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Biorremediación de agua residual de la industria textil por medio de *chlorella vulgaris*

Bioremediation of wastewater from the textile industry by Chlorella vulgaris.

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ABSTRACT

The textile industry often utilizes dyes containing pollutants that cause irreparable damage to the environment and may have adverse effects on human health when discharged into water sources or soils. Therefore, it is essential to explore environmentally friendly alternatives, such as the latest technologies involving microalgae. In this study, microalgae technology, specifically Chlorella vulgaris was utilized at a laboratory scale for the bioremediation of wastewater from the textile industry. The culture conditions included a pH range of 7-8, a temperature between 17 °C and 20 °C with constant agitation, and a supply of red LED light. In the bioremediation process, three samples were used, each with its respective replicates, at concentrations of 50%, 25%, and 12.5% by volume of wastewater, with an initial volume of 200 mL of microalgae for each. Results indicated bioremediation percentages exceeding 95%. Notably, it was observed that lower wastewater percentages correlated with higher bioremediation percentages. This observation suggests a potential relationship between concentration and efficacy. Considering the promising results, we propose a basic design for scaling up this process to an industrial level. This involves identifying the most suitable equipment and conducting corresponding calculations to optimize the efficiency of the bioremediation process.

Key words: *Chlorella vulgaris, wastewater, bioremediation, textile industry, dyes, absorbance.*

RESUMEN

En la industria textil se emplean tintes con contenido contaminante que causan daños irreparables al medio ambiente, así como posibles efectos sobre la salud humana al momento de vestirse a las fuentes hídricas o arrojarse a los suelos. Por ende, es primordial buscar alternativas bioamigables, como las últimas tecnologías del uso de microalgas. Esta tecnología se empleó en este trabajo, mediante la microalga *Chlorella vulgaris* a escala laboratorio para la biorremediación de aguas residuales de la industria textil. Las condiciones de cultivo fueron pH entre 7-8, temperatura entre 17 °C y 20 °C con agitación constante y suministro de luz LED roja. Para el proceso de biorremediación

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se emplearon tres muestras con sus respectivas réplicas, en concentraciones de 50%, 25% y 12.5% en volumen de agua residual, teniendo un volumen inicial de 200 mL de microalga para cada una de estas. Los resultados obtenidos de este proceso indicaron porcentajes de biorremediación mayores al 95%. Se observó que mientras menor sea el porcentaje de agua residual, mayor será el porcentaje de biorremediación. Teniendo en cuenta los resultados obtenidos, se plantea un diseño básico para este proceso a escala industrial, buscando los equipos más adecuados para este proceso con los cálculos correspondientes.

Palabras clave: *Chlorella vulgaris, agua residual, biorremediación, colorantes, absorbancia.*

1. INTRODUCTION

The textile industry is considered one of the oldest and most influential activities in industrial development, contributing significantly to employment, modernization, technology, and the economy of countries worldwide and nationally (Superintendencia de Sociedades, 2017). The Colombian textile industry is a vital sector that contributes to 10% of the country's overall industrial production, almost 6% of total exports, and provides over 200,000 direct jobs and three times as many indirect jobs (Espinel González et al., 2018). However, its production process generates a significant amount of wastewater containing dyes, with approximately 2.8×10^5 metric tons of synthetic dyes discharged into water sources (Núñez & Victoria, 2020). On average, it takes between 100 to 150 L of water to dye 1 kg of textile material, emphasizing the considerable water consumption in the dyeing process (García, 2021).

Despite Colombia's abundance of water resources due to its high annual rainfall index and diverse geography, the textile industry's wastewater discharge poses a threat to water sources. To address the pollution generated by various industries, including the textile industry, Resolution 631 of 2015 was established. This resolution outlines the minimum conditions required for the discharge of industrial wastewater, aiming to mitigate the environmental impact of such discharges.

In most of the earth's water sources coexist a great diversity of microorganisms that can use photons as an energy source for the development of their metabolism process. Cyanobacteria and microalgae convert atmospheric CO_2 into sugars, lipids, and oxygen through the process of photosynthesis (Ararat Orozco et al., 2021). Due to this, microalgae are currently of great interest thanks to their rapid growth and good capacity to adapt to different temperatures and concentrations of the nutrients necessary for their growth, such as carbon, nitrogen, and other heavy metals (Ortiz et al., 2018). Microalgae are eukaryotic, unicellular, or filamentous microorganisms that vary greatly in size and shape (Castro, 2018).

In turn, considering the different species of microalgae and their capacity for both rapid growth and easy adaptability to different environments, the microalgae *Chlorella vulgaris* was taken as a bioremediation agent, which "has a rapid growth in autotrophic, heterotrophic and mixotrophic conditions, a characteristic that has promoted its commercial production" (Gómez et al., 2022). This species of microalgae has a size between 2-10 microns and an absorption peak between 430-675 nm (Avellaneda, 2023).

The application of microalgae in wastewater treatment dates to approximately 1940, when the first studies on the possibility of mass cultivation of microalgae to treat industrial effluents were reported (Ramos & Pizarro, 2018). *Chlorella vulgaris* is used for this process because it can assimilate nitrogen and phosphorus from wastewater in the form of biomass, which can be a more economical and sustainable process compared to other types of tertiary treatments (Prieto, 2019). Several applications of *Chlorella vulgaris* have been carried out, such as the integration in the purification of wastewater, using the organic matter and nutrient present in the water as a culture medium (Aguilar, 2022), in turn it has also been used for the purification of urban wastewater (Prieto, 2019). On the other hand, it has been used to treat the eutrophication of the Ubaque Lagoon, Colombia (Ortiz et al., 2018). It was also used to treat wastewater generated in the culture of the goldfish *Seriola lalandi* (*Perciformes: Carangidae*) (Ramos & Pizarro, 2018). Another application has been as an alternative for the removal of heavy metals (Vitola et al., 2022). Due to its high efficiency, it is used in the treatment of wastewater generated in tanneries (Jacome et al., 2021) and for the bioremediation of wastewater from the coal extraction stage, using a system of bacteria and microalgae immobilized in alginate spheres for iron absorption (Pérez, 2021).

Therefore, a wastewater bioremediation system is proposed to evaluate the removal of dyes from wastewater from the textile industry by means of *Chlorella vulgaris*, developing samples with different proportions of real wastewater looking for the best possible efficiency. In addition, a basic design of this plant at industrial level is proposed, looking for the most suitable operation units for this process.

2. METHODOLOGY

The problem of wastewater discharges from the textile industry was addressed through a global process, which includes four interrelated stages: cultivation of the microalgae *Chlorella vulgaris*, bioremediation process in laboratory conditions, the study of color removal from the actual wastewater resulting from the weaving process, flat and knitted finishing in the presence of JAKAZOL BLACK dye and finally the basic design of bioremediation on an industrial scale was proposed, as shown below:

a. Cultivation of the microalgae *Chlorella vulgaris*

Initially, the glass container to be used was disinfected with ethanol 97% (v/v). Then, *Chlorella vulgaris* was cultivated in a glass container with a commercial culture medium diluted in distilled water until 1200 mL, giving a pH between 7- 8. After this, the container was closed and stored under a source of constant supply of red LED light, at a temperature between 17 °C and 20 °C; and constant agitation using a simple aquarium pump (Blanco et al., 2022) as shown in Figure 1.

Figure 1: Photobioreactor.

Source: Own **e**laboration.

The cultivation time was two months, with control every 7 days, in which absorbance measurements were taken through a spectrophotometer and every 15 days distilled water was added, to maintain a constant culture volume.

b. Bioremediation of wastewater

Three samples were created, each one with its respective replica, handling percentages of 50%, 25% and 12.5% in volume of real residual water resulting from the weaving, flat finishing and knitting processes, in the presence of JAKAZOL BLACK dye, which is a black reactive dye in the used for dyeing cellulose and related fibers. In the experimental design, two key variables were selected. First, the color removal efficiency, as the objective function. The independent variable was the concentration of wastewater (%v/v) in the culture, proposing three levels: high concentration, or 50%; medium concentration, or 25% of wastewater as solute; and finally low concentration of 12.5% solute. Therefore, the following Hypotheses are proposed:

1. **Hypothesis**

$$H_0: M_{1-2} = M_{3-4} = M_{5-6} \quad (2)$$
$$H_A: M_{1-2} \neq M_{3-4} \neq M_{5-6} \quad (3)$$

2. **Hypothesis**

$$H_0: TC_{15} = TC_{30} \quad (4)$$
$$H_A: TC_{15} \neq TC_{30} \quad (5)$$

For this stage, the number of each sample and its corresponding concentration level is shown in Table 1.

SAMPLE CODE	Wastewater percentage, % (v/v)
M1 M2	50
M3 M4	25
M5 M6	12,5

Table 1: Experimental design.
Source: Own elaboration

Each sample, composed of 200 mL of *Chlorella vulgaris* and its respective concentration of residual water, was kept in clean containers, closed and at a temperature between 17 °C and 20 °C, and with continuous aeration. After 30 days, a fragment of each sample goes through centrifugation to be analyzed in the spectrophotometer, to evaluate which of these would be the most suitable to carry out the bioremediation process. The biodegradation percentage, according to Kumar et al. is calculated as follows with the centrifugation supernatant.

$$\%Removal = \frac{ABS_i - ABS_f}{ABS_i} * 100 \quad (1)$$

Where ABS_i is the initial absorbance and ABS_f is the final absorbance, both at 575 nm according to a previous spectral scan which gave this wavelength as the peak of optical absorbance for the color. For this procedure a Thermo Scientific GenesysTM 20 visible spectrophotometer was used.

c. Basic design of bioremediation at industrial scale.

Initially, the unit operations of the process were selected according to the bibliography. Then, based on the removal efficiency obtained in the previous stage, the dimensions of the bioreactor were calculated. But the type of the bioreactor was chosen following the Analytic Hierarchy Process (AHP) because it "shows results that could facilitate the planning work of the technical intervention task, becoming a concrete contribution" (Ríos, 2022). This approach started with the main objective of selecting the most optimal bioreactor, using critical criteria such as environmental, economic, social, technical, or technological considerations and aspects related to safety and risks. The hierarchy of these criteria was established systematically, assigning them calculated weights, with the purpose of reflecting their relative importance in the system design environment. These weights were obtained through a process of surveys to experts among teachers and graduates with more than 5 years of experience in the chemical engineering profession, with specialized knowledge in topics related to process design, microalgae cultivation and wastewater bioremediation, among others. Finally, the decision matrix was created, which allowed the selection of the preferred bioreactor type.

3. RESULTS

Development of the cultivation, growth, and deployment of *Chlorella vulgaris.*

An increase in the absorbance of *Chlorella vulgaris* can be seen in Figure 2. This growth has been achieved thanks to the optimal conditions of the culture (Blanco et al., 2022). The growth of *Chlorella vulgaris* goes through several phases according to the Aguilar-Reynaga et al. (2022): a) adaptation phase, b) acceleration, c) exponential growth, d) deceleration or slow growth, e) stationary growth and f) death phase. Using this classification, the natural logarithm of the average absorbance (Ln (X)), is plotted as a function of the days of cultivation.

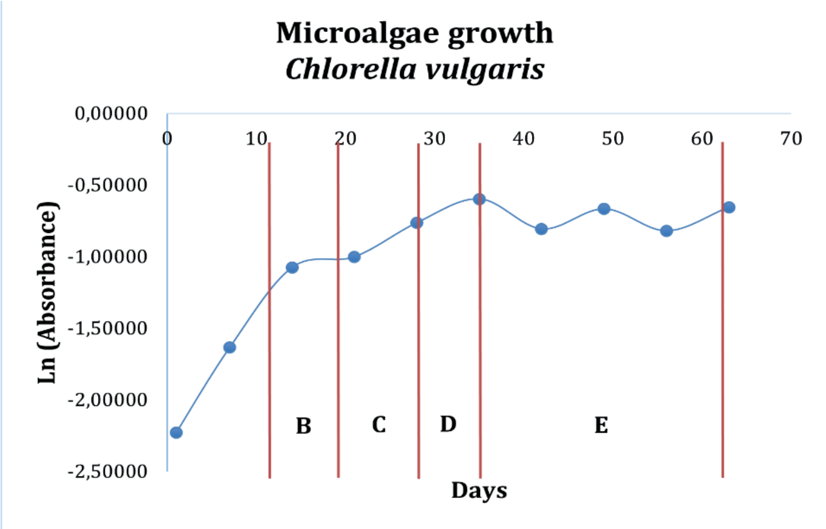


Figure 2: Microalgae growth. Natural logarithm of average absorbance as a function of time.

Source: Own elaboration

b. Color removal

The industrial water was obtained from a company where cotton is handled as one of its main raw materials. The wastewater presented a high absorbance of 0,411 due to dyes used in the production process; it had a biochemical oxygen demand, BOD, equal to 170 mg/L; Chemical oxygen demand, COD, equal to 1.908 mg/L; total suspended solids of 499 mg/L and pH of 5,8. Other components, according to literacy, are detergents, emulsifiers, sequestering agents, defoamers, solvents, softeners, gumming products, colorants, equalizers, dispersants, defoamers, among others (Ramírez-Rodríguez 2023).

A decrease in the color concentration of each sample can be observed in Table 2, where the minimum removal percentage is 94% for samples M1 and M2; and the maximum is 98%, for samples M5 and M6. These results are higher than those obtained by Moreno & Herrera (2022) where they found 91,7% of Erionyl Turquoise removal in synthetic textile wastewater. The pH level complies with the discharge regulations. Thus, it can be established that the lower the percentage of wastewater, the higher the percentage of color removal. Considering this, this microalga is effective with this wastewater, as one can find with other types of wastewater, such as urban where according to the article (Prieto, 2019) the result was a removal percentage between 92% and 94%; and tannery industry (Jacome et al., 2021) with more than 90%.

Sample number	M1 50%	M2 50%	M3 25%	M4 25%	M5 12,5%	M6 12,5%
INITIAL	0,427	0,479	0,423	0,409	0,412	0,544
FINAL	0,025	0,028	0,016	0,02	0,01	0,012
%Removal	94%	94%	96%	95%	98%	98%
pH	5-6	6	6-7	6	6	6-7

Table 2: Color removal percentage and pH results.
Source: Own elaboration

In the case of ANOVA, to evaluate the efficiency of *Chlorella vulgaris*, according to the hypotheses proposed, an analysis of variance was carried out with a significance level (α) set at 0.1, as shown in Table 3. **F0** was greater than **Fα** in the possible cases, it is confirmed that the null hypotheses are rejected. This indicates that, in terms of concentrations, as in the resting times, there are significant differences in the removal.

ANALYSIS OF VARIANZA						
Origin of variations	**Sum of squares**	**Degrees of freedom**	**Mean squares**	**F**	**Probability**	**Critical value for F**
Sample	0,025117	1	0,025117	1163,710	4,2258E-08	3,77595
Columns	0,001252	2	0,000626	28,99228	8,2457E-04	3,46330
Interaction	0,000187	2	0,000093	4,32046	6,8825E-02	3,46330
Within the group	0,000130	6	0,000022			
Total	0,0267	11				
	GL	***Fα***	***Fo***	***Comparison***		
	1	3,77595	1163,710	Fo > Fα	Rejected	
	2	3,46330	28,99228	Fo > Fα	Rejected	
	3	3,46330	4,32046	Fo > Fα	Rejected	

Table 3: Table of ANOVA analysis results.

Source: Own elaboration

c. Basic design of bioremediation at industrial scale.

In the process design, using information from research and experimentation, the mass balance was developed**.**

STREAM	1	2	3	4	5	6	7
FLOW (kg/s)	1,89	0,95	0,95	0,24	1,18	0,26	0,92
X-SOLIDS	0,10	0,19	0,01	0,00	0,01	0,04	0,00
X-COLOR	0,20	0,00	0,02	0,00	0,02	0,07	0,00
X-WATER	0,70	0,81	0,97	0,00	0,78	0,08	0,97
X-MICROALGAE	0,00	0,00	0,00	1,00	0,20	0,81	0,03
EFFICIENCY	***%E1***	90					
	%E2	98					
	%E3	90					

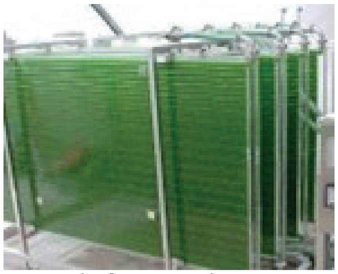
Table 5. Results obtained from the mass balance of the process.

Source: Own elaboration

After the design of the process, it is searched for suitable equipment for process conditions of 1.89 kg/s input flow as shown in the balance sheet. In the first stage, known as filtration, the following types of filters were suggested based on the research carried out:

- **Sand filter:** It is one of the most widely used filters in wastewater treatment due to its easy handling and low cost, it has a removal efficiency of "65% of suspended solids" (Malusin, 2019), with a diameter of 1.2 m and a thickness of 0.8 m.
- **Cartridge Filter:** Normally used in the treatment of wastewater from the textile industry, due to its 90% filtration efficiency, this filter has a diameter of 1.4 m and a height of 0.533 m.
- **Membrane ultrafiltration:** This type of filtration is more focused on waste treatment, removal of suspended solids, and microorganisms, among others, achieving 99% filtration; however, this requires "a large economic investment that is not always profitable" (Solís et al., 2017).

Upon analyzing the characteristics of each filter and comparing them with the needs of this process, it was determined that the ideal is the cartridge filter due to its high efficiency, zero energy consumption and affordable cost. Next, the suitable bioreactor that allows the growth of the microalgae under the growth conditions mentioned in the methodology was selected, between the following options:

Name	Image	Advantages	Disadvantages
Closed tube photobioreactors	 (Garcia, 2015)	• High efficiency inspace and resources. • Good capacity forcontrol. • Increased safety interms of leakage and contamination.	• Growth in construction and maintenance expenses. • Difficulty in cleaning and constant maintenance.
Tubular photobioreactors	 (Gutiérrez, 2017).	• Low constructionand maintenance costs. • Early detectionof anomalies. • Adaptability and scalability according to the needs of the process.	• Less control of growing conditions. • High risk of contamination and possible presence of pests. • Increased exposure to weather conditions.
Flat reactors	 (Urban, 2019)	• Energy efficiencyis relatively high. • Moderate social impact due to its enclosed location andmore compact design.	• Reduced control ofgrowth variables. • Requires training adequate. • Higher initial cost.

Open ponds	 (Urban, 2019)	• Low costsoperative. • Relatively low construction and maintenance costs. • Lower energy costs.	• Additional measures should be implemented to prevent leakage and contamination. • Increased resource consumption.
Closed flat plate photobioreactors	 (Boullosa, 2018)	• High energy savings. • Less risk of environmental contamination. • Greater control ofgrowing conditions.	• Higher construction and maintenance costs. • High need for constant cleaning and maintenance. • Increased complexity technology.

Table 5: Characterization of bioreactors.

Source: Own elaboration

- **Hierarchy of criteria:**

This method has as its main objective the selection of the bioreactor, and to carry out this stage of the project, key criteria have been established, addressing critical aspects, such as environmental, where compliance with Colombian regulations is ensured; economic, with a range of approximate costs managed in the project; social, linked to the positive contribution to the welfare of the community; technical or technological, linked to the efficiency of bioremediation; as well as safety and risks. It is important to note that, although these criteria have been addressed, the survey of engineering experts did not establish specific economic or environmental limits, which could have affected the comprehensiveness of the evaluation. Despite this limitation, the factors of relevance considered for each of the above criteria are detailed below:

CRITICAL ASPECT	RELEVANCE FACTOR
ENVIRONMENTAL	• Energy consumption. • Standby time. • Gas and/or sludge generation.
SOCIAL	• Visual impact. • Social acceptance.
TECHNICAL OR TECHNOLOGICAL	• Bioremediation efficiency. • Sludge treatment. • Operation time and flow rates handled.
ECONOMICAL	• Equipment costs. • Maintenance and operation. • Area needed.
SAFETY AND RISK	• Personnel security. • Implementation of protocols for safe handling of microalgae. • Resilience to natural disasters.

Table 6: Critical Aspect according to Relevance Factors.

Source: Own elaboration

Assignment of calculated weights

In turn, a weight was assigned to each possible score that each aspect could receive according to its factors, to calculate the critical aspect of greatest interest. It was made to normalize results. 0,07 for Score 1; 0,13 for score; 0,2 for score 3; 0,27 for score 0,27 and 0,33 for score 5.

Survey results:

The weighted sum of the weights assigned to each critical aspect was calculated. According to Table 7, it is evident that the aspects considered to be more important are the environmental and technical aspects.

	1	*2*	*3*	*4*	*5*	W
Environmental	0	0	0	2	6	2,53
Technical	1	1	0	4	2	1,93
Social	0	0	4	4	0	1,87
Security	1	3	0	3	1	1,60
Economical	2	1	2	2	1	1,53

Table 7. Results of the survey with the score for each critical aspect.

Source: Own elaboration.

Decision matrix:

The environmental aspect, and the technical aspect, are the highest-scoring criteria. These are considered key factors for the selection of the bioreactor, therefore, a final score was evaluated for each factor, to discover the essential elements for each aspect, as can be seen in the following table:

CRITICAL ASPECT	RELEVANT FACTOR	1	2	3	4	5	W
Environmental	Energy consumption	1	0	0	3	4	2,20
	Resting time	2	1	3	2	0	1,40
	Generation of gases and/or sludge	1	0	0	3	4	2,20
Social	Visual impact	3	0	1	4	0	1,47
	Social acceptance	0	0	0	5	3	2,33
Technological	Bioremediation efficiency	0	0	1	0	7	2,53
	Sludge treatment	0	0	5	3	0	1,80
	Operating times and flow rates	0	0	2	5	1	2,07
Economical	Equipment costs	0	0	1	6	1	2,13
	Maintenance and operation	0	0	3	2	3	2,13
	Area needed	0	0	4	3	1	1,93
Safety and risks	Personnel security	0	1	2	0	5	2,20
	Safe handling of microalgae.	0	1	2	0	5	2,20
	Resilience to natural disasters	0	3	3	0	2	1,67

Table 8. Critical aspect according to relevance factors with score and corresponding weight.

Source. Own elaboration.

Next, the following factors were considered: energy consumption, generation of gases and/or sludge for the environmental aspect and bioremediation efficiency according to the technical aspect. However, during the evaluation process, the social aspect was positioned in third place, highlighting its importance under Colombian laws, such as 2234 of 2022, which promotes social entrepreneurship, contributing positively to the welfare of the community where the project is planned. In addition, law 2294 of 2023, issued by the national development plan 2022-2026, "Colombia, the world power of life", emphasizes the importance of sustainable environmental projects that promote the quality of life and the preservation of the environment. In this way, the project is likely to foster local acceptance and community participation, a key element for its long-term success.

Because of the critical aspects, the closed flat panel photobioreactor was selected, since it handles a lower risk of environmental contamination, and compared to other equipment, it has a higher energy efficiency and better stability capacity.

Finally, in the concentration stage, different equipment was investigated, such as the disc centrifuge, known for being used in cases of "concentrations of lower solids and smaller particles and droplets" (Cruces, 2023). The basket centrifuge is used in the pharmaceutical, biotechnology, chemical and food industries. Finally, the screw centrifuge, is used in the removal of sludge since it focuses on the separation of various solids in liquids. It was determined that the optimum equipment for the concentration stage is the disc centrifuge, since it has greater power and a more feasible price, among other favorable characteristics.

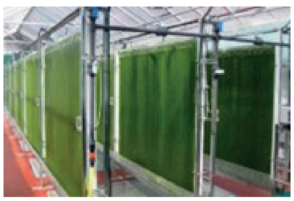
FILTERING EQUIPMENT	**Cartridge filter**	
	Energy consumption (W)	0
	Maximum flow rate(m^3/h)	113
	Efficiency	90
	Outer diameter (m)	0,17
	Length (m)	1,52
	Micron age	5
	Max temperature (°C)	52
Ltda, L. F. I. (s/f) 2022	Línter Industrial Filters S.A.	
CULTIVATION EQUIPMENT	**Photobioreactor**	
	Maximum flow rate (L/d)	200
	Height (m)	2
	Length (m)	10
	Width	0,1
	% Sunlight input	50
(Estevez, 2021)	(Arribas Jimeno, 2020)	
CENTRIFUGATION	**Disc centrifuge**	
	Maximum flow rate (L/h)	10.000
	Maximum centrifugalforce	12.000
	Max speed (U/min)	9300
	Motor power (kW)	5,5
	Efficiency	90
	Flottweg S.A.	

Table 9. Table of bioremediation equipment characteristics

Source. Own elaboration.

As a result, the PFD diagram for the process is shown below:

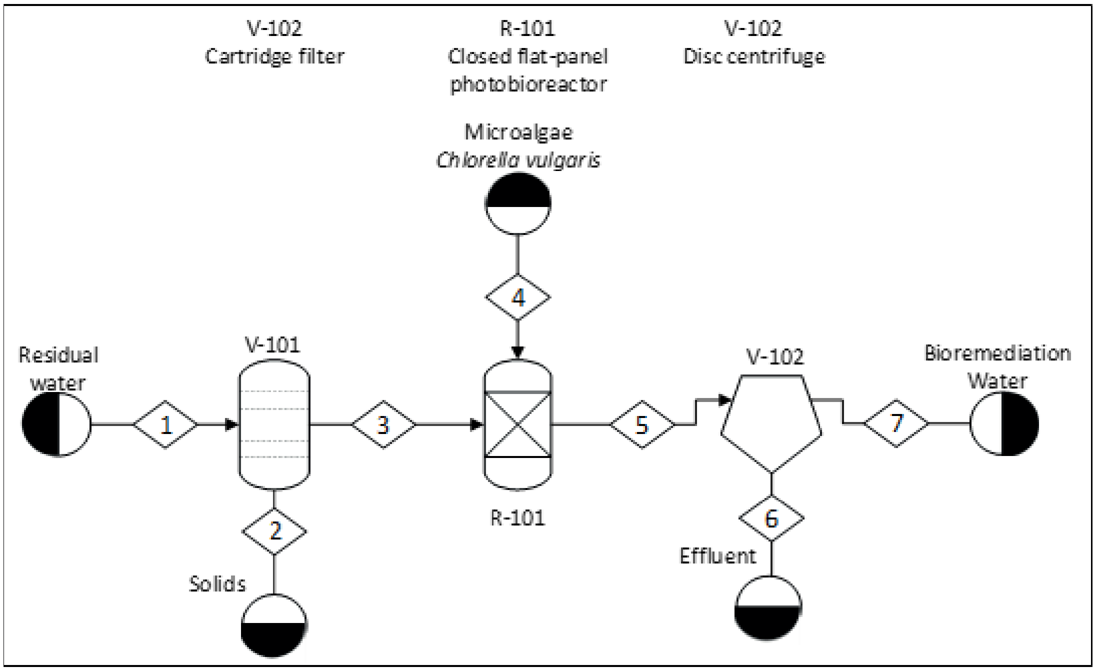


Figure 3. PFD diagram of the process

Source. Own elaboration

Subsequently, the economic feasibility is considered, which focuses on the different possibilities found through bibliography for each of the equipment previously determined, as can be seen in Table 14. To know the specific costs by means of the main equipment.

TEAM	COST (USD)	REFERENCE
Cartridge filter	$13.089,18	EQUIPNET. Filtrox Securox 40/16 Stainless Steel Vertical Cartridge Filter.
Closed flat-plate photobioreactor	$21.902,78	Sanz, V. (2019) Design of a photobioreactor for obtaining bioluminescent compounds.
Disc centrifuge	$31.247,97	Castro, j. (2018) Design of a pilot plant for heterotrophic microalgae growth.

Table 10. Equipment Costs.

Source. Own elaboration.

Based on the equipment costs in Table 10, it can be said that the physical methods based on coagulation, flocculation, filtration and adsorption, which produce a large amount of sludge, have low effectiveness and generate high costs (Espejo, 2019), and for a quantity of 3 m^3 generate costs of $ 24 877.6 USD (Alvarado, 2017), while the bioremediation process generates total costs of $ 64 991.96 USD for a quantity of 1.03 m^3/s. By means of these costs it can be observed that there is not a significantly higher difference at an economic level, and this can be justified due to the higher efficiency and lower quantity of sludge obtained in this bioremediation process, generating in the long-term economic savings and a lower dependence on different chemicals.

4. CONCLUSIONS

It was evidenced that the microalgae *Chlorella vulgaris* grew progressively in a simple manner under controlled conditions of pH, illumination, agitation, and temperature, reaching a maximum growth in 30 days, allowing to study its stationary phase at 2 months of cultivation, according to Aguilar-Reynaga et al (2022).

It was shown that although this bioremediation process with the presence of the Jakazol black dye may have a slightly higher cost, it can be justified because in the future it generates a cost reduction, given that the greater efficiency presented is equal to 98% in the sample containing 12.5% by volume of wastewater and in turn produces a smaller amount of sludge, compared to conventional methods.

Considering the cultivation process of *Chlorella vulgaris*, it was analyzed that, to guarantee optimal growth, it is essential to maintain adequate cultivation conditions, such as its closed and controlled storage, among other aspects. In line with this objective, the application of the Hierarchical Analysis Method (AHP) for the selection of the photobioreactor, allowed finding that the closed flat panel type is the most suitable option for the cultivation of *Chlorella vulgaris* in the process of bioremediation of wastewater from the textile industry.

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