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Environmental Diagnosis of Estância Velha City (RS Leather Region) Based on Analytical Data of its Microwatershed

Horst Mitteregger Júnior[1]; Lisiane Emilia Grams Metz[2]; Alice Riehl[3]; Marina Medtler Seewald[4]

[1]Instituto SENAI de Tecnologia Couro e Meio Ambiente, Rua Gregório de Matos, 111. CEP 93600-000. Estância Velha – RS, Brasil. (51) 3904-2735. horst.jr@senairs.org.br.

[2]Instituto SENAI de Tecnologia Couro e Meio Ambiente, Rua Gregório de Matos, 111. CEP 93600-000. Estância Velha – RS, Brasil. (51) 3561-1500. lisiane.metz@senairs.org.br.

[3]Instituto SENAI de Tecnologia Couro e Meio Ambiente, Rua Gregório de Matos, 111. CEP 93600-000. Estância Velha – RS, Brasil. (51) 3561-1500. alice.riehl@senairs.org.br.

[4]Instituto SENAI de Tecnologia Couro e Meio Ambiente, Rua Gregório de Matos, 111. CEP 93600-000. Estância Velha – RS, Brasil. (51) 3561-1500. marina.seewald@senairs.org.br.

Abstract

Estância Velha, a town located in the northern part of Porto Alegre metropolitan area, Rio Grande do Sul (RS), Brazil, since its establishment, has as one of its main economic activities the leather tanning and finishing industry. The population of 35,132 inhabitants in 2000 has increased to 45,986 inhabitants in January 2014.As a result of the town development and the different demands of the domestic and world market, other industries have been settling in the town, such as: metallurgy, chemicals and plastics. In this context, Estância Velha stream, which is about eight kilometers long, receives domestic and industrial wastewater originated from different points of the town, and its watershed is considered an important environmental quality indicator. In order to assess the wastewater impact to Estância Velha Stream water quality, physic chemical and microbiological analysis has been performed on its water since 2003 and ecotoxicity tests since 2011. Preliminary analysis of the analytical historical data indicates high variation of contaminants in the environment, such as: total nitrogen, ammonia nitrogen, oil and grease, thermotolerant coliforms, chromium, copper and zinc, which allow an environmental diagnosis of this region. Although the presence of toxicity has been identified, the results suggest an improvement of the stream condition on this period, which may be associated to a greater environmental control, investments by companies on industrial wastewater treatment systems and change of the city's profile over this period.

Keywords: leather, monitoring, toxicity, environment.

1 – Introduction

Estância Velha town located near the Rio dos Sinos river, has a large population and industrial concentration, and is characterized over the years as one of the cluster of the leather industry, which has been operating since XIX century (Prefeitura de Estância Velha, 2015). In this context Estância Velha Stream is identified as an important water body that has received domestic and industrial wastewater generated in the town over the years (Naime&Fagundes, 2005), being inserted into the hydrographic map of Rio Grande do Sul (RS) Brazil.

The Estância Velha stream is one of the interfluents of Portão stream, with its river mouth into Rio dos Sinos, originating one of the nine basins the hydrographic map of the RS, the Sinos river basin, which corresponds to 1.3% of the total area of Rio Grande do Sul, covering all or part of 32 cities (Plano Municipal de Saneamento Básico de Estância Velha, 2014), Figure 1.

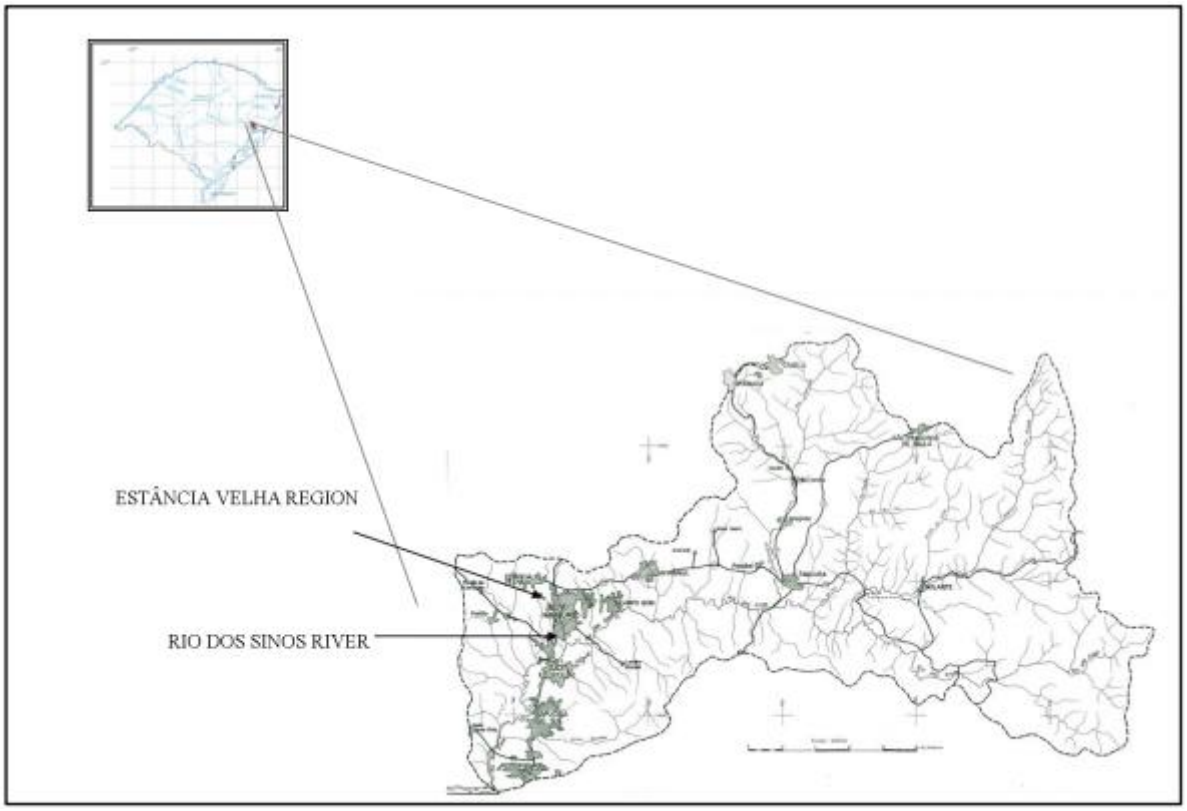


Figure 1-Hydrographic map of Estância Velha Region. Source: http://www.sema.rs.gov.br

In 1994, the Technical Program for the Management of Greater Porto Alegre (RS) had already identified this municipality activities that were characterized by the use of natural resources. These activities provided a disorderly growth in the town, as well as the presence of sewage, disposal of industrial wastewater (mostly tanning and processing of leather) with high organic load, presence of solids, oil and grease, chrome, sodium, sulfides, sulfates, chlorides, nitrogen, and other metals. (Krebs & Reis, 1994).

According to Vargas (2001) the presence of contaminating agents was identified in the Rio dos Sinos river, including Portão stream river mouth, by mutagenic activity and the presence of metals in the sediment such as iron, manganese, chromium, lead, copper, zinc and nickel, manganese and lead standing out with the highest concentrations. These elements may also have its origin in the geological formation or as a result of tanning chromium.

The use of physical and chemical analysis has been one of the main procedures used in the characterization of the impact of industrial wastewaters into the Estância Velha stream, which seek to obey the criteria adopted by environmental agencies, however the association with ecotoxicological tests is necessary to evaluate toxic compounds from anthropogenic activity (Bertoletti 1992; SmakaKincl et al., 1995).

The ecotoxicological tests using bioindicators as Daphnia similis, Daphnia magna, *Ceriodaphniadubia* and *Hyallelaazteka* which have been used by environmental protection agencies in the evaluation of

industrial wastewaters, enable the determination of the toxicity of complex mixtures present in the environment (Ingersoll et al, 1995;. Wang et al.; 2004).

This study allowed the environmental assessment using chemical and physical analysis as well as ecotoxicological analysis of different points located along the Estância Velha stream/RS, from 2003 to 2015, and its relation with the population increase and industrial development.

2 – Materials and methods

2.1. Sampling

The sampling of the Estância Velha stream water has been performed since 2003 initially at three different points, reaching 14 sampling points in 2015, which are distributed from the headwaters to the mouth of the Portão stream, in the limits of the town (Figure 2).

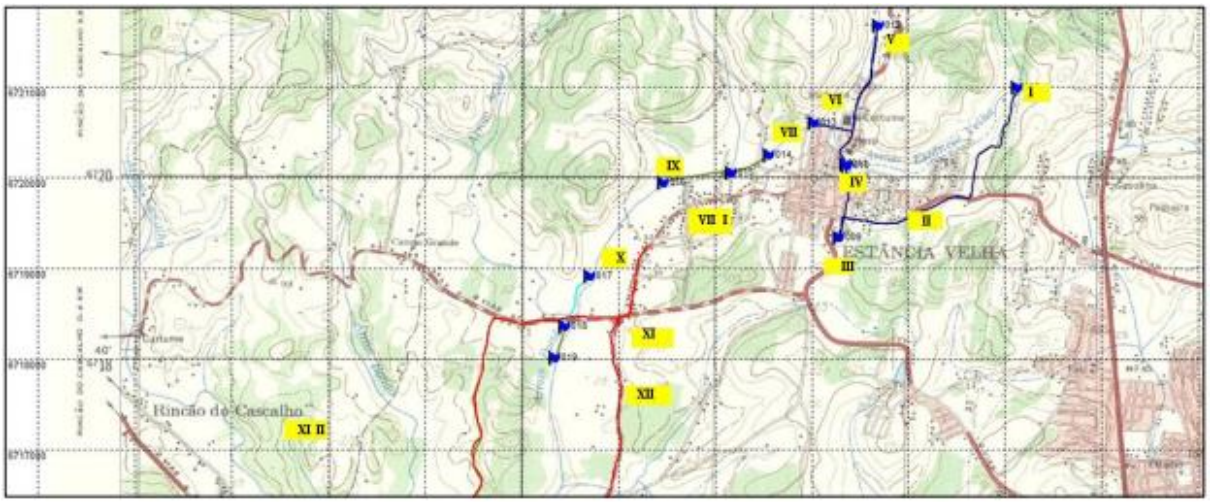


Figure 2 -Sampling points in Estância Velha stream

The points were identified according to their geographical coordinates, with the use of the GPS equipment APR 62 SC (Table 1).

Table 1 - Location of sampling points

Sampling points	Geographical location (DATUM: SIRGAS 2000)	
	South	West
I	29° 38.476'	051°09.254'
II	29° 39.359'	051°10.402'
III	29° 38.927'	051°10.340'
IV	29° 38.920'	051°10.356'
V	29° 38.476'	051°09.254'
VI	29° 38.476'	051°09.254'
VII	29° 38.476'	051°09.254'
VIII	29° 38.476'	051°09.254'
IX	29° 38.476'	051°09.254'
X	29° 38.476'	051°09.254'
XI	29° 38.476'	051°09.254'
XII	29° 38.476'	051°09.254'
XIII	29° 38.476'	051°09.254'
XIV	29° 38.476'	051°09.254'

2.2. Chemical and physical analysis of ecotoxicological water

For the planning of microbiological, physical and chemical analysis to be evaluated in the water the NBR 9898 (ABNT, 1987) was used, relating to the leather industry, being the total nitrogen determinations, ammonia nitrogen, oils and greases, fecal coliforms, total chromium, copper and zinc performed according to Standard Methods 2012.Ecotoxicity tests were done using the algae *Psudokirchneriella subcaptata* NBR 12648 (ABNT, 2011), microcrustacean *Ceriodaphnia dubia* NBR 13373 (ABNT, 2010) and fish species Pimephales promelas NBR 15499 (ABNT, 2007).

The determination of the chronic toxicity of bioindicators was determined by statistically significant difference between the observed effect (mortality, growth in body weight, reproduction or inhibition of algal growth algal growth inhibition) for organisms exposed to the control group and the test sample. Acute toxicity may be determined by statistically significant difference between the observed effect (mortality, immobility or inhibition of algal growth) for bodies exposed to the control group and the test sample after 48h or 72h (algae) of exposure.

2.3. Town profile survey

The town's development (economic production, industry and trade) considering the number and type of licensed companies, was identified from county data literature review and consultation on the data basis from the Estância Velha Town Environmental Department.

3 – Results and Discussion

During the years 2013 and 2015 the data collection of the licensed companies distribution in the town still shows the presence of companies associated with the leather industry (Table 2), especially the manufacture of various artifacts hides and skins (except footwear) as main activity of the sector in 2015 (55 companies) and manufacturing many artifacts hides and skins (except footwear) in 2013 (48 companies).

From the analyses of different industries located in the town, it is possible to highlight the increase of companies based in the town, especially the manufacturing of shoe components, chemicals production,

metal materials (mainly electroplating) and textiles. These results differ from previous years, where the leather industry was the main activity in the town (Krebs & Reis, 1994).

Table 2 - Licensed Companies for Estância Velha town in the years 2013 and 2015

Typology of Licensed Companies	Year	
	2013	2015
Footwear manufacturing	19	22
Textiles	11	19
Chemical inputs	24	33
Leatherindustry	65	88
Concrete / plaster	7	13
Wood	19	26
Footwear components	33	44
Metal	50	67
Foods	5	18
Dry gas vehicles	6	12
Plastic	7	13
Industrial solid waste class II	6	11
Manufacturing cardboard artifacts	9	17
Others	140	143

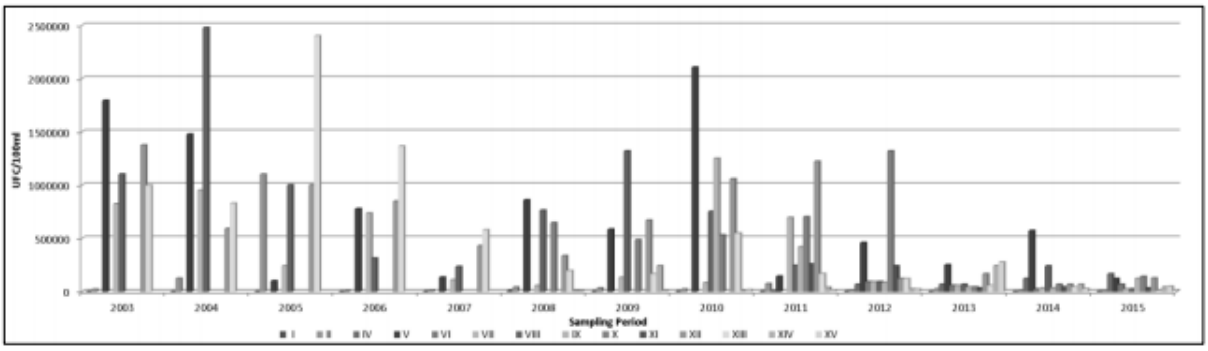
The population was 35,132 inhabitants in 2000 and increased to 42,574 inhabitants in 2014 (IBGE, 2015), and the sewage treatment is still done by a basic system which consists of septic tanks.

Considering the results of physical and chemical analysis and microbiological analysis obtained between the years 2003 to 2015 and Resolution CONAMA 357 (2005), the reduction of the concentration of thermotolerant coliforms (Chart 2) Total Chrome (Chart 3), Oil and Greases, Total Nitrogen, Ammonia Nitrogen, Copper and zinc (Table 3) can be highlighted in most of the points. In this context the increase in the concentration of dissolved oxygen, indicating the improvement of environmental quality was observed.

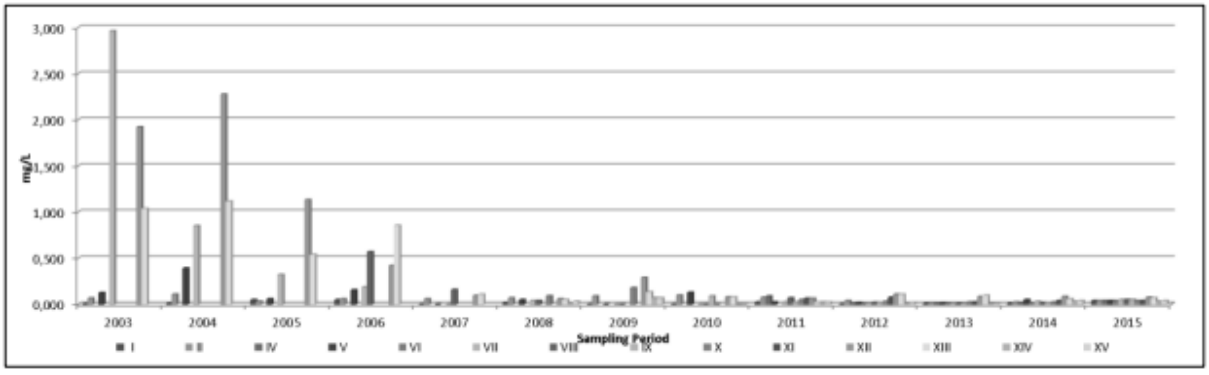
Table 3 - Changes in zinc concentration, copper, total nitrogen, ammonia nitrogen and oxygen in different sampling points

Sampling Points	Average Values(mg/L)					
	Ammonia Nitrogen**	Total Nitrogen**	OilandGreases**	Dissolved Oxygen**	Copper*	Zinc*
I	1.5-0.0	1.5-5,7	10.6-0.0	3.1-7.0	0.02-0.00	0.01-0.00
II	2.0-0.0	7.2-2.5	12.4-14.0	4.5- 7.1	0.02-0.00	0.01- 0.01
III	9.3-5.7	12.1-8.2	39.3-0.0	4.6-5.6	0.01-0.00	0.01- 0.01
IV	3.0- 4.7	38.2-7.8	12.0-0.0	3.7- 1.8	0.05-0.00	0.02 -0.02
V	0.0-0.0	6.2-4.0	13.7-11.2	5.6-8,2	0.01-0.00	0.02-0.00
VI	3.0-3.6	11.0-7.1	15.8-12.7	4.7- 6.3	0.26-0.14	0.56- 0.05
VII	7.6- 4.3	54.1-7.3	32.4-0.0	4.3- 5.2	0.13-0.02	0.19-0.02
VIII	6.5- 3.5	17.0-7.3	0.0- 0.0	6.5- 6.5	0.14-0.02	0.17- 0.01
IX	14.1- 4.5	18.9-7.7	15.2- 0.0	4.7- 4.2	0.04-0.01	0.05-0.01
X	22.0- 2.9	27.6- 6.6	16.4-0.0	4.8- 6.6	0.03- 0.02	0.05- 0.01
XI	5.5- 4.2	68.3- 7.1	22.4-22.2	4.2- 7.1	0.02-0.01	0.05- 0.01
XII	12.9-4.5	47.4-7.1	15.2 – 15.7	3.5- 6.7	0.02-0.01	0.04- 0.01
XIII	1.4- 0.0	1.9- 2.20	15.6-16.1	7.1- 7.8	0.01-0.00	0.01-0.01
XIV	5.3- 2.3	6.8- 4.4	22.5-15.4	6.2- 7.0	0.02-0.00	0.01 -0.01
Class 1***	-	-	Absent	6.0	-	0.18
Class 4***	-	-	-	2.0	-	-

* Considering the average values of 2011 and 2015 years. ** Considering average values of 2003 and 2015 years. *** Limits established by Resolution CONAMA 357 (Conselho Nacional do Meio Ambiente, 2005) and Resolution 149 (Rio Grande do Sul, 2014) Class 1–water intended: a) to supply for human consumption after simplified treatment; b) the protection of aquatic communities; c) the primary contact recreation such as swimming, water skiing and scuba diving. Other points Class 4 - water intended: a) for navigation; b) for the landscape harmony.



Graphic 2 - Concentration of thermotolerant coliforms in different sampling sites in the Estância Velha stream



Graphic 3- Concentration of Total Chrome in different sampling sites in the Estância Velha stream

The results of ecotoxicity tests show the presence of greater toxic effect in points located between the points VI (downstream of Estância Velha town) and the point XI (at the end of the stream), in an area of higher concentration of industries. The toxicity on algae Psudokirchneriella subcaptata (Table 4) was found in most of the analysed points.

Table 4 – Results of Ecotoxicity Tests

Sampling Points	Year				
	2011	2012	2013	2014	2015
I	Chronic toxicity to algae only	No effect	Chronic toxicity to algae only	No effect	Chronic toxicity to algae only
II	No effect	Chronic toxicity to algae only	Chronic toxicity to algae only	Chronic toxicity to algae only	Acute toxicity to microcrustacean and chronic to algae
III	Not performed	No effect	Acute toxicity to fish and microcrustacean; Chronic toxicity to algae.	Acute toxicity to fish and microcrustacean; Chronic toxicity to algae.	Chronic toxicity to microcrustaceans and algae.
IV	Not performed	No effect	Acute toxicity to microcrustacean; chronic toxicity to algae.	Acute toxicity to fish and microcrustacean.	Chronic toxicity to microcrustaceans and algae.
VI	Acute toxicity to fish and microcrustacean; Chronic toxicity to algae.	No effect	No effect	Acute toxicity to fish and microcrustacean.	Chronic toxicity to algae only
VII	Acute toxicity to microcrustacean; chronic toxicity to algae.	No effect	Chronic toxicity to algae only	Chronic toxicity to algae only	Chronic toxicity to microcrustaceans and algae.
VIII	Acute toxicity to microcrustacean; chronic toxicity to algae.	Chronic toxicity to algae only	Chronic toxicity to algae only	Acute toxicity to fish; Chronic toxicity to microcrustaceans and algae.	Chronic toxicity to microcrustaceans and algae.
IX	No effect	Chronic toxicity to algae onlys	Chronic toxicity for all trophic levels	Acute toxicity to fish; Chronic toxicity to microcrustaceans.	Chronic toxicity to microcrustaceans and algae.
X	Chronic toxicity to algae only	Chronic toxicity to algae only	Chronic toxicity to algae only	Chronic toxicity to fish and microcrustaceans.	Chronic toxicity to microcrustaceans and algae.
XI	Chronic toxicity to algae only	Chronic toxicity to algae only	No effect	No effect	No effect
XII	No effect	Chronic toxicity to algae only	Chronic toxicity to fish only	No effect	No effect

4 – Conclusions

Despite the increase in population and industry development of other industries besides the leather such as electroplating, food, textile among others, the results of total chromium analysis, fecal coliform, oil and grease, total nitrogen, ammonia nitrogen, copper and Zinc demonstrate the improvement of the Estância Velha stream quality over the years. In association with this fact, the limits set by environmental legislation, increased enforcement of environmental agencies and the implementation of technologies for the wastewater treatment are stricter these days.

The toxicity presence and the high concentration of fecal coliform is still an indicator of untreated sewage discharge, mainly from the presence of sewage and disposal of industrial wastewaters. The analysis of data obtained corroborate to future projects for the environmental risk assessment in watersheds subject to different types of anthropogenic contamination.

5 – Acknowledgement

Town Council of Estância Velha, Instituto SENAI Couro e Meio Ambiente

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