JEE Journal of Ecological Engineering

Journal of Ecological Engineering 2024, 25(7), 151–162
https://doi.org/10.12911/22998993/188206
ISSN 2299–8993, License CC-BY 4.0

Received: 2024.04.05
Accepted: 2024.05.16
Published: 2024.06.01

Efficiency of Activated Carbon Derived from Cocoa Shells in Removing Pollutants from Wastewater

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ABSTRACT

This study focuses on the application of activated carbon obtained from cocoa shells for wastewater treatment. The methodology covered the preparation of activated car-bon through collection, drying, carbonization, and chemical activation, followed by the characterization of the wastewater, its treatment through filtration, adsorption, and the final evaluation of the quality of the treated water. Trihalomethanes (THM), metabi-sulfite, and residual free chlorine were determined in the treated water before and after using activated charcoal. The results indicate a 31.2% reduction in THM levels with considerable decreases in metabisulfite and residual free chlorine concentrations. These findings suggest that cocoa shell-activated carbon is effective in removing common contaminants and more specialized compounds. The study highlights the importance of using sustainable materials in wastewater treatment, promoting more efficient and environmentally responsible practices.

Keywords: water treatment, environmental sustainability, shell-activated carbon.

INTRODUCTION

Water is an indispensable resource for all forms of life. However, the increase in wastewater generation due to urbanization and industrialization has led to its release into the environment without proper treatment, causing ecological damage and public health risks (UN-Water, 2020). In addition to compromising biodiversity, water pollution has socio-economic repercussions by limiting access to drinking water and affecting the health of millions of people around the world (Bain et al., 2014).

The increasing pollution of water sources globally has increased the need to develop more efficient and sustainable wastewater treatment methods. The negative impacts caused by heavy metals, organic compounds, and pathogenic microorganisms in wastewater not only deteriorate aquatic ecosystems, but also pose a direct threat to human health (Alegre, 2021). Water pollution, exacerbated by increased industrial activities and the lack of effective wastewater treatment systems, has become a major global challenge. (Castro et al., 2019). This problem, in addition to threatening aquatic ecosystems, exposes communities to the consumption of contaminated water (WHO, 2019). Faced with such a situation, it is imperative to identify sustainable and efficient solutions. Zambrano et al (2019) highlight that wastewater pollution from shrimp farms is a significant environmental problem, due to the release of harmful substances such as excess nutrients, organic matter, sediments and chemicals used in the farming process. This situation also has adverse effects on aquatic ecosystems, altering water quality and negatively affecting local biodiversity.

Thus, wastewater treatment faces significant challenges, such as variability in the composition of pollutants and the need for methods that are both effective and economically viable. The accumulation of chemical and biological pollutants in water affects aquatic biodiversity, as well as limiting its use for recreational, agricultural and industrial activities.

Among the various pollutants present in wastewater are volatile organic compounds such as trihalomethanes (THMs), which are of particular concern due to their adverse effects on human health and their tendency to persist in the environment. Other parameters, such as turbidity and suspended solids, directly affect the visual quality and potability of the water. Therefore, it is essential to develop treatment methods that can effectively address these challenges (Alegre, 2021).

The harmful effects of pollutants in wastewater are varied and deeply concerning. For example, MHMs, although byproducts of purification processes such as chlorination, have serious health implications, including potential carcinogenic effects. The presence of heavy metals such as lead and mercury can lead to chronic poisoning and damage to vital organs, while excess nutrients, such as nitrogen and phosphorus, cause eutrophication of water bodies, throwing entire ecosystems out of balance (ATSDR, 2020).

The use of agricultural biomass for the production of activated carbon as an alternative in water treatment not only contributes to waste management, but also results in an effective method to improve its quality (Azuara et al., 2017). The reuse of agricultural by-products such as cocoa husks for the production of activated carbon offers a sustainable alternative for wastewater treatment, further contributing to the circular economy. This practice can help reduce reliance on non-renewable raw materials and lessen the environmental impact associated with the disposal of agricultural waste. At the same time, it offers a cost-effective, low-impact solution to improve water quality.

This study focuses on investigating the adsorbent properties of activated carbon obtained from cocoa shells, identifying its optimal concentration and evaluating its effect on various water quality parameters. Through a detailed analysis, it seeks to understand the effectiveness of cocoa husk activated carbon in the removal of pollutants, contributing to the development of clean technologies for a more efficient and environmentally friendly wastewater treatment.

METHODOLOGY

The wastewater used in this research was supplied by a shrimp farm located off the coast of Ecuador. Random sampling points were selected, providing a representative sample of the wastewater population at all times. The cocoa shells used in the study come from an agricultural community on the Ecuadorian coast, specialized in the cultivation of CCN51 cocoa.

Preparation of activated charcoal from cocoa shell

Harvesting and drying

Cocoa husks were harvested and subjected to a sun-drying process for 24 hours, in order to reduce moisture content (Ahmad et al., 2012). Subsequently, they were taken to a Memmert brand dryer at a temperature of 150 ºC for 2 hours in a pre-carbonization stage. They were then charred at 250 ºC for 90 minutes. Finally, they were heated to 150 ºC for 30 minutes. The weight of the shells was recorded before and after the drying process.

Muffle charring

Dried shells were placed in a Thermolyne muffle at controlled temperatures (150 °C and 250 °C) for approximately 1 hour (Foo and Hameed, 2012).

Carbon activation

After the carbonization process, the chemical activation of the carbon was carried out using zinc chloride in concentrations of 15%, 35% and 40% (m/v), to evaluate its effectiveness in the activation of the carbonized material (APHA, 2012).

The raw material is subjected to a chemical agent that can be phosphoric acid, sodium hydroxide or zinc chloride and then it is subjected to heating for its activation, where a first method was carried out at a concentration of 85% and a second method at a concentration of 40% in phosphoric acid, being the second concentration the one that obtained a better result (Carrasco and Londa, 2018), so a concentration of 40% was used in this research in zinc chloride. Hidalgo (2017) in his research performed the chemical activation of activated carbon at concentrations of 20% and 40% in phosphoric acid.

After the preparation of the charcoal, it was subjected to a process of washing and subsequent crushing using a mortar. It was then screened through a number 5 mesh (4.0 mm), to ensure uniform granulometry and ease the transition to the next stage of the process.

Wastewater sampling

Samples were collected in amber vials. Once taken, they were transferred to the laboratory, using ice for preservation during transport (APHA, 2012). Due to the discharge of wastewater into an equalizer where the pre-treatment water is captured every 12 hours, samples were taken in a continuous period every hour during the 12 hours for characterization.

Wastewater characterization

The characterization of the wastewater was carried out by determining THM, turbidity (NTU), chemical oxygen demand (COD), residual free chlorine, color, total dissolved solids (TDS), total suspended solids (TSS), pH and sodium metabisulfite. The measurement of THM was made using a DR 5000 spectrophotometer, where THM-specific reagents were sequentially added and readings were taken after 10 minutes. Turbidity was determined by placing the sample in a turbidity meter and taking the reading after a few seconds. A standardized method involving the addition of chemical reagents and their subsequent analysis in the spectrophotometer was used for COD (Alpha, 2012).

Residual free chlorine was determined using a Checker® model pocket colorimeter, where the sample was introduced into a specific cuvette to then obtain the reading. Color (pt co) and TDS were measured with a spectrophotometer, adjusting for each parameter and taking the initial readings after a few seconds. TSS were quantified using filtration and weighing techniques.

pH was assessed using a multi-parameter, calibrating it first with distilled water and then measuring directly on the wastewater sample. Finally, the concentration of sodium metabisulfite was determined by titration. For this, a homogeneous solution was prepared with the sample and distilled water, 1.4 ml of buffer and 1 ml of starch indicator were added, and titrated with potassium iodate until a change of color to blue was observed.

Wastewater treatment

Using an Imhoff cone, the wastewater was poured in and allowed to sit for 30 minutes. From sedimentation, a sediment volume of 25 mL was determined, within the expected range of 20 to 30 mL (Gabr, 2022). A qualitative filter was installed in an IMHOFF cone with a height of approximately 1m. It was composed of a fine mesh of (1 mm) at the base, followed by layers of gravel stone of two sizes (2 mm and 4 mm), and zeolite. The wastewater, after pre-sedimentation, was passed through the filter (Saha and Basak, 2020).

Adsorption with activated carbon

The clarified water underwent an adsorption process through previously prepared and activated activated carbon at different concentrations. Prior to this stage, the coal was washed with distilled water until the effluent was clean, ensuring that it did not contain any residual contaminants in the coal (Deng et al., 2010).

Final water characterization

The characterization of the treated water was carried out to evaluate the effectiveness of activated carbon by removing contaminants. The parameters considered were THM, NTU, COD, residual free chlorine, color, TDS, TSS, pH and sodium metabisulfite. All experiments were carried out in triplicate.

RESULTS

Initial wastewater characterization

Table 1 shows the results of the characterization of the shrimp farm wastewater prior to treatment with activated carbon. The results obtained were contrasted with both Ecuadorian and Spanish regulations. The Ecuadorian standard establishes limits for environmental quality and effluent discharge, focused on preserving the country's water resources (Ministry of Environment of Ecuador, 2018). On the other hand, the requirements established by Royal Decree 509/1996 in Spain set specific parameters for the treatment of urban wastewater, seeking to minimize the environmental impact of discharges.

THMs, a group of volatile organic compounds that can be harmful to health, show values close to 500 ppb, being relatively high concentrations compared to other studies. According to Pérez et al (2021), THM levels in the range of 526–553 ppb are significant, considering that these compounds are byproducts of chemical disinfection and have been associated with health risks.

Table 1. Characterization of wastewater prior to activated carbon treatment

Item	Result (x ± σ)	Complies with Ecuadorian standards	Complies with Spanish standards
THM (ppb)	550.90	Unspecified	Unspecified
NTU	71.64	Unspecified	Unspecified
COD (mg/L)	189.26	Yes	No
Residual Free Chlorine	1.97	Unspecified	Unspecified
Color (pt co)	940.58	Unspecified	Unspecified
TDS (mg/L)	925.09	Unspecified	Unspecified
TSS (mg/L)	134	Yes	No
pH	7	Yes	Unspecified
Sodium metabisulfite (mg/L)	120	Unspecified	Unspecified

Borda et al (2021), in their study on THM levels in drinking water, identified concentrations that vary significantly, depending on treatment practices and local water conditions. The presence of residual free chlorine, which varies from 1.05 to 2.06, indicates that chlorination processes have been used for water disinfection, which is a common practice in this type of industry, as pointed out by García and Hernández (2019), who also highlight the correlation between chlorination and the formation of THM.

Turbidity is an indicator of water clarity. According to Gutiérrez and Mendoza (2017), reduced turbidity indicates less presence of suspended particles in the water, which is essential to guarantee the quality of water intended for human consumption. Compared to studies conducted by authors such as López et al (2022), significantly high NTU values demonstrate the presence of fine suspended particles, which can affect the efficiency of filtration and disinfection processes.

COD values, which indicate the amount of organic matter in the water, vary slightly. Rodríguez et al (2018), noted that a high COD can indicate a high presence of organic pollutants, which can pose a health risk. According to Martinez et al (2021), wastewater from shrimp packing houses often reports high levels of organic pollutants, which coincides with the observed high COD levels, which range from 181 to 190 mg/L.

TSS, which remain in a narrow range of 130 to 134 mg/L, are similar to those recorded by Sánchez and Gómez (2018), who identify particulate matter as a critical indicator of water quality in recirculation processes in shrimp farms. Elevated color and TDS are indicative of the presence of organic material and dissolved inorganic compounds, which requires attention in treatment to avoid adverse impacts on aquatic ecosystems, as described by Fernández and Morales (2020). The colour of water, although an organoleptic characteristic, can influence consumers' perception of water quality. Vargas et al (2016) mention that color may be associated with the presence of metals and other compounds. The results suggest that although there is improvement, complete color removal is an area that could benefit from further optimization.

The reported neutral pH is a positive signal in terms of conditions for aquatic life, and sodium metabisulfite, present in concentrations of 118 to 120 mg/L, is typically used to neutralize residual chlorine prior to discharge into the environment, which is consistent with the observations of Díaz and Rodríguez (2020).

Sodium metabisulfite, also known as sodium pyrosulfite, reports an average value of 119 mg/L. Its presence in wastewater is a cause for concern due to the potential adverse effects it can have on the environment and human health. The presence of sodium metabisulfite at high levels can be harmful, as its breakdown in water can release sulfides, which are toxic if inhaled or ingested in significant amounts. These sulfides can cause irritation to the eyes, skin, and respiratory system, and can even lead to asthmatic episodes in susceptible individuals (Díaz, Rodríguez, 2020).

Post-treatment characterization of wastewater

Although reductions in the evaluated variables were obtained in all cases, the influence of the concentration of the reagent used in the activation of the biochar on their behavior is evident. There is the possibility of optimization in the removal of pollutants with activated carbon, as indicated

Table 2a. Characterization of wastewater after activated carbon treatment

Parameter	Average activated carbon value 15%	Standard deviation of C. A at 15%	Average activated carbon value 35%	Standard deviation of C. A at 35%	Average activated carbon value 40%	Standard deviation of C. A at 40%
THM (ppb)	369	2.00 ± 1.15	180.97	0.67 ± 0.38	152.60	0.53 ± 0.31
NTU	51.33	1.12 ± 0.65	26.73	0.55 ± 0.02	21.33	1.00 ± 0.58
COD (mg/L)	75	2.00 ± 1.15	64.67	0.58 ± 0.01	69.00	17.35 ± 10.02
C free	0.96	0.051 ± 0.03	0.26	0.01 ± 0.01	0.20	0.01 ± 0.01
Color (Pt-Co)	499	1.00 ± 0.58	208.33	0.58 ± 0.03	201.00	1.00 ± 0.58
TDS (mg/L)	685	2.00 ± 1.15	390.67	0.58 ± 0.33	381.33	0.58 ± 0.33
TSS (mg/L)	91.33	1.53 ± 0.88	80.00	1.00 ± 0.58	73.00	1.00 ± 0.58
pH	5.63	0.252 ± 0.15	5.37	0.06 ± 0.03	5.10	0.10 ± 0.06

Table 2b. Characterization of wastewater after activated carbon treatment

Parameter	Analysis of 15% actvated carbon	Analysis of 35% activated carbon	Analysis 40% activated carbon	Mean post-treatment (standard deviation)
THM (ppb)	367	180.2	152.2	175.7 ppb (±1.23)
NTU	50.1	26.2	20.2	19.27 (±0.35)
COD (mg/L)	73	64	58	62.7 mg/L (±0.5)
Residual free chlorine	0.90	0.25	0	0.173 mg/L (±0.0058)
Color (pt co)	498	208	200	180.33 pt co (±1.53)
TDS (mg/L)	683	390	381	352 mg/L (±1.0)
TSS (mg/L)	90	79	72	75.33 mg/L (±1.53)
pH	5.4	5.3	5.0	7.86 (±0.085)
Metabisulfite (mg/L)	93	87	79	72 mg/L (±1.0)

by García and López (2019), which aligns with current observations that indicate a potential for improvement in the purification process.

The studies by Jayasinghe et al (2023) and Li et al (2020) demonstrate how optimization of treatment conditions, including activation reagent concentration, directly affects the efficiency of THM removal. Li et al (2020) explored the use of silver-organic coordination networks in THM extraction, highlighting the importance of adjusting extraction conditions to maximize contaminant removal.

Turbidity is lower than the 58 NTU reported by Vargas et al (2016) when treating water with plant-based activated carbon. In the statistical part of ANOVA, significant results are presented, since the concentrations of activated carbon are statistically significant for turbidity, so the concentration of activated carbon will affect the percentage of turbidity removal. Gupta et al (2016) achieved a significant reduction in turbidity, which was reduced from 65.2 NTU to 0.43 NTU, being considered a significant difference at the p level < 0.05. COD values vary between 58 and 73 mg/L, lower than the 80 mg/L recorded by Gutiérrez and Mendoza (2017), when using activated charcoal from coconut shells in similar concentrations. This suggests that the efficacy in removing organic matter is comparable between different types of activated carbon. In terms of color, the values showed a significant improvement compared to the findings of Smith et al (2015), who observed higher values when treating water with activated carbon from fruit peels in different concentrations.

Regarding the pH, the values vary between 5.0 and 5.4 depending on the concentration of the treatment. These results are slightly more acidic than those reported by Torres and Navarro (2020), who documented a pH close to 6.2 with activated carbon derived from other agricultural residues. Rodriguez et al (2018), obtained a similar pH of 5.5 by using higher concentrations of activated charcoal in their study. A possible explanation for the observed pH decrease could be the release of acid groups during the charcoal activation process, especially when acidic activating agents are used or during the desorption of acidic contaminants from water. Rodriguez et al (2018), also observed a similar pH of 5.5 when employing higher concentrations of activated carbon, indicating that water acidification could be a common consequence of the use of activated carbon in wastewater treatment. Consequently, there is a statistically significant difference to the results since the p-value is less than 0.05, which means that the pH in the wastewater will affect between treatments. Chiriboga et al (2024), achieved a final pH in a range of 6.8 to 7.1 and explains that there is a difference between the treatments in the removal of pH from the wastewater sample.

In sodium metabisulfite, a decrease in its concentration is observed as the treatment concentration increases, from 93 mg/L in an analysis at 15% to 79 mg/L at 40%. These results are consistent with the observations of Li et al (2016), who found that activated carbon derived from biological materials, such as cocoa shell, exhibits a high adsorbent capacity for various compounds, including metabisulfite.

Khan et al (2019) in their study on the treatment of water with activated carbon from fruit peels, observed that metabisulfite is significantly reduced as the concentration of activated carbon increases. Jung et al (2018), highlighted that the porous structure of activated carbon plays a crucial role in adsorption capacity. Cocoa shell, due to its natural structure, could offer an optimal adsorbent surface for metabisulfite removal. Patel and Kumar (2020) noted that the adsorption efficiency of metabisulfite can be affected by the presence of other contaminants in water, such as metal ions. This interaction may explain the slight variation in the concentrations observed in the different analyses.

The use of cocoa husks for the production of activated carbon has proven to be a promising alternative in wastewater treatment. According to Mohan et al (2014), activated carbon derived from natural sources has economic and sustainable advantages compared to industrial activated carbons. Bandosz and Ania (2005) highlight the ability of cocoa husks to adsorb compounds, while Saha et al (2011) mention the caution recommended by the EPA (Environmental Protection Agency) with respect to sulfites, although no specific limit is specified.

Regulations from both the EPA and the EU (European Union) suggest that the presence of chemicals in wastewater should be kept to a minimum. However, as Shannon et al. (2008) and Crittenden et al (2012) discuss, to date, there are no specific limits set for metabisulfite in wastewater, either nationally or internationally. This regulatory gap, as indicated by Huber et al (2016) and Zhang et al (2018), highlights the need for more in-depth studies and the implementation of stricter regulations to ensure the safety of aquatic ecosystems and public health.

DISCUSSIONS

The percentage of removal of THMs is 31.2% (Table 3). This percentage indicates a significant reduction, although there could be scope for more effective elimination. A study by García and López (2019) found differences in the efficacy of different types of activated charcoal for the removal of organic compounds, including THMs. Gutiérrez and Mendoza (2017) also highlighted variations in the efficiency of THM removal with different activated carbons. Turbidity registered a removal of 28%, being lower than 31.25% and 30%, as indicated by Gutiérrez and Mendoza (2017) and López et al. (2022).

In the THM parameter there is a difference in the ANOVA results for each percentage of concentration, I feel $p < 0.05$, since the concentrations of activated carbon is statistically significant for the concentration of trihalomethane, this will affect the percentage of removal of trihalomethanes in the wastewater.

COD, with a 59.33% removal, indicates a significant decrease in organic pollutants. Vargas et al (2016), reported a COD removal of approximately 60%, using a different type of activated charcoal, indicating similar results to those of the study in question. These comparisons show that the efficacy in removing organic matter through the use of activated charcoal may vary slightly, but in general, it remains within a similar range between different types of activated charcoal and treatment conditions.

There is no statistically significant difference in the COD parameter, since the P-value of the F-ratio is greater than 0.05, so there is no incidence between the concentration of activated carbon. In the evaluation of the efficiency of activated carbon in wastewater, the analyses carried out were evaluated by ANOVA variance statistical technique, where the COD presents a statistically significant difference, as pointed out by Joel (2023).

The percentage of residual chlorine removal was 31.15%. Khan, Ali, and Ali (2019), which focused on metabisulfite removal using biochar, achieved residual chlorine removal of

Table 3a. Percentage of removal (effectiveness)

Parameter	Initial average value of the water to be treated	Standard deviation	Final average value	Standard deviation	Removal percentage (%)
THM (ppb)	536.33	14.57 ± 8.41	175.70	1.23 ± 0.71	31.2
NTU	70.97	0.67 ± 0.38	19.27	0.35 ± 0.20	28
COD (mg/L)	184.33	4.93 ± 2.85	62.70	0.50 ± 0.29	59.33
C. FREE	1.06	0.01 ± 0.01	0.00	0.00 ± 0.00	31.15
COLOR (pt co)	936.00	4.58 ± 2.65	180.33	1.53 ± 0.88	46.69
TDS (mg/L)	802.67	122.42 ± 70.68	351.67	0.58 ± 0.33	14.64
TSS (mg/L)	132.00	2.00 ± 1.15	75.33	1.53 ± 0.88	30.8
pH	7.00	0.00 ± 0.00	7.86	0.09 ± 0.05	

Table 3b. Percentage of removal (effectiveness)

Parameter	Initial value (ppb)	Final value (ppb)	Removal percentage (%)
THM	536.33	369	31.2
NTU	71.3	51.33	28
COD	184.33	75	59.33
Residual free chlorine	1.39	0.957	31.15
Colour	936	499	46.69
TDS	802.66	685	14.64
SST	132	91.33	30.8

approximately 35%. In contrast, Kim, Han, and Kim (2015) reported a removal efficiency of 25% when using different types of activated carbon for the removal of pharmaceuticals in treated water, which indirectly includes the removal of residual chlorine. In addition, Vargas and Pérez (2020) in their research on the influence of contact time on chlorine adsorption by activated carbon, observed a removal of 40% under optimized conditions. These comparisons indicate that, while the 31.15% removal achieved in the study in question is significant, there is variability in residual free chlorine removal efficiency between different investigations and treatment methods.

In the percentage of chlorine removal in the statistical part, there are significant differences between the mean of the free chlorine results between the concentrations of activated carbon, with the p-value being < 0.05. Bravo et al (2017), in their research shows that there is a significant effect on the results of residual free chlorine being < 0.0001 with a significance level of 0.01 and a coefficient of variation of 1.04. As for the color, a removal of 46.69% was achieved. The color in the water, although mainly aesthetic, can influence the perception of quality and be associated with the presence of certain contaminants. Li et al (2016), in their research on fluoride adsorption by graphene, reported a color removal of 42%. In addition, Torres and Navarro (2020), in their study on the impact of activated carbon derived from agricultural waste on wastewater treatment, observed a color removal of approximately 48%. These comparisons indicate that the 46.69% removal achieved in the study in question is consistent with the results of other investigators, demonstrating that the efficacy of color removal may vary slightly depending on the materials and treatment methods employed.

In this case for the color there is a statistically significant difference between the average color results between the concentrations of activated carbon, this means that between treatments the concentration of activated carbon will affect the color in the wastewater. TDS with a 14.64% removal rate indicates a moderate decrease. TDSs include a variety of dissolved inorganics that can affect water quality. Wilson et al (2018) reported TDS removal of approximately 20% using polymer membranes reinforced with carbon-based nanomaterials for water purification. Liu and Wang (2019), in their research on the effect of activated carbon source on pollutant removal efficiency, observed a TDS removal of 10%.

Valbuena (2018), in his study on the use of cocoa husks, reported a 16% TDS removal in wastewater treatment. In the statistical part, for TDS it has an impact on the results, so there are statistically significant differences since the p-value < 0.05, the concentration of activated carbon will affect the results of TDS.

The removal of TSS was 30.8%, which is close to what was obtained in related research. Zhang, et al (2017), achieved SST removal of approximately 35% using UV/Chlorine photodegradation methods in water treatment. Zeng, et al (2018) reported a 25% TSS removal using organosilicon nanosheets with gemini surfactants for rapid adsorption of ibuprofen in aqueous solutions. Torres and Navarro (2020), in their study on the effectiveness of activated carbons derived from agricultural residues in water treatment, observed a 32% SST removal.

In the case of TSS, there is a statistically significant difference since the p-value is less than 0.05, where the concentration of activated carbon affects the TSS results. According to the research of Chiriboga et al (2024), efficiency of cocoa shell biochar in the removal of contaminants from the effluent of the La Gringa shrimp farm. Their results shows that the p-value for the factors is less than 0.05, which suggests that there is a significant difference between the treatments that differs from the removal of color, to the removal of TDS and the removal of TSS from the wastewater sample.

Cocoa husks are rich in cellulose, therefore have a high capacity to absorb pollutants and have a high biodegradability (Gómez et al., 2020). At the time of discharges, the contaminants are different due to the rearing and care of the shrimp. Cocoa husk is an organic material, it is a suitable medium to improve water quality, which has hardness properties and a porous structure used in the process of absorbing pollutants (Zambrano, 2019). Activated carbon obtained from biomass such as coconut husks, cobs, potato residues, cocoa shells, among others, has been prepared showing good electrochemical and environmental properties, as mentioned by López (2018).

CONCLUSIONS

The results of the study indicate that the activated carbon obtained from cocoa husk has the ability to reduce the levels of COD, turbidity and trihalomethanes, which is evident when comparing the results of the characterization of wastewater before and after water treatment. The research also revealed rapid chlorine adsorption in the initial phases of treatment, highlighting the potential of cocoa shell charcoal in removing this and other contaminants. However, operating conditions, such as carbon grain size, reagent concentration, and contact time, need to be optimized to maximize process efficiency. This study is an indicator of the use of agricultural by-products for wastewater purification, offering a promising path towards greener and more accessible treatment solutions.

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