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BOD_5 AND COD REMOVAL EFFICIENCY BY *Chlorella vulgaris* IN WASTEWATER FROM TANNING PROCESSES

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ABSTRACT

Microalgae are a very heterogeneous microbial group that provides several applications nowadays, including wastewater treatment. The treatment of wastewater is very important, as it contains pollutants that prevent its reuse. In the present study, the growth potential of the microalga *Chlorella vulgaris* and its purification capacity in wastewater from tanning processes were evaluated. *Ch vulgaris* was bioaugmented in a bioreactor, using exponential phase cells of 106 cells/mL. The Ch. vulgaris cells were treated with tanning wastewater for 20 days. BOD_5 and COD parameters were measured daily. The results of the organic load degradation tests confirm that *Ch. vulgaris* reduces BOD_5 and COD to values below those permitted by the regulations established for the leather manufacturing, tanning and dressing industry. *Ch. vulgaris* is able to survive the adverse conditions present in wastewater, efficiently removing pollutants present in wastewater from tanning processes.

Keywords: Wastewater, tanning process, microalgae, organic load, pollutant reduction.

INTRODUCCIÓN

The transformation of a fresh bovine hide into finished leather involves a set of steps grouped into beam, post-tannage tanning, drying, pre-finishing and finishing. As these steps are carried out, the commercial value of the product increases. In Brazil, for example, finished leather accounts for 59.6% of leather exports (Bharagava and Mishra, 2018). As the post-tannage process uses recalcitrant and toxic chemicals, the treatment of post-tannage wastewater is an issue of concern that has prompted studies towards new wastewater treatment technologies.

Colombia, the eighth largest cattle-breeding country in the world, now produces the world's finest hides and skins. the finest furs in the world. This is confirmed by the growing demand for leather products in demanding markets such as the United States, Canada, Europe demanding markets such as the United States, Canada, Europe, Australia and Caribbean countries. The leadership that until a few years ago was held by Argentina, Brazil and Uruguay in Latin America has been taken over by the United States, Canada, Europe, Australia and the Caribbean. Uruguay, has been taken over by Colombian manufacturers in Latin America.

The tanning process consists of transforming the skin of cattle or other animals into leather, which is a valuable raw material, incorruptible, flexible and immune to bacterial attack" (Ortiz, 2012). immune to bacterial attack" (Ortiz, 2012). This process can be carried out using tannins, substances of vegetable origin, requiring between one and two weeks, or with chromium in some weeks, or with chromium over a period of 6 to 8 hours (Ortiz, 2012).

With regard to manufacturing industries, it should be noted that the tanning industry is one of the most polluting industries, as its operations and processes generate liquids and solids that are characterized by a high organic load and chemical agents that can have toxic effects, such as sulphur and chromium (Miranda, 2019; Rosales and Rodríguez, 2018). The discharge of wastewater with a high concentration of chromium generates an alteration in the quality of water bodies, affecting the morphology of plants, causing them to present dwarfism and discoloration of their leaves (Panda and Choudhury, 2005). It also causes serious public health risks such as respiratory problems, carcinogenicity and mutagenicity (OMS, 2019). Aquatic fauna is also affected, as it increases their mortality, interferes with their hormone-regulating functions and scale erosion (OMS, 2019). Within the field of bioremediation is the use of green algae, because they have the capacity to accumulate heavy metals, which are considered high risk due to their toxicity and capacity for accumulation in living tissues, such as Cr (VI). Their use for pollution control is limited to the factors present in the environment, such as pH, hardness, chlorides, sulphates, etc. These factors can limit the biological processes of the algae, reducing the availability of oxygen and therefore the presence of algae. Likewise, microalgae through biosorption in living or dead biomass have a high potential to reduce toxicity levels and to transform toxic compounds into harmless ones. Also, Arias (2017), indicates that microalgae have remediation properties, as they do not generate pollutants as a consequence of their process, due to the fact that the biomass obtained after the remediation process allows the recycling of nutrients.

From the early 1970s until around 1990, wastewater treatment included aesthetic and environmental concerns, bringing the reduction and removal of BOD, suspended solids and pathogenic micro-organisms to a higher level of demand, and the beginning of concern for nitrogen and phosphorus removal.

These compounds contribute to imparting a poorly biodegradable effluent. Post-tanning effluents also show high total dissolved solids (TDS), and suspended solids (SS), nitrogen compounds (organic and ammonium nitrogen, chemical oxygen demand (COD), and chromium (III) (Hansen et al., 2020; Mannacharaju et al., 2020). For these reasons, this project aimed to evaluate the efficiency of Chlorella vulgaris in the removal of chemical pollutants (BOD_5 and COD) from wastewater from manufacturing industries such as tanneries.

2. MATERIALS AND METHODS

2.1 Sampling, storage, processing, packaging and chain of custody for water quality analysis obtained from leather washing. The wastewater from the tanning process was collected at the discharge point of the tannery industry located in the municipality of Sampués, Department of Sucre. The chemical properties of the wastewater collected will be analyzed according to the parameters established by Resolution N°0631 of 2015 of the Ministry of Environment and Sustainable Development for the following parameters: BOD_5, and COD.

2.2 BOD_5 AND COD removal test. The treatment systems consist of 6 funnels, each with a capacity of 1000 mL of water. In the two initial tanks the water from the tanning process will be collected, in this initial stage a flocculants will be applied which allows all the sediment from the fleshing process to precipitate to the bottom of the tanks, these sediments will be collected to carry out a composting process (Tzoupanos and Zouboulis, 2008). In turn, the water will be deposited in two reactors (1000 mL Erlenmeyer), each reactor will be inoculated with 10 mL of *Chlorella vulgaris* in its exponential phase and left in constant agitation for biological treatment. A control with tanning process waste water without microalgal will be used.

2.3 Statistical analysis: The results were expressed as the mean ± Standard Deviation, an analysis of variance was carried out using a completely randomized design, with a 2 x 3 factorial arrangement; previously determining the normality criterion by means of the Shapiro Wilk test (5%). Significant statistical differences were determined by Tukey's test ($p < 0.05$). All experiments were performed in triplicate and analyzed in the free version of InfoStat software.

3. RESULTS AND DISCUSSION

Figure 1 shows the stages of the tanning process in a leather company in the municipality of Sampués, Sucre, Colombia.

Table 1 shows the BOD_5 and COD parameters measured during the experiment. The table shows that the values found are above those established in Resolution No. 0631 of 2015 of the Ministry of Environment and Sustainable Development.

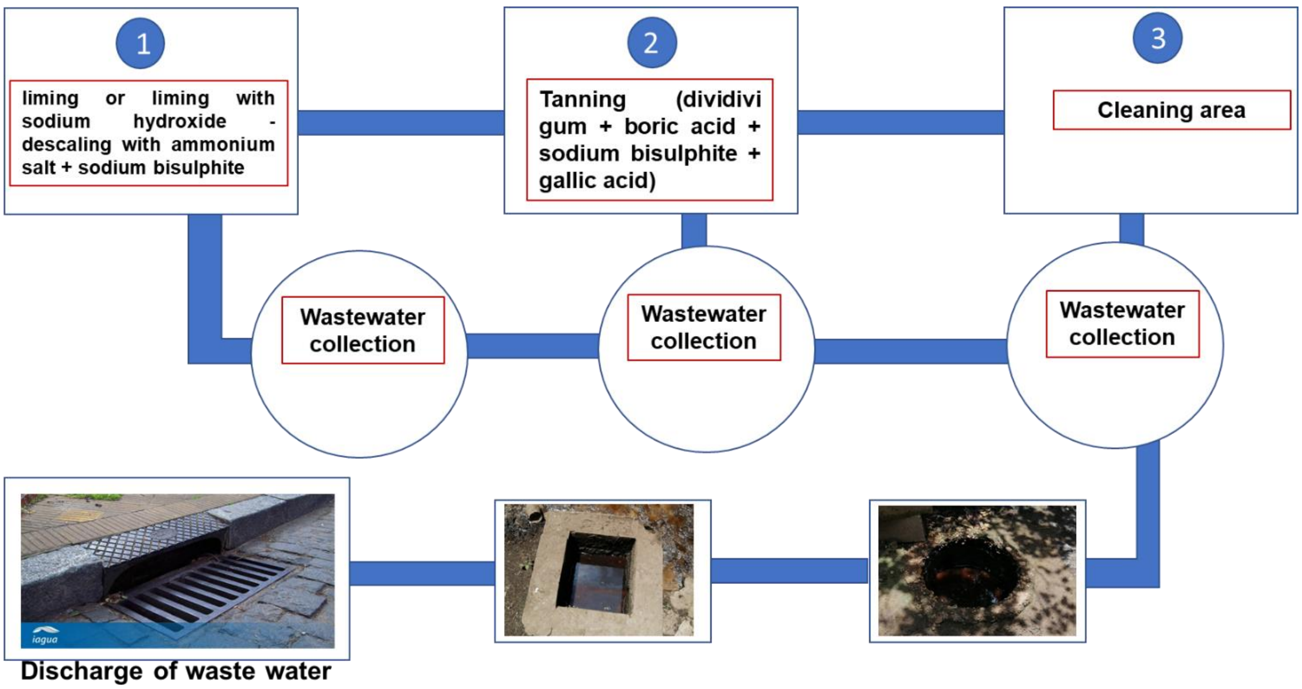

Figure 1. Stages of the tanning process. Source: Pérez, 2022.

Table 1. BOD5 and COD values measured in wastewater from the tanning process.

TIME (DAYS)	BDO_5 (mg/l O_2)	COD (mg/l O_2)
1	1320	1900
2	1320	1900
3	1320	1900
4	1320	1900
5	1320	1900

6	1320	1900
7	1320	1900
8	1320	1900
9	1320	1900
10	1320	1900
11	1320	1900
12	1320	1900
13	1320	1900
14	1320	1900
15	1320	1900
16	1320	1900
17	1320	1900
18	1320	1900
19	1320	1900
20	1320	1900

Figure 2, shows the growth curve of the *Chlorella vulgaris* cell during the remediation process. *Ch. vulagaris* showed growth from day 3 to day 16, with maximum growth at 17 days, after which time it enters the stationary phase and finally the lysis stage. The growth curve indicates that the microalgae grows under the chemical conditions of the wastewater from the tanning process.

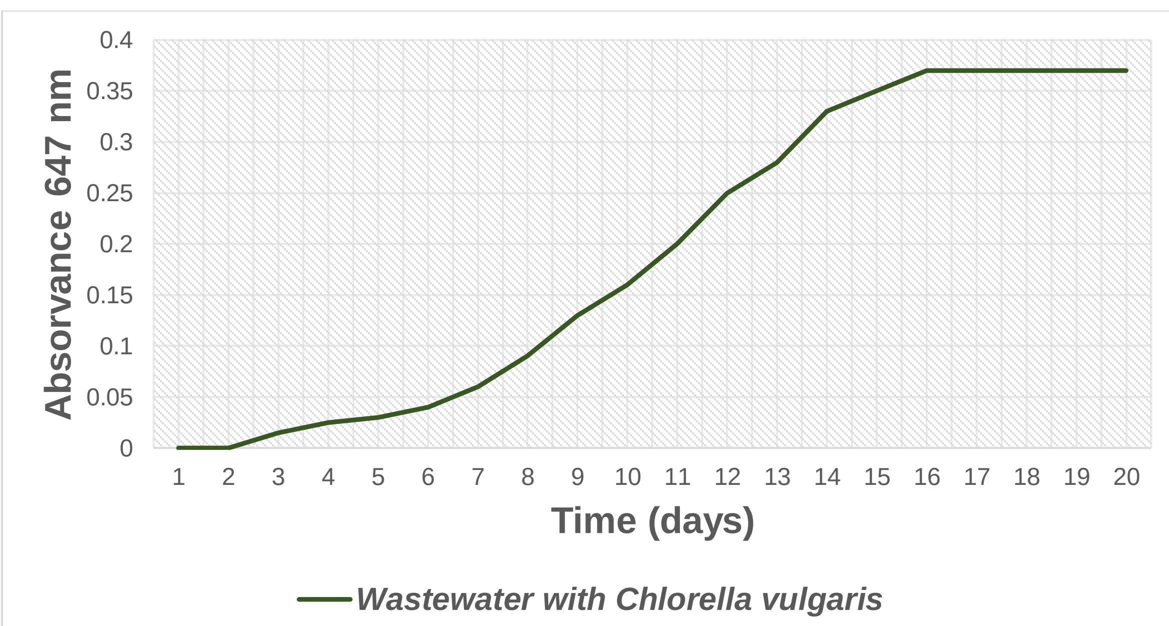

Figure 2. Growth curve of Chlorella vulgaris in tanning process wastewater.

Figure 3 shows the chemical pollutant removal behaviour of *Chlorella vulgaris*. It can be seen in the figure that *Ch. vilgaris* reduced the initial BOD_5 values from 1320 to 420 mg/L O_2 18 days after being in contact with the chemical compound. Likewise, it decreased the COD values from 1900 to 980 mg/L O_2. According to the regulations, both parameters were reduced below the limit allowed by Resolution No. 0631 of 2015 of the Ministry of Environment and Sustainable Development. The results obtained demonstrate the efficiency of *Chlorella vulgaris* in the reduction of these two chemical parameters indicators of pollution in wastewater from the tanning process in the department of Sucre, Colombia.

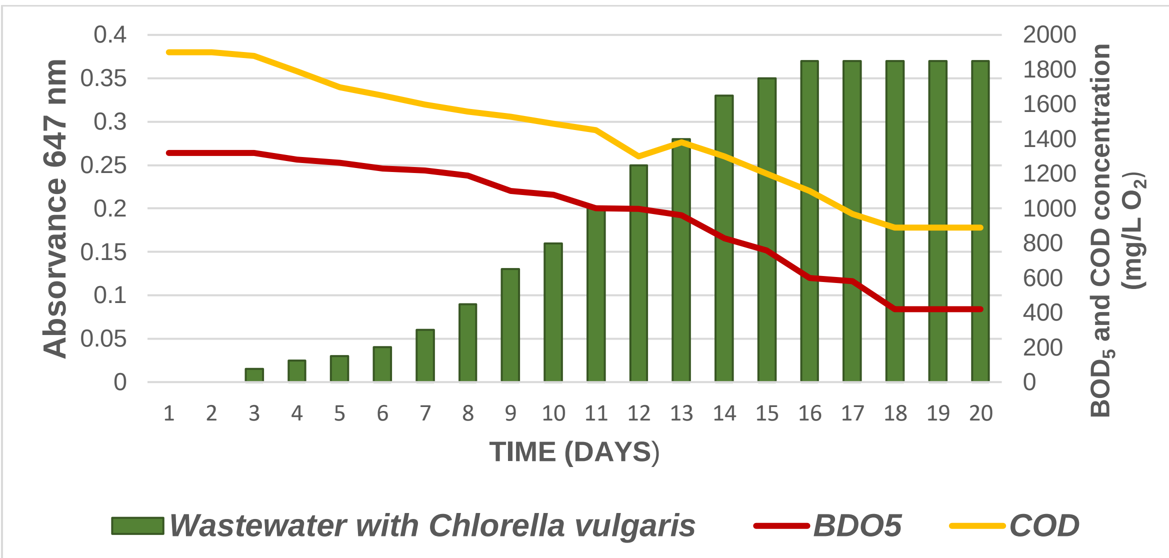

Figure 3. Growth curve of Chlorella vulgaris in tanning process wastewater in the presence of BOD_5 and COD parameters.

As reported by Perez et al. (2023), concerning the biochemical oxygen demand is one of the principal parameters when assessing the characteristics in waste water from the tanning process. In the tannery water used in the present study, the initial BOD5 value was 18520 mg/L which was reduced during treatment with microalgal consortium to 2105 mg/L, showing a percentage removal of 89%, higher than reported in the work of Ajayan et al., (2015), for tannery waters with microalgae of the genus *Scenedesmus*.

Chlorella vulgaris has been widely investigated for its high capacity to remove pollutants from wastewater, as well as for the high lipid content of its organic matter (Mata et al., 2010; Maguire-Boyle and Barron 2014; Elliott et al., 2017).

Chlorella vulgaris is part of the diverse group of unicellular microorganisms with around 300,000 different species on the planet, of which only around 40,000 have been described (Lewandowski et al., 2018). This group includes cyanobacteria (prokaryotes) as well as eukaryotic microalgal species capable of growing in diverse environments (Lewandowski et al., 2018). Most are photoautotrophic, i.e. light is their energy source, while CO_2 is their carbon source.

Microalgae require nitrogen, phosphorus, CO_2, light and a number of micronutrients for their growth. Since, as mentioned above, urban wastewater is rich in nitrogen and phosphorus, the cultivation of microalgae in urban wastewater could microalgae cultivation would allow the removal of these pollutants by incorporating them into the microalgal biomass. microalgal biomass. Specifically, for *C. vulgaris*, more than 64% of the total nitrogen is recycled as biomass (He et al., 2013). The undoubted ability of microalgae to remove inorganic nitrogen and phosphorus means that they can be used inorganic nitrogen and phosphorus removal, they can be used as a bioremediation tool for wastewater treatment, and are considered to be an wastewater treatment, and is considered an economical and promising practice (Ledda et al., 2015). The microalgal treatments offer an inexpensive option for nutrient removal by tertiary treatment (Tang et al., 2015).

4. CONCLUSION

Wastewater from the tanning process can be used synergistically to remove nutrients present in the wastewater, as well as to cultivate microalgae. The results obtained in the present study indicate that the use of the microalgae *Ch. vulgaris* for nutrient uptake and growth in wastewater is feasible. These microalgae demonstrated the ability to reduce the BOD_5 and COD values of tanning wastewater.

5. AUTHORSHIP CONTRIBUTIONS

All authors have jointly and equally contributed to the argumentation and writing of the manuscript.

6. FUNDING

None.

7. CONFLICT OF INTEREST

None.

8. REFERENCIAS

[1] Arias, A. M. (2017). *Análisis de remoción de cromo por acción de la microalga Chlorella sp. Inmovilizada en perlas de alginato* [Universidad Politécnica Salesiana]. http://dspace.ups.edu.ec/bitstream/123456789/5081/1/UPS-CYT00109.pdf

[2] Bharagava, R.N., Mishra, S. (2018). Hexavalent chromium reduction potential of Cellulosimicrobium sp. isolated from common effluent treatment plant of tannery industries. *Ecotoxicol. Environ. Saf.* 147: 102–109. https://doi.org/10.1016/j.ecoenv.2017.08.040.

[3] Elliott, E. G.; Ettinger, A. S.; Leaderer, B. P.; Bracken, M. B.; Deziel, N. C . (2017). A Systematic Evaluation of Chemicals in Hydraulic-Fracturing Fluids and Wastewater for Reproductive and Developmental Toxicity. *J. Expo. Sci. Environ. Epidemiol* 27 (1): 90–99.

[4] Hansen, E., ´Monteiro de Aquim, P., Hansen, A.W., Cardoso, J.K., Ziulkoski, A.L., Gutterres, M. (2020). Impact of post-tanning chemicals on the pollution load of tannery wastewater. J. *Environ. Manag.* 269:110787. https://doi.org/10.1016/j.jenvman.2020.110787.

[5] He, P.J., Mao, B.L.F., Shao, L.M., Lee, D.J., & Chang, J.S. (2013). The combined effect of bacteria and Chlorella vulgaris on the treatment of municipal wastewaters. *Bioresource Technology* 146: 562-568. https://doi.org/10.1016/j.biortech.2013.07.111

[6] Ledda, C., Romero Villegas, G. I., Adani, F., Acién Fernández, F. G., & Molina Grima, E. (2015). Utilization of centrate from wastewater treatment for the outdoor production of Nannochloropsis gaditana biomass at pilot-scale. *Algal Research* 12: 17-25. https://doi.org/10.1016/j.algal.2015.08.002

[7] Lewandowski, I., Lippe, M., Montoya, J.C., Dickhöfer, U., Langenberger, G., Pucher, J., & Lippert, C. (2018). Primary production. In I, Lewandowski (Ed.), Bioeconomy: Shaping the transition to a sustainable, biobased economy (pp. 97-178).

[8] Mannacharaju, M., Chittybabu, S., Sheikh John, S.B., Somasundaram, S., Ganesan, S., (2020). Bio catalytic oxidation of sulphide laden wastewater from leather industry using sulfide: quinone oxidoreductase immobilized bio reactor. *Biocatal. Biotransform* 38: 123–137. https://doi.org/10.1080/10242422.2019.1666107.

[9] Mata, T. M.; Martins, A. A.; Caetano, N. S. (2010). Microalgae for Biodiesel Production and Other Applications: *A Review. Renew. Sustain. Energy Rev* 14 (1): 217–232.

[10] Maguire-Boyle, S. J.; Barron, A. R.;(2014) Organic Compounds in Produced Waters from Shale Gas Wells. *Environ. Sci. Process. Impacts* 16 (10: 2237–2248.
[11] Miranda, K. X. (2019). *Efecto de diferentes concentraciones de Pseudomonas sp en la biorreducción de cromo VI en agua residual de curtiembre de la provincia de Trujillo, 2017* [Universidad Nacional del Santa]. http://repositorio.uns.edu.pe/handle/UNS/3200.
[12] OMS. (2019). Chromium in Drinking-water. En *World Health Organization 201x* (Número September). https://www.who.int/water_sanitation_health/water-quality/guidelines/chemicals/draft-chromium-190924.pdf
[13] Ortiz, N. (2012). Recuperación y reutilización de cromo de las aguas residuales de curtiembres de San Benito, Bogotá. Intekhnia, 7(2): 143-161. ISSN: 1900-7612.
[14] Panda, S. y Choudhury, S. (2005). Chromium stress in plants. *Scielo*, *0*, 95-102. https://doi.org/https://doi.org/10.1590/S1677-04202005000100008
[15] Pérez-Cordero Alexander; Montes-Vergara Donicer; Aguas-Mendoza Yelitza. 2023. Remediation of wastewater from the semi-artisanal tanning process using microalgal consortium. *Journal of Positive Psychology & Wellbeing* 7(1):620 – 625. http://journalppw.com.
[16] Resolución N°0631 de 2015 del Ministerio Ambiente y Desarrollo Sostenible. https://www.minambiente.gov.co/wp-content/uploads/2021/11/resolucion-631-de-2015.pdf
[17] Rosales, A. G., y Rodríguez, C. D. (2018). *Remoción de contaminantes y crecimiento del alga Scenedesmus sp. en aguas residuales de curtiembres, comparación entre células libres e inmovilizadas*. *14*(28): 11-34. https://doi.org/10.17230/ingciencia.14.28.1.
[18] Tang, D., Han, W., Li, P., Miao, X., & Zhong, J. (2011). CO2 biofixation and fatty acid composition of Scenedesmus obliquus and Chlorella pyrenoidosa in response to different CO2 levels. *Bioresource Technology* 102(3): 3071-3076. doi:10.1016/j.biortech.2010.10.047
[19] Tzoupanos, N. D., & Zouboulis, I. (2008, August). Coagulation-flocculation processes in water/wastewater treatment: the application of new generation of chemical reagents. In 6th IASME/WSEAS international conference on heat transfer, thermal engineering and environment (HTE'08), August 20th–22nd, Rhodes, Greece (pp. 309-317).