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USE OF COAGULANT FROM PLANT ORIGIN AS AN ALTERNATIVE IN THE TREATMENT OF EFFLUENTS FROM SANITATION INDUSTRY

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Abstract: The use of aluminum sulphate-based coagulants, associated with flocculants, is frequent in the treatment of effluents. However, as a by-product, chemical sludge is produced, containing aluminum salts, which pollute the environment. The present work aimed to evaluate the performance of a vegetable coagulant based on tannin in the treatment of effluent from a sanitizing industry. Three experiments were carried out, using 1.0 % w/v of aluminum sulfate and vegetable coagulant, and using 0.25 % w/v of the vegetable coagulant. According to the tests, the vegetable coagulant at 0.25 % m/v reduced 60.4 % of turbidity, 71.0 % of total phosphorus, 98.0 % of anionic surfactants and completely removed animal and vegetable oils and greases and total suspended solids, generating an aluminum-free sludge. The vegetable coagulant acted simultaneously as a coagulant and flocculant and did not require adjustment of effluent pH, not requiring the use of flocculants and alkaline agents, in addition to being effective at lower dosages in relation to the coagulant based on aluminum sulfate. Therefore, the use of vegetable coagulant is technically feasible due to its biodegradability, sludge application potential, and because it does not require special investments or major changes to the existing effluent treatment infrastructure.

Keywords: biodegradability, primary treatment, sludge utilization and disposal, tannins, vegetable coagulant.

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1. INTRODUCTION

The National Basic Sanitation Survey, carried out by the Brazilian Institute of Geography and Statistics (IBGE) in 2017, demonstrated that around 21.3 million cubic meters of effluent were generated daily in Brazil at that time (CAMPOS, 2020). The industry is responsible for a large part of the waste generated, producing effluents with the potential to contaminate water resources and the soil when discarded without the necessary treatment.

Based on the resolution of the National Council for the Environment (CONAMA) nº 430/2011 and of the Rio Grande do Sul State Council for the Environment (CONSEMA) nº 355/2017, the effluents must receive the proper treatment and meet the established emission parameters to be then released to the receiving bodies. In this scenario, industries are looking for technologies that allow meeting legal requirements through effective treatments combined with sustainable input alternatives.

Conventional effluent treatment processes start with the use of coagulants in order to destabilize the colloidal particles in the system. Then, a flocculant is used to agglomerate the particles into flocs, facilitating decantation and thus separating the liquid phase from the solid. Finally, the treated effluent passes through a filtration system to be subsequently released into water bodies.

In this way, the sludge generated in the treatment can be considered an environmental liability due to the need for subsequent treatment and disposal. According to IBGE data, in 2008, 67 % of Brazilian municipalities disposed of sludge from the treatment of domestic effluents in rivers and other water bodies, while only 2 % of municipalities reused sludge (GROTTO, 2021).

Coagulants containing aluminum are widely used in physical-chemical treatment of effluents. According to Batista et al. (2021), the Al^{+3} ion is the most toxic form of aluminum, impacting plant root growth, especially in acidic soils, interfering with growth and reducing size.

A study evaluating the growth of corn plants grown in soil containing ETA sludge treated with an aluminum sulfate-based coagulant associated with sugarcane bagasse and vinasse, at high doses, showed that the plants had lower initial growth and smaller shoot size. The leaves showed a more yellowish color, possibly associated with the presence of Al^{3+} in the sludge. In addition, the presence of aluminum, associated with iron, can cause nutritional imbalances in plants (BITENCOURT et al., 2020). Batista et al. (2021) reported that ETA decantation sludge showed toxicity to microcrustaceans at concentrations above 15 wt.%, which indicates the need for prior treatment of this sludge before it is disposed/applied in aquatic environments.

Studies show a potential relationship between Al^{3+} ion concentrations in the human body and the development of Alzheimer's disease or damage to memory capacity, with possible damage to the cerebral cortex and hippocampus

(FREITAS, 2021). Furthermore, it is important to note that aluminum sulfate is obtained from bauxite mining. According to Guimarães et al. (2012), this mining process impacts vegetation, soil, contamination of rainwater with solids and oils, in addition to noise and particulate emissions in the atmosphere. Thus, there is a growing need for alternatives to the use of aluminum-based coagulants that are more sustainable and less harmful to the environment and human health.

Among the products of plant origin that have potential for use as coagulants are tannins, a class of phenolic compounds produced by some plant species. The obtainment of tannins can be performed by solid/liquid extraction techniques or by using more sustainable methods, such as microwaves, ultrasound, or pressurized water. Due to the properties of tannins, they can perform simultaneous coagulant and flocculant functions, producing a biodegradable sludge that can be reused for other applications (FRAGA-CORRAL et al., 2020).

In water treatment, tannins act simultaneously as a coagulant and flocculant, destabilizing the colloidal system and decreasing the Zeta potential, neutralizing the charges and forming bridges between the particles, allowing the formation of flocs. According to Nepomuceno et al. (2018), as these coagulants have long chains, the amount of free adsorption sites increases, and, consequently, allows more particles to be aggregated for the formation of the floc. Tannins are more effective coagulants/flocculants in water and effluents with a pH between 6.0 and 8.0 and because they have a cationic charge, and unlike metallic salts, they do not consume the alkalinity of the medium. Thus, it is not necessary to correct the pH after adding the coagulant (CRUZ, 2004).

Siqueira et al. (2018) observed removal of 95.6 % of the color and 97.6 % of the turbidity of domestic effluent using a tannin-based coagulant (Tanfloc SG®), with better performance compared to other coagulants tested separately, such as *Moringa oleifera* and aluminum sulfate.

Nepomuceno et al. (2018), in the treatment of water from a dam, reported removal of 95.1 % of turbidity using a tannin-based coagulant (Tanfloc SG®), at a concentration of 30 mg/L. The authors noted that the aforementioned coagulant was effective in smaller doses, indicating the possibility of using smaller amounts of coagulant, reducing operating costs and the amount of sludge produced.

Lima et al. (2019) verified a reduction in the pH of samples of raw water as the concentration of aluminum sulfate coagulant increased, as this agent consumes the alkalinity of the medium. However, this behavior was not observed when Tanfloc SL® vegetable coagulant was used. As for turbidity, the vegetable coagulant showed better results than the chemical coagulant, with the best performance in concentrations in the range of 40 – 50 mg/L and pH equal to 8.0. Regarding color removal, it was possible to verify that aluminum sulfate was effective only at concentrations above 40 mg/L, while the vegetable coagulant performed better at a concentration of 30 mg/L. Higher tannin dosages tend to produce a higher color, a characteristic due to its own natural color, and this fact was also observed by Nepomuceno et al. (2018).

Soroka et al. (2020) observed that the use of vegetable coagulant was less effective in removing phosphorus from domestic effluent, in the range of 50 – 60 % at a concentration of 50 mg/L. Ribeiro et al. (2015) also found low phosphorus removal with the use of tannins in the treatment of sanitary sewage. The authors attributed this behavior to a possible influence of the pH of the medium. On the other hand, the vegetable coagulant at a concentration of 40 mg/L showed 76.5 % of total ammoniacal nitrogen removal from the effluent.

Trevisan (2014) reported 88 % of turbidity removal and 84.6 % of color removal after 30 min of treatment using Tanfloc SG® coagulant at a concentration of 10 mg/L in water treatment in a water treatment station (ETA). In addition, the pH of the water was not influenced, presenting values similar to those at the beginning of the process.

Morandi and Kempka (2018) observed that the black wattle extract, rich in tannins, was efficient in clarifying oily effluents (soybean and sunflower oil), with removal of 50 % of the color using concentrations in the range of 0.5 to 1.0 wt.% of coagulant. The vegetable coagulant based on tannins, according to Beltrán-Heredia et al. (2009), was effective in removing surfactants (about 70 %), such as sodium dodecyl benzenesulfonate for a dosage of 150 mg/L of coagulant. The authors also reported that, with the increase in the concentration of coagulant, the concentration of surfactants was reduced to a point where a residual concentration of surfactants, difficult to remove, was reached. This phenomenon could be associated with equilibrium and, therefore, after a certain concentration, greater performance of the coagulant was not verified.

Given the above, it is observed that the vegetable coagulant, based on tannins, is a product with promising potential for use in the treatment of water and effluents, replacing coagulants containing metals. Furthermore, there are few studies in the literature addressing the performance of coagulants containing tannins in the treatment of industrial effluents in the field of sanitizing products. Thus, the present work aimed to evaluate the feasibility of using coagulants of vegetable origin, based on tannins, as an alternative to conventionally used coagulants, in the treatment of effluents from a sanitizing industry.

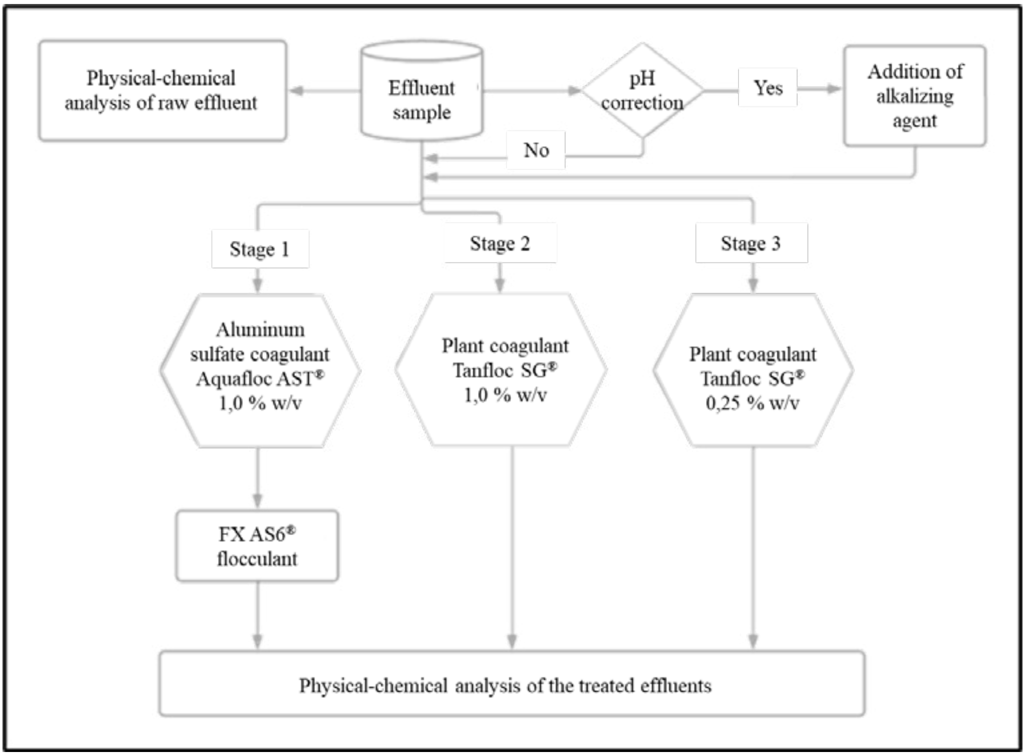
2. DEVELOPMENT

2.1 MATERIAL AND METHODS

The evaluated effluent came from an industry in the field of sanitizing products, with a monthly effluent production capacity of 30 t for cleaning products in the automotive line and 250 t in the line for products in the domestic line (FEPAM, 2021). The effluent was collected through channels installed on the floor, directed to a collection box and, finally, sent to two mixing tanks, with the aid of a pump.

Samples of raw effluent were collected directly from the company's waste treatment station (ETE) receiving tank and packed in polyethylene gallons with a capacity of 5 L and 25 L. To avoid variations in the analysis results, 30 L of raw effluent was collected, enough volume to carry out all tests.

Figure 1 – Simplified flowchart of the experimental procedure adopted in this study.



Source: Authors (2023).

The experimental procedure was performed starting with the physical-chemical analyzes in the raw effluent. In the first stage of the test, the conventional treatment adopted by the company was carried out, with the use of the coagulant based on aluminum sulfate Acquafloc AST® (Faxon Química Ltda., Brazil), followed by the use of the anionic polymeric flocculant FX AS6® (Faxon Química Ltd., Brazil). Based on the pH values obtained from the effluent, the need to use an alkalizing agent (sodium hydroxide PA, Dinâmica, Brazil) was evaluated.

In the second stage, the treatment of the effluent was used the coagulant of plant origin Tanfloc SG® (Tanac SA, Brazil), based on tannin, in the same concentration of the chemical coagulant (aluminium sulfate) and in the concentration of 10 % w/v, according to the manufacturer's guidance. After the respective treatments, the treated effluents had their physicochemical parameters evaluated. Figure 1 shows the simplified flowchart of the experimental procedure.

For the experimental procedure, a Velp Scientifica Jar Test model FC65 was used, with six jars and individual jar capacity of 2 L. The stirring speeds were determined based on the conditions recommended by Richter (2009), initially performing a rapid mixing of the coagulant with the effluent (120 rpm for 1 min), in order to promote homogeneous dispersion. Subsequently, the speed was reduced to 45 rpm for 20 min in order to promote the flocculation process. Finally, the system was kept at rest for 30 min so that the flocculated material decanted by gravity.

In the first stage of the test, the same proportions of inputs used by the company supplying the effluent used in the treatment were used. The pH of the raw effluent was 7.07, being adjusted to 11 with sodium hydroxide. Then rapid mixing was started and approx. 20 g of the chemical coagulant were added to 2 L of effluent (1.0 % w/v). After 1 min, the speed was reduced and 0.01 g of polymeric flocculant was added. After 20 min of slow mixing, the equipment was turned off and the gravitational decantation process was maintained for 30 min.

In the second stage of the test, which used the tannin-based coagulant, it was not necessary to correct the pH, as the effluent had a pH within the recommended range (pH between 6 and 8) by the product manufacturer. The rapid mixing process was started, adding 20 g of coagulant in 2 L of raw effluent sample (1.0 % w/v). After 1 min, the speed was reduced to 45 rpm for 20 min, and then the gravitational decantation process was performed for 30 min.

In the third stage, 5 g of vegetable coagulant were used for 2 L of effluent, corresponding to 0.25 % w/v. The remainder of the experiment followed the procedures described for the second stage of the test.

The treated effluents were evaluated according to the methods proposed by Standard Methods for the Examination of Water and Wastewater (SMWW) for the parameters of sedimentable solids (method 2540-F), total suspended solids (method 2540-D), turbidity (method 2130-B), pH (method 4500-H+B), apparent color (method 2120-B), vegetable and animal oils and greases (methods 5520-D and 5520-F), biochemical oxygen demand (method 5210-B), chemical oxygen demand (method 5220-C), ammoniacal nitrogen (method 4500-NH3 BC), total phosphorus (methods 4500-P, B, and E), and anionic surfactants (method 5540-C).

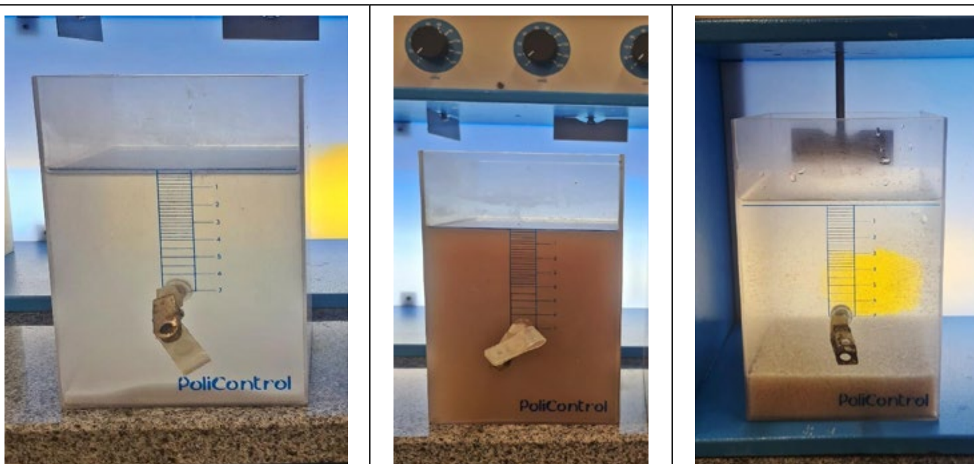
The amount of sludge generated for each treatment configuration was also evaluated. After removing the treated liquid effluent, the sludge formed was filtered under vacuum with qualitative filter paper and dried in an oven at 95 – 100 ºC for 72 h to completely remove moisture.

The sludge produced by the company is classified as class IIB (non-hazardous controlled waste). The collection cost is BRL 93.66 per drum (0.2 m³), corresponding to BRL 468.30 per cubic meter, in addition to the additional cost of transport and disposal. In this sense, the evaluation of the amount of sludge is also a relevant point, since the cost of sludge treatment is proportional to the amount produced.

3. RESULTS AND DISCUSSION

The visual appearance of the effluents after the tested treatment steps are shown in Figure 2.

Figure 2 - Visual aspect of the effluent samples treated with the coagulant based on aluminum sulfate 1.0 % w/v followed by the anionic flocculant (A) and with coagulant of vegetable origin at concentrations of 1.0 % w/v (B) and 0.25 % w/v (C).



(A) (B) (C)

Source: Authors (2023).

It can be observed, according to Figure 2, that in the effluent treated with the coagulant based on aluminum sulfate (A) small flocs formed. However, after the decantation period, part of the flocs remained dispersed in the liquid fraction, which, consequently, maintained high turbidity values. In the treatment with the coagulant of vegetable origin at 1.0 % w/v (B) the formation of flocs was not observed. The effluent showed a brown color, indicating that there was excess coagulant added, showing that the coagulation process did not occur. In the test using vegetable coagulant at 0.25 % w/v (C), flocs formed, and, after 30 min of decantation, there was a significant reduction in turbidity in the sample.

The results referring to the analysis of the quality parameters of the raw effluent and the treated effluents are compiled in Table 1.

Table 1 – Results of the analysis of the effluents treated with the coagulant based on aluminum sulfate followed by the anionic flocculant and with the coagulant of vegetable origin.

Parameter		Raw effluent	Acquafloc AST® 1.0% m/v	Tanfloc SG® 1.0% m/v	Tanfloc SG® 0.25% m/v	Standard CONSEMA 355/2017
BOD	mg O_2/L	2362	2642	4528	2497	≤ 120
COD	mg O_2/L	5748	3148	9856	3168	≤ 330
total alkalinity	Mg $CaCO_3$/L	279	< LQ	< LQ	< LQ	≤ 200
apparent color	uC	< 1	< 1	30	10	- (1)
total phosphorus	mg P/L	8.3	1.3	5.0	2.4	≤ 4
ammoniacal nitrogen	mg NH_3-N/L	20.7	22.4	152.9	47.1	≤ 20
Animal and vegetable oils and greases	mg/L	44.0	28.4	214.0	< LQ	≤ 30
pH	-	7.07	4.1	3.6	4.9	6.0 - 9.0
sedimentable solids	mL/L	< LQ	< LQ	< LQ	< LQ	≤ 1.0
Total suspended solids	mg/L	135	253	973	< LQ	≤ 140
anionic surfactants	mg MBAS/L	269	14.2	188	5.5	≤ 2.0
turbidity	NTU	240	320	2100	95	- (2)

BOD: biochemical oxygen demand; COD: chemical oxygen demand. Note: (1) The effluent emission color must not change the color of the receiving water body. (2) There are no limits, in NTU, established in CONSEMA 355/2017. Source: Authors (2023).

With the use of vegetable coagulant at 1.0 % w/v, an increase in several physicochemical parameters was observed in relation to the raw effluent due to the excess of coagulant used, since the coagulation and flocculation process did not occur. On the other hand, the use of vegetable coagulant at a concentration of 0.25 % w/v improved the parameters of oils and greases, pH, total suspended solids, anionic surfactants, and turbidity in relation to the chemical coagulant containing aluminum. Thus, it was determined that the most suitable concentration of vegetable coagulant corresponded to 0.25 % w/v.

Table 2 shows the percentage increase or decrease in the parameters analyzed in the treated effluents in relation to the raw effluent, as well as compliance with the emission standard established by the CONSEMA 355/2017 regulation.

Table 2 - Percentage of increase or decrease in the parameters of the effluents treated with the coagulant based on aluminum sulfate at 1.0 % w/v and with the vegetable coagulant at 0.25 % w/v in relation to the raw effluent and compliance with the relevant legislation (emission standard CONSEMA 355/2017).

Parameter	Acquafloc AST® 1.0 % w/v	Compliance with legislation	Tanfloc SG® 0.25 % w/v	Compliance with legislation
BOD	+11.9%	does not attend	+5.7%	does not attend
COD	-45.2%	does not attend	-44.9%	does not attend
total phosphorus	-84.5%	he meets	-71.0%	he meets
ammoniacal nitrogen	+8.3%	does not attend	+128.1%	does not attend
Animal and vegetable oils and greases	-35.5%	he meets	-100.0%	he meets
Total suspended solids	+87.4%	does not attend	-100.0%	he meets
anionic surfactants	-94.7%	does not attend	-98.0%	does not attend
turbidity	+33.3%	(1)	-60.4%	(1)

BOD: biochemical oxygen demand; COD: chemical oxygen demand. The '+' sign represents the increase, while the '-' sign corresponds to the decrease of the parameter. (1) There are no limits, in NTU, established by CONSEMA 355/2017. Source: Authors (2023).

The total phosphorus content had a removal percentage of 84.5 % with the aluminum-based coagulant and 71.0 % with the coagulant from vegetal origin. Both forms of treatment generated effluents whose total phosphorus levels were in accordance with the emission standard stipulated by the CONSEMA 355/2017 regulation.

According to Metcalf and Eddy (2016), phosphorus can be present in particulate or soluble form, reactive and non-reactive. Non-reactive forms include phosphorus adhered to organic matter, which can be a constituent present in industrial sewage. This element can be metabolized by microorganisms to insoluble forms or by the use of chemicals that include aluminum, Fe^{+3} and Ca^{2+} ions, and polymers. Removal by means of salts occurs with the formation of aluminum oxides and phosphates, which precipitate. Thus, the portion of phosphorus that remained in the treated liquid effluent may correspond to non-reactive forms of phosphorus, whose removal efficiency by coagulation processes is low.

The removal of animal and vegetable oils and greases was complete (100 %) when using the vegetable coagulant, while the aluminum-based chemical coagulant had a removal percentage of 35.5 %. The superior performance of the vegetable coagulant may be related to its simultaneous performance as a coagulant and flocculant. In addition, the composition of the vegetable coagulant, which includes long-chain compounds, provides a greater number of free adsorption sites, which neutralize the negative charges of the layers of suspended oil particles, reducing their electrostatic repulsion, facilitating their aggregation into larger flocs. (MEDEIROS et al., 2022).

Regarding the total suspended solids, there was an increase in this parameter in the treatment with aluminum sulfate. This may have been a result of the coagulation process, with the formation of small flocs that did not have sufficient density to settle, being dispersed in the liquid fraction. This fact may be associated with the coagulant concentration, the fast mixing speed or even the amount of anionic flocculant used in the process. However, with the use of vegetable coagulant, it was possible to completely remove (100 %) the suspended solids, remaining below the detection limit of the analysis, and meeting the emission standard.

The turbidity of the effluent treated with the vegetable coagulant was reduced by 60.4 %, while the reduction promoted by the aluminum-based chemical coagulant increased by 33.3 %. According to Telles and Costa (2007), turbidity is associated with the amount of solids in suspension, which indicates the existence of small flocs that not decanted in the system treated with the coagulant based on aluminum sulfate.

Removal of anionic surfactants was above 90 % in both treatments. The coagulant of vegetable origin had a reduction of 98.0 %, while the coagulant based on aluminum sulfate had a removal of 94.7 %. Anionic surfactants are used on a large scale by industries, and the removal of this parameter is induced by the cationic character of the coagulant, which interacts with the active centers of negatively charged surfactants (BELTRAN-HEREDIA et al., 2009). Surfactants, when incorrectly disposed of in water resources, produce a layer of foam on the surface of the water that makes it difficult for sunlight to reach it and decreases the rate of mass transfer of oxygen from air to water. This leads to a reduction in levels of dissolved oxygen, which can cause the death of aerobic aquatic life (OLIVEIRA FELIPE; DIAS, 2017).

The apparent color of the treated effluent increased with the vegetable coagulant, being associated with the natural brown color of the tannins. Nepomuceno et al. (2018) also observed this color change when using higher dosages of tannin-based coagulants. In this sense, the association of the use of tannin-based coagulants with unit operations, such as, for example, adsorption, can be an alternative for reducing the color of the effluent, since the effluent emitted should not cause a change in the color of the receiving water body.

COD values, after treatment with aluminum sulfate, had a reduction of 45.2 %, similar to the reduction obtained with the use of vegetable coagulant, which was 44.9 %. On the other hand, BOD increased by 11.9 % in the effluent treated with the aluminum sulfate-based coagulant and 5.7 % in the effluent treated with the vegetable coagulant. Dezotti (2008) observed that the greater the difference between BOD and COD values, the lower the tendency of the effluent to present non-biodegradable pollutants. According to Metcalf and Eddy (2016), the biodegradability ratio of the effluent, given by the BOD/COD ratio, greater than or equal to 0.5 indicates that the effluent can be treated by biological means. The raw effluent sample showed a BOD/COD ratio of 0.41, indicating the existence of substances with low biodegradability.

Regarding the pH values, it was noted that this parameter reduced from 7.07 in the raw effluent to 4.89 in the effluent treated with the vegetable coagulant. This behavior differs from that observed by Lima et al. (2019) and the product's data sheet itself, since the coagulant, as it does not consume alkalinity from the medium, should not change the pH of the effluent. The pH reduction was even more pronounced with the use of aluminum-based coagulant, in which the treated effluent had a pH of 4.11. Both treated effluents did not comply with the pH emission standard for release into the environment. It is important to highlight that the pH was measured a few days after the effluent treatment and, considering the existence of degradable organic matter still present, the effluent may have gone through a stabilization process after treatment with coagulants. Furthermore, the alkalinity values for both treated effluents were below the quantification limit of the method.

The association of low alkalinity, high BOD, increased ammoniacal nitrogen content (from organic nitrogen to ammoniacal form), and low pH may be related to the biological decomposition of organic matter. According to Ferreira Filho (2020), the organic compounds that make up the organic matter of the different effluents may originate from biogenic and anthropogenic processes, with concentrations in the range of nanograms per liter to milligrams per liter. These can be classified as partially degraded/stabilized compounds of vegetable, fungal, and animal origin (humic substances), products of the metabolism of algae and microorganisms (originate odor and taste), compounds of synthetic and industrial origin, and compounds formed during treatment (by-products of effluent treatment steps).

Humic substances comprise humic and fulvic acids and the non-humic fraction. These substances, when present in the aqueous phase, release H^+ ions, acidifying the medium. Therefore, in effluents with high concentrations of humic substances, the pH is generally lower than 5.0, with alkalinity levels lower than 20 mg $CaCO_3$/L, a scenario like that observed in the treated effluents (FERREIRA FILHO, 2020; METCALF; EDDY, 2016).

Ferreira Filho (2020) points out that the treatment often used to remove suspended solids, which contribute to turbidity, is not effective enough for the complete removal of natural organic compounds (NOCs). Considering that NOCs show great variability in molecular weight, polarity, and volatility, it is necessary to use associated unit operations in order to guarantee the efficient removal of this class of substances. Furthermore, the dosages of coagulant necessary for optimizing removal by the coagulation technique are normally higher than the dosages necessary to destabilize the colloidal particles. It is possible that, depending on the type, dosage of the coagulant and the pH of the effluent, the organic molecules are adsorbed to the metallic hydroxide particles or their interaction with the monomeric and polymeric species formed by the coagulant occurs, although this coagulation process is partial.

The visual appearance of the sludge generated in treatments with 1.0 % w/v of coagulant based on aluminum sulfate and with 0.25 % w/v of coagulant of vegetable origin is shown in Figure 3.

Figure 3 – Visual appearance of the sludge samples generated (A) after treating the effluent with an aluminum sulfate-based coagulant (B) and a vegetable-based coagulant (C).

(A) (B) (C)

Source: Authors (2023).

Regarding the amounts of sludge produced, the average mass of sludge generated using the coagulant based on aluminum sulfate at a concentration of 1.0 % w/v was 2.60 g for each 2 L of effluent treated, whereas the amount of sludge generated using the tannin-based coagulant at a concentration of 0.25 % w/v was 2.80 g for 2 L of treated effluent. This scenario may be associated with a greater efficiency of the coagulation/flocculation process of the plant-derived coagulant, resulting in a greater number of destabilized colloids and a greater number of formed flocs.

Piantá (2008) reported that the use of vegetable coagulants reduced about 15 % of the amount of sludge generated when compared to coagulants containing aluminum sulfate. The author attributed this behavior to the use of lower concentrations of coagulant and without the need to use flocculating agents. Evaluating the treatment of poultry slaughterhouse effluents, Costa (2016) noted that there was no significant difference in sludge production when using plant-based or aluminum sulfate-based coagulants.

According to the observed results, it can be noted that the vegetable coagulant based on tannins can be an economical and environmentally interesting alternative for the treatment of effluents from the sanitizing industry, replacing coagulants based on aluminum sulfate.

4. CONCLUSION

The vegetable coagulant based on tannin proved to be a product with potential for use as an alternative to chemical coagulants based on aluminum sulfate in the treatment of effluents from sanitizing industry. In addition, the vegetable coagulant is biodegradable, producing an aluminum-free sludge, which can be used as a by-product for other applications. It is important to highlight that the vegetable coagulant was effective in smaller dosages, with a reduction in the amount of inputs to be used and, consequently, a decrease in costs and demand for raw materials.

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