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UTILIZAÇÃO DE MICROALGAS NO TRATAMENTO DE RESÍDUOS DA INDÚSTRIA LÁCTEA

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RESUMO: Nos últimos anos, as microalgas têm sido alvo de estudos devido à sua versatilidade industrial e por serem potenciais fontes de energia, especialmente na biorremediação de efluentes. O soro de leite, quando mal destinado pela indústria de laticínios, pode causar impactos ambientais significativos devido às suas altas cargas orgânicas poluindo corpos d’agua e o solo. As microalgas, por sua composição bioquímica, podem converter nutrientes presentes no resíduo em biomassa útil. Esta pesquisa teve como objetivo analisar o soro como fonte de nutricional para microalgas, visando reduzir as cargas orgânicas e produzir biomassa para aplicações industriais. Realizado no IFAL Campus Piranhas, durante o estudo foram testadas concentrações de soro de 2%, 4%, 6% e 8%, com 6% apresentando melhor desempenho. Em um experimento subsequente, três reatores com 6% de soro foram comparados ao uso de NPK líquido, com aplicações semanais durante um mês. Ao final, todas as algas estavam vivas, indicando que o soro de leite pode ser uma alternativa promissora na biorremediação e produção de biomassa.

Palavras-chave: Biorremediação, microalga, Efluente, Biomassa.

USE OF MICROALGAE IN THE TREATMENT OF DAIRY INDUSTRY WASTE

ABSTRACT: In recent years, microalgae have been the target of studies because of their industrial versatility and because they are potential sources of energy, especially in the bioremediation of effluents. Whey, when misused by the dairy industry, can cause significant environmental impacts because of its high organic loads, which pollute water bodies and soil. Owing to their biochemical composition, microalgae can convert nutrients present in the residue into useful biomass. This project aimed to analyze whey as a nutritional source for microalgae, aiming to reduce organic loads and produce biomass for industrial applications. At the IFAL Campus Piranhas, serum concentrations of 2%, 4%, 6% and 8% were tested, with 6% performing best. In a subsequent experiment, three reactors with 6% serum were compared to those with liquid NPK, with weekly applications for one month. In the end, all the algae were alive, indicating that whey can be a promising alternative for bioremediation and biomass production.

Keywords: Bioremediation, microalgae, effluent, Biomass.

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1 INTRODUCTION

Drinking water is an essential resource that has been diminishing in recent times due to human action. As a result, several methods for treating effluents have been devised so that this waste has an appropriate destination, avoiding the contamination of water bodies and soil. One of these alternatives may be through the use of microalgae, since they reduce the chemical loads considered contaminants (Castro *et al.*, 2020).

Microalgae are photosynthetic organisms capable of absorbing certain elements in the culture medium to meet their nutritional needs and transform them into bioproducts, allowing their use in effluent treatment. This absorption capacity results in a reduction in heavy metals, removal of coliform bacteria, removal of nitrogen and/or potassium, and a reduction in chemical oxygen demand (COD) commonly found in whey and other waste, making microalgae alternative options for effluent treatment (Abdel rao uf; Al - homaidan; Ibraheem, 2012).

In addition to the importance of microalgae for maintaining oxygen in the atmosphere, the efficiency of O2 release by microalgae is much greater than that of other photosynthetic organisms and can even be considered the most efficient, being capable of being a remedy for problems such as the emission of gases into the atmosphere and even allowing its use as an energy source (Pina *et al*., 2021).

Whey is a byproduct of the dairy industry and is produced on a large scale in Brazil. Although much of it is used to manufacture products, there is still a need for more efficient methods of use. The main problem is the toxicity of the residue due to its high organic load, which is extremely harmful when it is discarded into the environment (Soares; Vendramel; Souza, 2021). Approximately 40% of the whey produced in Brazil has an inadequate destination and is discarded into the environment. It is believed that only 15% of the residue produced is used to manufacture new products (Alba; Morioka; Suguimoto, 2021). According to Lira *et al*. (2009) Due to its high biochemical oxygen demand (BOD), its pollution capacity can be considered up to 100 times greater than that of effluents from domestic sewage.

However, we can also find considerable amounts of β-lactoglobulin, lactoperoxidase, glycomacropeptide, α-lactalbumin, immunoglobulin, bovine serum albumin, and lactoferrin, among other biologically active enzymes (Velemir *et al*., 2020), that is, practically half of the nutrients originally found in milk, which makes it quite rich in proteins and nutrients.

Microalgae are believed to be a unique option as an energy solution since they produce oxygen, fix carbon and bioremediate wastewater, such as “water contaminated by dairy industries, breweries, agribusinesses, domestic sewage, among others” (Paula; Chagas; Mendonça, 2023). Research has shown the removal of approximately ≥ 60% of nitrogen and ≥ 90% of phosphorus. In wastewater, especially in the exponential growth phase, several other macro- and micronutrients decrease, depending on the genus of microalgae, as described by Dias *et al*. (2019).

Microalgae are present in various freshwater and saltwater aquatic environments. They are responsible for much of the CO2 fixation present in the atmosphere, in addition to being able to remove organic matter and toxic metals from effluents. Some essential elements in their development are carbon, nitrogen and phosphorus (Vonshak, 1997). Effluents that contain significant concentrations of these compounds with favorable environments of physical-chemical factors such as temperature, luminosity, salinity, pH and CO2 availability can promote good expansion of these organisms since their growth is directly influenced by these factors (Schmitz; Magro; Colla, 2012).

The resulting biomass can be applied in several areas of industry, such as cosmetics and food, as it is rich in nutrients and therapeutic substances. Despite this, there are still few countries that invest in food products enriched with microalgal biomass, which becomes an investment opportunity for innovation in functional food products (Almeida *et al*., 2017). Another segment that has been widely explored is the use of biomass in agriculture. In agriculture, for example, we use biomass as a biofertilizer to improve the productivity of demanding crops because nutrients are easily absorbed by plants (Albuquerque *et al*., 2024).

Concern about the destinations of industrial and domestic waste is growing due to the environmental impacts caused by these effluents when untreated. There is also a growing demand for research that evaluates the cultivation of microalgae from the use of these residues, thus identifying some possible potential (Postaue; Morais; Asmus, 2020).

Considering the nutritional needs of microalgae and the chemical composition of whey, this research aimed to analyze the possibility of a symbiotic relationship between the two, using whey as a culture medium and promoting its treatment. As a result, a biomass with high added energy value is expected to be obtained, contributing to the reduction in the environmental impact of the effluent.

2 MATERIALS AND METHODS

The study was developed in the zootechnics laboratory of the Federal Institute of Alagoas – IFAL, Piranhas *Campus*, in an environment controlled for temperature, oxygenation and time of exposure to light, in the most appropriate way for the well-being of the crop. The average temperature was set between 28+- 1°C in the morning and 31+- 1°C in the afternoon, oxygenation was activated for 30 continuous minutes and turned off for 30 minutes, and the lighting was activated at a 12/12 ratio, with 12 hours on and 12 hours off.

The microalgae used was *Chrorella spp*. (chrorella) in 2 replicates (bioreactor).

For the present study, different concentrations of whey (treatments) were analyzed: T1: 2%, T2: 4%, T3: 6%, T4: 8% whey and the T5 control (NPK 10:10:10, commercial liquid) (T = treatment). In bioreactors with a capacity of 5 liters, with respect to the percentage of the corresponding *starter solution treatment*, 2 liters of microalgae were added, and 3 liters (approximately) of filtered water were added.

The experiment lasted 30 days, and we sought to find a dose that favored microalgal survival and growth.

Figure 1. Four whey concentrations, T1: 2%; T2: 4%; T3: 6%; and T4: 8%, were tested to determine a suitable concentration for microalgal growth.

Source: personal archive (2024).

At the end of the concentration test, the concentration that showed the greatest potential for replication was selected. This test sought to compare the serum in the concentration that stood out the most to NPK (control reactors) as a form of nutrient for microalgae. Thus, 2 reactors with the commercial solution and 3 reactors with the alternative solution (serum) were used. The control reactors received a dose of 0.07% NPK (2 ml), and the serum reactors received a dose of 6% NPK (180 ml), with a volume of 3 liters, 2 liters of microalgae, the addition of nutrient solution and the remainder of the volume supplemented with filtered water.

3 RESULTS AND DISCUSSION

The concentration test was performed over a period of 30 days. In the first week, the concentrations of 2% and 4% were discarded because they were not effective. The likely explanation is that the whey concentration was not sufficient to keep them alive or meet their nutritional demands. After two weeks of reapplication at the 6% and 8% doses, treatment 4 (8% concentration) resulted in fermentation, which caused microalgal death. This left T3, which resisted the 4 applications.

Figure 2. In treatments 1 and 2, the plants died during the first week, possibly because of low nutrient concentrations.

Source: personal archive (2024).

After approximately three days of replication in the third treatment, all six reactors died, which encouraged investigations and hypotheses. They were replicated once more with the same serum concentration and fortunately remained alive throughout the experiment. The first attempt to replicate the third treatment was unsuccessful, probably because of the presence of chlorine in the water that was added to the reactor; as Neto and Neycombe (2017) explained, chlorine is a strong oxidizing agent that leads to cell rupture and is therefore efficient for the removal of cyanobacteria present in unwanted locations.

According to Bastos *et al*. (2010), microalgae strongly absorb and convert nitrogen into biomass, and the considerable use of phosphorus is also emphasized. The dairy industry residue is characterized by high rates of carbon, nitrogen and phosphorus (Wang; Huang; Yuan, 2005). These characteristics make the residue an excellent source for cultivation.

The second test using treatment concentration 3 was successful and remained stable throughout the testing process. In total, this treatment included 4 doses of whey, and one difficulty was the increase in volume in the reactors. At the end of thirty days, the reactors that used whey as a nutritional source presented a higher concentration of solids than did the reactors that used the commercial solution in visual analysis. In addition, after the whey dosage was applied for 5 days, the strong odor that was present during the first few days disappeared as if the microalgae performed a detox and removed this unpleasant odor from the whey, possibly due to the bioremediation action of the microalgae acting to remove the high organic loads. These findings demonstrate that whey can be a viable alternative for the production of microalgal biomass.

4 CONCLUSIONS

This research, which aimed to analyze microalgae as potential bioremediators of whey, concluded that whey can be used as an alternative source of nutrients and that the resulting biomass contains more solids than the biomass resulting from the use of commercial nutritional solutions. However, studies with more precise results are needed in terms of organic load removal values, biomass generation, more efficient effluent concentrations, varieties of microalgae with better absorption power, etc. With this, the use of microalgae in the treatment of whey will become a more promising proposal owing to concise evidence and may be used by industries.

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