	2,34	0,53	3,03	0,21	0,34
Sodium (mg.L^{-1})	mean	2,64	2,1	2,96	6,1	9,5	9,91
	median	2,55	2,1	2,7	5,7	5,8	7,8
	s.desviation	0,28	0,06	0,83	1,68	7,74	6,54
Total Solids (mg.L^{-1})	mean	42,16	95,33	98,5	188,33	179,16	147,5
	median	52	100	97	184,5	175	134
	s.desviation	18,35	22,37	14,81	25,47	33,45	24,69
Turbidity (NTU)	mean	3,69	6,73	24,46	47,21	31,42	36,05
	median	3,7	6,4	22,73	49,03	36,9	41,43
	s.desviation	0,59	1,72	5	8,65	16,32	28,16
Zinc (mg.L^{-1})	mean	0,01	0,01	0,01	0,019	0,04	0,011
	median	0,01	0,01	0,01	0,012	0,01	0,01
	s.desviation	0	0	0	0,01	0,05	0

The data presented in Table 02 are the values related to the collections of the Caí River Basin, from its source (point 01) to its mouth (point 06), showing the conditions of the river.

The classification of the use of raw water according to CONAMA Resolution 357/2005, determines the use of water according to which class it fits. At point 01, the source of the river Caí has a soil with rocks and clay, the watercourse has a small slope, has an altitude of 890 m above sea level, has the anthropic impact caused by the planting of beans, being present in both sides of the river, where riparian forests were removed, exposing the characteristic of using fire to clean the soil. The location presents the predominance of rural properties, with low population density, we can observe satisfactory values for the results of neutral pH, dissolved oxygen, total solids, turbidity, lead, zinc, total chromium, total phosphorus, nickel, manganese, mercury and coliforms feces frame the point as class I and II (CONAMA 357, 2005). From point 02 to point 06, we can observe that there was an increase in the percentage of contaminants of some parameters, at points 02 and 04 pH are no longer neutral, as they present values of 5.71 and 5.01 respectively, being considered acids, being out of standards of CONAMA resolution nº 357/2005 (limit between 6 and 9), the acidic pH causes the reduction of oxygen in the water, which is essential for aquatic life and for human life (SILVA; ARAÚJO, 2003). According to the resolution, the parameters lead, total chromium, mercury, DO, total solids, turbidity and zinc presented tolerable limits, being classified in class I.

For the limits of quantification of the parameter BOD_5, it was impossible to state the exact classification of Rio in the six verified points. The result of BOD_5, <5.0 $mgO_2.L^{-1}$, where the stretch of Rio is classified as class II, but at point 05, the result was 20 $mgO_2.L^{-1}$, is now classified as class IV . For Juras (2015), BOD_5 reflects the organic matter content of the water body whose main origins are the release of untreated sewage, the collection point is close to the treatment ponds of the Petrochemical Complex. According to the Department of Environment and Sustainable Development - SEMA (2019) it was verified that the monitoring in order to assess the polluting loads in the River Caí Hydrographic Basin in 2008, the points were classified as Class I, and it was verified that BOD_5 is in class II, going against the value verified in the present study. The DO values in none of the studied points were less than 5.85 $mgO_2.L^{-1}$, being in class I between points 01 and 05, in class II at point 06. Dissolved oxygen is of fundamental importance in the maintenance of life water quality and water quality (PINTO et. al., 2010). For Araújoet. al. (2004) oxygen is used as the main water quality parameter and serves to determine the impact of pollutants on water bodies. It is the main element in the metabolism of aerobic microorganisms that inhabit natural waters or reactors for biological sewage treatment. In natural waters, oxygen is also indispensable for other living beings, especially fish, where most species do not resist dissolved oxygen concentrations in water below 4.0 $mg.L^{-1}$. It is, therefore, an extremely relevant parameter in natural water classification legislation, as well as in the composition of water quality indices.

The incidence of lead, chromium, mercury and zinc in the Caí River is relatively low, with values below the limits recommended in environmental legislation for classification as Class I. In the analysis, the results for Lead, chromium, mercury and zinc had the lowest values of <0.0112 $mg.L^{-1}$, <0.182 $mg.L^{-1}$, 0.022 $\mu g.L^{-1}$, <0.01 $mg.L^{-1}$, respectively. Manganese presented class I at points 1 and 3, at other points it presented class III. For Oliveira and Nascimento (2006), the micronutrient iron and manganese are the most abundant in the soil. Gonçalves et al (2011) state that the soils of Rio Grande do Sul come from different source materials (basalt, sandstone, siltstone, and granite), which contribute to variations in the total iron and manganese contents. Copper and iron were classified as class III, with the lowest value of <0.013 $mg.L^{-1}$ and 0.622 $mg.L^{-1}$, respectively. Copper showed an increase in the last point, passing to class IV. For the nickel parameter, classifies it for all points in Rio as class IV. Comparing the results obtained with CONSEMA Resolution No. 355/2017, the values meet the resolution, as they present values lower than the daily entry. The metals were detected at practically all points and in all collections and presented themselves sometimes in lower concentrations, sometimes in higher concentrations. This suggests that the possible sources of contamination of these metals are punctual. According to Costa et. al. (2008) point source emissions (treatment of industrial effluents, domestic sewage networks and mining areas) are more easily detected and controlled and generally result in direct discharges of contaminants into water bodies. According to Freiberger (2012), water samples collected at different points of the Caí River were classified in Class I, however, parameters such as total phosphorus, iron and fecal coliforms present altered values. The variables that are fully compliant were OD, chromium and pH.

The microbiological parameter of fecal coliforms presented values that classify the stretch into class between II and IV. Of the values analyzed in the points, the smallest amount presented was in Point 06, 217 NMP/100 mL, whereas in Point 03, with 4433.3 NMP/100 mL was the highest concentration. According to Oliveira (2015) for Rio's framing purposes, the value of fecal coliforms cannot exceed 4,000 NMP/100mL to be classified as Class 3 and in turn allow the use of water for public supply after treatment. For the values of total coliforms, the values analyzed in the points, the largest amount presented was at point 05, 33,556.7 NMP/100mL, whereas point 01 had the lowest concentration, the amount of 2,000 NMP/100mL. The values of total and fecal coliforms in Table 2 show high values, considering the population of the Basin and the rate of treated sewage, it is possible to conclude that the set of results presented in the points is a consequence of the pollutant loads drained by the streams into the river.

It is essential to emphasize the influence of rainfall in the variation of some parameters evaluated, on rainy days there is a greater release of soil particles and organic material in rivers, which increases the organic load and, consequently, the value of BOD (VASCO et. al., 2011). The runoff of rainwater carries organic and inorganic materials in suspension or soluble to the water sources, significantly increasing its pollutant load. These pollutants have a diverse origin, garbage accumulated on public roads, organic waste from animals, construction activities, fuel waste, automotive oils and greases, air pollutants, household and industrial waste and pesticides (FREIBERGER, 2012).

The percentage of conductivity identified in the samples had a value of 148.39 µs.cm^{-1} at point 05, which is located next to the treatment ponds of the Petrochemical Complex, point 02 had a value of 24.74 us.cm^{-1}, the lowest percentage among the 06 points. According to Venzkeet. al. (2017), the percentage of conductivity identified, represents the amount of salts dissolved in the water.

Chemical oxygen demand (COD) is a global parameter used as an indicator of the organic content of wastewater and surface water, and is widely used in monitoring liquid effluent treatment. Although CONAMA resolution 357/05 does not refer to the DQO parameter in the classification of water bodies and in the standards for the release of liquid effluents, in Rio Grande do Sul, CONSEMA Resolution No. 355/2017 establishes maximum limits for this parameter in its release patterns. Checking the results obtained in the collections, the values meet the resolution, as they present percentages lower than the daily release (CONSEMA 355, 2017). Maratha that flows with some turbulence near the point. For Silva and Araújo (2003), turbidity is the matter suspended in water, which can attach itself to pathogens in the environment, in the treatment process, hindering the action of chlorine on them. The total solids content did not exceed the established legal limits, between points 04 and 06 there is a greater flow in Rio and there are already urban and industrial interferences, the increase in turbidity and total solids was expected.

Evaluating the values of the analyzed parameters in a set, we verified that no single point stands out in terms of pollution. In each collection, a different point presented higher values for a certain parameter. Potentially toxic substances can be degraded by abiotic and biotic processes that occur in nature, however, some of these resist degradation processes and are able to persist in the environment for long periods of time (COSTA et. al., 2008).

The results verified throughout Rio confirm the data presented by the authors and are consistent with the on-site visits to the collection points, in which the appearance of the river is less attractive, with a predominance of dark coloring and in certain places with a strong sewage odor cloacal, in addition to floating waste, characterizing the release without treatment of effluents in the Caí River.

IV. CONCLUSION

From the scenario presented in this study, it is possible to state that the Caí River has been suffering from changes in human activities. The high levels of fecal coliforms found in Rio characterize the problem of lack of basic sanitation in the CaíRiver Caí Hydrographic Basin.

Finally, it is possible to conclude that the water quality of the Caí River is a reflection of the environmental conditions in which the Hydrographic Basin is found. The lower the anthropogenic interference, the better the water quality will be, that is, upstream from the River the region is more preserved, while downstream, especially close to urban centers, the water quality is precarious, not allowing activities such as public supply, fishing, agriculture, recreation, among others.

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