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# Assessment of Tannery-Derived Pollution in the Sinos River Basin, Brazil

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**Abstract** The leather industry is water-intensive and generates highly polluted wastewater. Brazil, with the world's largest commercial cattle herd, is a leading leather producer. The state of Rio Grande do Sul holds a prominent position in national exports, with a high concentration of tanneries in the Sinos River Basin. Thus, this study aimed to assess tannery wastewater treatment practices in the basin, quantify pollution loads, and evaluate their impact on surface water quality. Data from the State Environmental Agency were collected, including treatment technologies, discharge volumes, guideline exceedances, and pollutant concentrations. Frequent violations involved thermotolerant coliforms, nitrogen, total chromium, chemical oxygen demand (COD), oils and greases, and suspended solids. Pollution loads ranged from 27.2 kg/year (total chromium) to 94.5 t/year (COD), indicating a contribution from tanneries to basin contamination.

**Keywords:** Tannery; Wastewater; Sinos River Basin; Surface water pollution.

## 1. Introduction

The leather industry is economically relevant in many developing countries, but it also poses environmental risks due to the discharge of toxic and hazardous wastewater when not properly treated. Brazil is a leading leather exporter, with intense activities concentrated in the Sinos River Basin region (southern Brazil). This basin has become a major industrial center, particularly known for its leather and footwear production. Over the past few decades, the rapid economic growth of cities has been accompanied by severe environmental challenges. These include the overexploitation of water resources, unregulated land use, insufficient basic sanitation infrastructure, and a high concentration of industrial activities with considerable pollution potential (Kieling-Rubio *et al*., 2015). As a result, the Sinos River has been classified as one of the ten most polluted rivers in Brazil (Popp, 2021).

Leather processing consists of a sequence of physicochemical and mechanical treatments applied to animal hides, using a range of chemicals in water-based processes. A relevant portion of these chemicals is not fully retained by the hides and is discharged into raw wastewater. Tannery wastewater is characterized by high concentrations of dissolved and suspended solids, total and ammoniacal nitrogen, chemical oxygen demand, sulfides, and chromium (Hansen *et al*., 2021; Zhao *et al*., 2022). Thus, this study aimed to evaluate the current wastewater treatment practices employed by tanneries in the Sinos River Basin, quantify the pollution loads discharged, and assess their relationship with surface water quality.

## 2. Methodology

Tanneries within the Sinos River Basin were identified using data from the State Environmental Agency. A total of 25 tanneries were recorded: 18 discharged treated wastewater into surface water bodies, 4 fully reused wastewater, 2 disposed wastewater on agricultural land, and 1 sent raw wastewater to an external treatment facility.

Data obtained for the 18 tanneries that discharged treated wastewater into the basin (Figure 1) included: (i) the treatment technologies employed at the Wastewater Treatment Plants (WTP); (ii) the number of parameters exceeding the environmental guidelines; (iii) the flow rates of wastewater discharged into the basin; and (iv) the concentrations of chromium, COD, ammoniacal nitrogen ($NH_3$), oils and greases (O&G), and total suspended solids (TSS) in treated wastewater. All data were collected for the year 2024. Based on the flow rates and pollutant concentrations, the corresponding pollution loads were calculated.

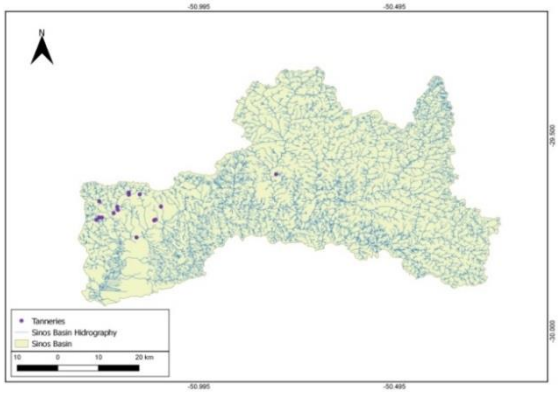


**Figure 1.** Tanneries with wastewater discharge into the Sinos River Basin.

## 3. Results and Discussion

The technologies employed in the tannery WTPs are shown in Figure 2.

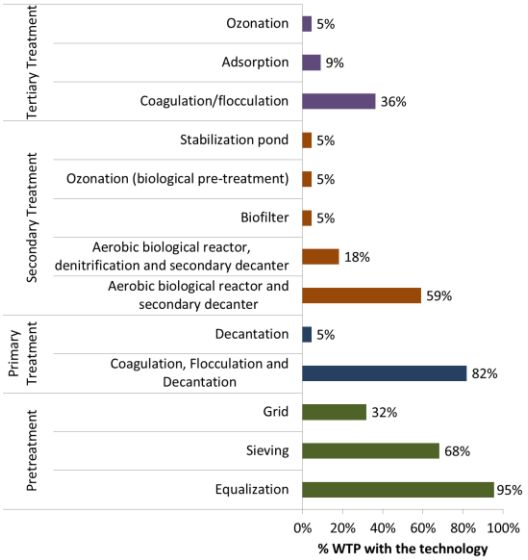


**Figure 2.** Treatment technologies in WTPs.

In the preliminary treatment, 95% of the WTPs utilize equalization tanks, while 68% employ sieving to remove solids, particularly fibers. During primary treatment, 82% of WTPs apply coagulation and flocculation, typically involving the addition of conventional inorganic coagulants or flocculants. This process primarily targets the removal of chromium, along with COD, TSS, and color (Zhao *et al*., 2022). In the secondary treatment, aerobic biological reactors are predominant, used by 59% of the WTPs to remove biodegradable organic matter. Additionally, 18% of these biological systems include a nitrogen removal stage. Finally, in the tertiary treatment, coagulation and flocculation remain common (applied in 36% of WTPs). Other advanced methods include adsorption using leather shavings, activated carbon, and ozonation.

The parameters most frequently exceeding environmental guidelines were thermotolerant coliforms (10 exceedances), nitrogen (8 exceedances), total chromium (3 exceedances), and COD, O&G, and TSS, each with two exceedances. Despite the common practice of mixing industrial and sanitary effluents to enhance biodegradability in WTPs, the disinfection stage is rarely implemented in the tertiary treatment (Figure 2). This may explain the high number of exceedances for thermotolerant coliforms. Figure 3 presents the pollution loads for chromium, COD, $NH_3$, O&G, and TSS released into the basin.

Analyzes of surface water in the Sinos River Basin indicate that approximately 50% of total chromium measurements in the Portão and Luiz Rau streams (areas with the highest concentration of tanneries) exceed guidelines for surface water used for human consumption after complete treatment (FEPAM, 2006). Monitoring data also indicate that microbiological and physicochemical contamination levels increase downstream along the river, primarily due to the absence of domestic sewage treatment in urbanized areas and the discharge of relevant industrial pollution loads (Rizzana *et al*., 2018). Based on the pollution loads released by tanneries (Figure 3), it is evident that this activity contributes, to some extent, to the levels of these parameters in the basin.

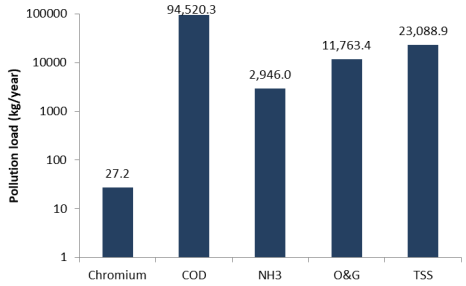


**Figure 3.** Pollution loads for chromium, COD, $NH_3$, O&G, and TSS.

Complementary technologies can enhance tannery wastewater treatment. A hybrid photoelectrochemical-electrodialysis process achieved high removal efficiencies for COD (87.3%), total solids (98.8%), and ammoniacal nitrogen (>99.9%), allowing water reuse in a closed-loop system (Rodrigues *et al*., 2008). Other studies report chromium removal of 97.6% via adsorption and up to 100% via membrane separation, which still removed 99% of COD and total solids. Similar high efficiencies were achieved using advanced oxidation processes (up to 100% Cr, 97.7% COD, and 99.3% total solids) (Hansen *et al.*, 2021). These technologies support water reuse and reduce pollution loads discharged into the basin.

## 4. Conclusions

Tanneries are a relevant activity in the Sinos River Basin, with 25 facilities currently operating in the region. The deterioration of water quality intensifies downstream, largely due to the cumulative impacts of human activities. Analysis of pollution loads associated with tannery operations provides evidence that this industry also contributes to the degradation of the basin's environmental quality.

**Acknowledgement**

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