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EFICIÊNCIA DE SEMENTES DE *MORINGA OLEÍFERA* E TEMPOS DE DECANTAÇÃO NO TRATAMENTO DE ÁGUAS

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RESUMO: A escassez hídrica é um fenômeno que provoca diversas consequências socioambientais no Brasil e no mundo, tornando-se necessário o desenvolvimento de tecnologias que promovam cada vez mais a acessibilidade à água de forma segura e eficaz. Estudos demonstram que a semente de *Moringa oleífera (MO)* possui propriedades de coagulação. Desta forma, o presente trabalho teve o intuito de avaliar a eficiência da semente de *MO* como coagulante natural no tratamento de água coletada em um pequeno reservatório no município de Queimadas, Paraíba, Brasil. As sementes de *MO* foram descascadas, secas em estufa, trituradas e aplicadas na amostra de água, que foi submetida a 2 e 48 horas de sedimentação. De maneira a facilitar a aplicação da metodologia em campo, utilizou-se o coagulante natural em tratamentos variando de 20 a 100 sementes por 500 mL de amostra. Como forma de avaliar o desempenho e eficiência do coagulante, a análise de qualidade da água foi feita por meio dos seguintes parâmetros físico-químicos: turbidez, cor aparente (CA), pH e condutividade elétrica (CE). Os resultados indicaram reduções de 88,25% e 70% de turbidez e CA, respectivamente, e os demais parâmetros se mantiveram dentro dos intervalos sugeridos pela literatura.

Palavras-chaves: coagulação, coagulante natural, escassez hídrica.

EFFICIENCY OF *MORINGA OLEÍFERA* SEEDS AND SETTLING TIME IN WATER TREATMENT

ABSTRACT: Water scarcity is a phenomenon that causes many socioenvironmental issues in Brazil and worldwide. Access to safe and efficient water resources through the development of technologies is needed. Studies have shown that *Moringa oleifera* seeds (*MOs*) have coagulation properties. Therefore, the present study aims to analyze the efficiency of *MO* seeds as a natural coagulant in the treatment of water from a small reservoir in the city of Queimadas, state of Paraíba, Brazil. *MO* seeds were deshelled, oven dried, powdered and applied to the water sample, which was then subjected to 2 and 48 hours of settling. To make this methodology easier to apply during field activities, a natural coagulant was used in the range of 20--100 seeds per 500 mL of water sample. To verify the performance and efficiency of the coagulant, water quality analysis was performed via the following physical–chemical parameters: turbidity, apparent color (AC), pH, and electrical conductivity (EC). The results revealed reductions of 88.25% and 70% in turbidity and AC, respectively, with the remaining parameters remaining within the suggested ranges in the literature.

Keywords: coagulation, natural coagulant, water scarcity.
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1 INTRODUCTION

The coagulation and flocculation processes constitute important steps in water treatment techniques since the effectiveness of subsequent processes is dependent on the effectiveness of these two procedures (Richter, 2009).

Moringa *oleifera* is a tree that can be cultivated in both dry and humid regions and can also bear fruit in soils with nutrient deficiencies. The presence of cationic proteins in the seeds of this tree gives the species coagulant properties, a factor responsible for helping to reduce turbidity and color during water treatment processes (Oliveira *et al.,* 2018).

In view of the above, the present study aimed to evaluate the efficiency of *Moringa oleifera seeds* as a natural coagulant in the treatment of water collected from a small reservoir in the municipality of Queimadas, Paraíba. For this purpose, water quality analyses were performed via physical–chemical parameters to obtain an overview of the functionality and influence of the natural coagulant in the water treatment process, in addition to the application of variance tests to verify its significance.

2 MATERIALS AND METHODS

To facilitate the application of the methodology in the field, the natural coagulant was quantified as the number of seeds per volume of water collected. Therefore, conventional methods with proportions based on seed mass were also avoided because they require an advanced technical and technological repertoire.

The research was carried out in a randomized block experimental design in a split-plot scheme with two treatments in the plot, corresponding to the decantation time after the application of the natural coagulant (2 and 48 hours), and six treatments in the subplot, referring to the six proportions of *MO seeds* (0, 20, 40, 60, 80 and 100 seeds/500 mL of sample). The tests were conducted in triplicate.

The statistical analysis of the data was based on analysis of variance (ANOVA), with an F test at probability levels of 1 and 5%, and the means were analyzed by the Tukey test. The statistical study of the results obtained was developed via Assistat 7.7 (Silva; Azevedo, 2016) and Excel *software*.

The water sample was collected in a small reservoir sheltered in the rural community of Sítio Soares, in the municipality of Queimadas, Paraíba, with geographic coordinates of 7°27′11 S for latitude and 35° 52′58 W for longitude. The experimental stage of this work was carried out at the Environmental Sanitation Laboratory (LABSAM) of the Federal University of Paraíba during the first semester of 2022, the summer period.

Prior to the application of the alternative treatment, physical–chemical analyses of the sample in its raw state were performed. The parameters selected for the analysis of water quality were turbidity, apparent color (AC), pH and electrical conductivity (EC), which were chosen on the basis of materials published by Almeida (2010) and by Ordinance GM/MS No. 888/2021 (Brazil, 2021).

The choice of decantation time (2 and 48 hours) was based on studies by Muniz, Duarte and Oliveira (2015), who reported high reductions in turbidity at 60, 90 and 120 minutes of sedimentation when water with different turbidity levels was treated with *Moringa oleifera seeds*.

Moringa oleifera seeds were collected in the state of Ceará in January 2022, dried in the shade and transported in PET bottles sealed with conventional adhesive tape. For application in laboratory tests, the pulp of the *MO seeds was counted, extracted*, peeled and dried in an oven at approximately 70°C for 30 minutes. Each sample was subsequently crushed in a domestic blender to obtain a uniform powder, which was weighed on an analytical balance (Table 1) and poured into the sample.

Table 1. Average mass of *MO seeds* and standard deviation (SD)

No. of seeds	20	40	60	80	100
Mass ± SD (g)	4.26 ± 0.34	8.63 ± 0.81	12.68 ± 1.58	17.43 ± 1.67	20.03 ± 1.98

Source: Own authorship (2023).

The material was mixed electronically via *a Jar* test. On the basis of methodologies proposed by Richter (2009), the rotation speed of fast agitation varies between 128 and 136 rpm, whereas that of slow agitation ranges from 66 to 72 rpm. The fast and slow agitations lasted 2 and 15 minutes, respectively.

3 RESULTS AND DISCUSSION

The analysis of variance revealed that turbidity, pH and electrical conductivity (EC) were influenced by the settling time (TD) and the number of seeds (NS) and by the interaction between the two factors at a significance level of 1% probability (Table 2). The apparent color (AC) was influenced by the settling time (TD) and the number of seeds (NS) at a significance level of 5% probability. The interaction between the settling time (TD) and the number of seeds (NS) did not significantly influence only the apparent color.

Table 2. Summary of the analysis of variance of the physical–chemical parameters of water collected in the municipality of Queimadas, Paraíba, and treated with Moringa oleifera seeds.

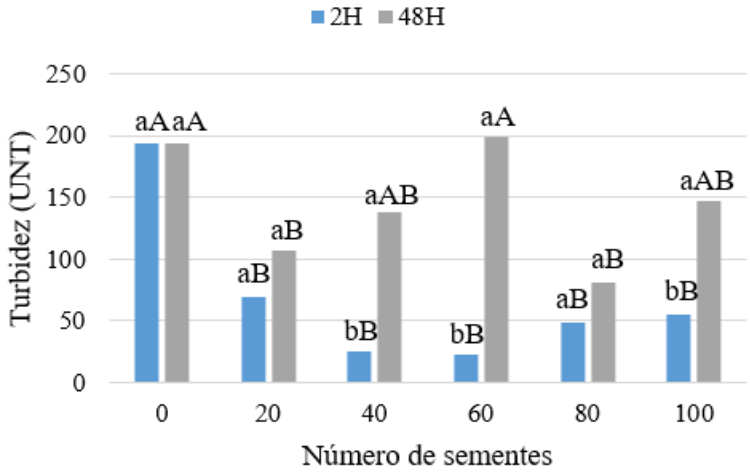
Source of Variation	GL	Mean Square			
		Turbidity (UNT)	CA (UC)	pH	EC (dS/m)
Decantation time (DT)	1	50648.75**	65025.00*	15,445**	1,3310**
Residue (A)	4	148.64	3755.56	0.002	0.0005
N. seeds (NS)	5	12340.97**	88029.44**	1,195**	1.0232**
Int. TD x NS	5	6248.82**	6051.67 ^{ns}	1,085**	0.0576**
Residue (B)	20	687.68	2728.89	0.008	0.0018
Total	35	-	-	-	-
CV (A) (%)	-	11.43	20.68	0.75	2.87
CV (B) (%)	-	24.58	17.63	1.61	5.58

**significant at 1%; *significant at 5% according to the F test; ^{ns} - not significant according to the F test. GL - degree of freedom; CV - coefficient of variation.
Source: Own authorship (2023).

Figure 1 shows the results of the average turbidity test of the samples after the application of the treatments. For the range between 20 and 60 *MO seeds, after 2 hours of decantation, a tendency for the parameter to decrease with increasing number of MO* seeds per 500 mL of sample was observed. After 48 hours of decantation, an increase in turbidity was observed for all proportions of *MO seeds*

in comparison to the results presented after 2 hours of decantation.

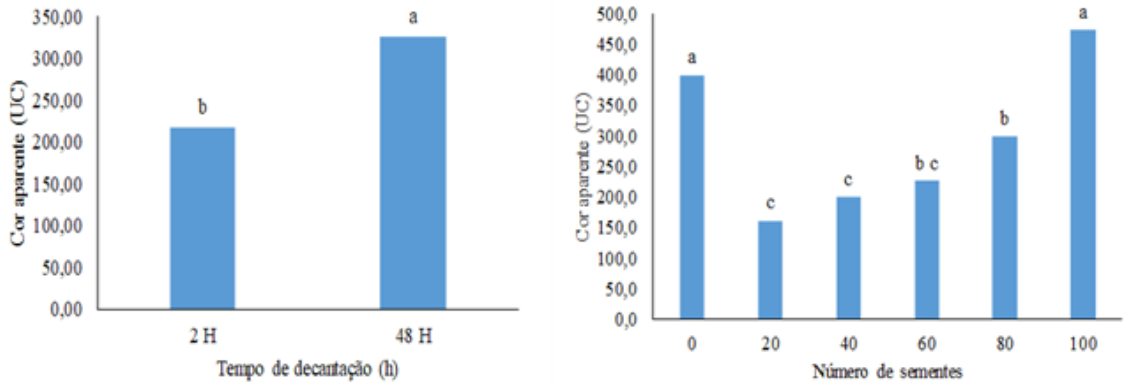
Figure 1. Results of the average test for water turbidity as a function of the number of *MO seeds* and number of decantations.



*Mean values followed by the same capital letter (number of seeds) do not differ statistically from each other. Mean values followed by the same lowercase letter (settling time) do not differ statistically from each other.
Source: Own authorship (2023).

Figure 2 shows lower rates of apparent color (AC) reduction as the proportion of *Moringa oleifera seeds* and the decantation time increased. Similar to turbidity, the most efficient results for reducing AC were obtained between 20 and 60 *MO seeds*, with 2 hours of decantation, which did not significantly differ from each other.

Figure 2. Results of the average test for apparent water color as a function of decantation time (a) and number of *MO seeds* (b).



(a) (b)

Source: Own authorship (2023).

The most efficient configuration for removing turbidity and apparent color was obtained by using 60 *Moringa oleifera seeds* in powder, equivalent to a proportion of 25.36 g/L, with 2 hours of decantation. The application of this treatment was efficient in reducing turbidity and apparent color by 88.25% and 70%, respectively.

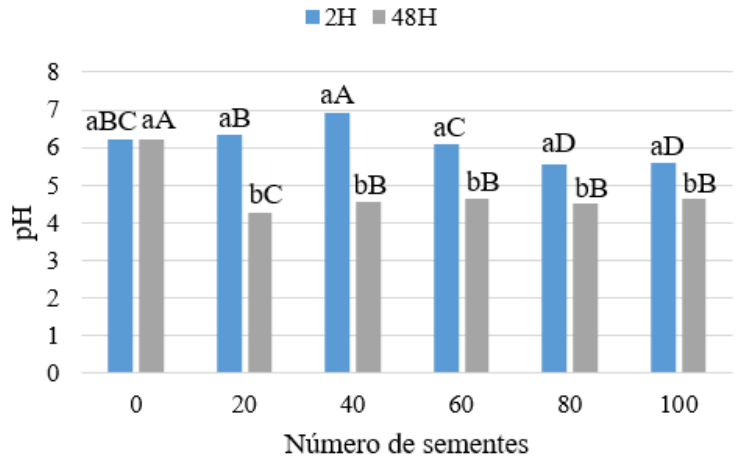
Similar results were reported by Souza *et al.* (2023), who reported 88.46% and 79.23% removal of turbidity and color, respectively, when treating water samples collected in a reservoir located in the state of Bahia with *OM seeds* dried in an oven.

The proportions of 20 and 60 *Moringa oleifera seeds* caused minimal changes in the

pH of the samples after 2 h of decantation (Figure 3). When studying coagulation diagrams in *MO seeds*, Valverde *et al.* (2013) did not observe significant changes in the pH of the water.

Water was treated with different amounts of seeds, and the water pH was maintained below 7.0. In the range of 60 to 100 *MO seeds*, a tendency for the pH to decrease was observed, and after 48 hours of decantation, the reduction was more pronounced than that in the raw water, with an average value of 4.52, indicating acidity (Figure 3). The usual ranges reported by Almeida (2010) and Ayers and Westcot (1985) for water intended for irrigation are between 6.0–8.5 and 6.5–8.4, respectively. The data obtained remained below those reported by the authors, with the exception of the treatment performed with 2 hours of decantation in up to 60 *MO seeds*.

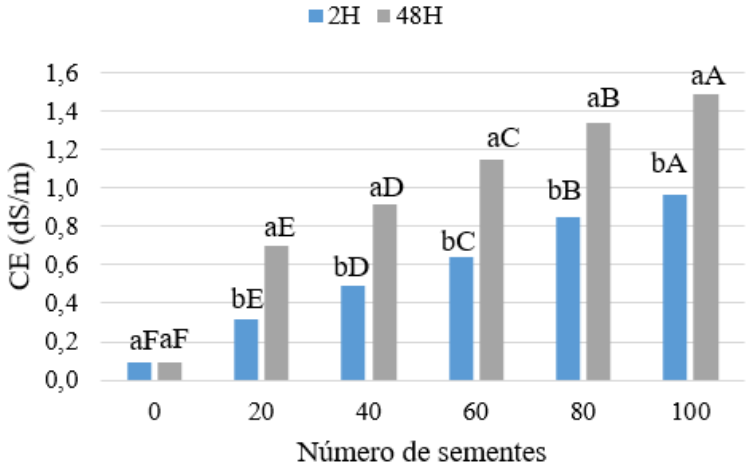
Figure 3. Results of the average test for water pH as a function of the number of *MO seeds* and decantation time.



*Averages followed by the same capital letter (number of seeds) do not differ statistically from each other. Averages followed by the same lowercase letter (decantation time) do not differ statistically from each other.
Source: Own authorship (2023).

The results of the average electrical conductivity (EC) test for the collected samples are shown in Figure 4. The EC increased as the number of *Moringa oleifera seeds* and duration increased. After 48 hours of decantation, a significant increase in EC was observed as a function of the number of *MO seeds*, with values ranging from 0.095 dS/m to 1.48 dS/m for raw water and water treated with 100 *MO seeds*, respectively. According to Richards (1954), the indicated electrical conductivity values for water intended for irrigation should be less than 0.75 $dS.m^{-1}$. In this work, these values were obtained after 2 hours of decantation with up to 60 *MO seeds and after 48 hours of decantation, with only 20 MO* seeds.

Figure 4. Results of the average electrical conductivity (EC) test of water as a function of the number of *MO seeds* and number of decantations.



*Averages followed by the same capital letter (number of seeds) do not differ statistically from each other. Averages followed by the same lowercase letter (decantation time) do not differ statistically from each other.
Source: Own authorship (2023).

These results are similar to those of the study published by Semanka, Seifu and Sekwati-Monang (2022), in which, when a sample from a borehole located in Botswana was treated with powdered Moringa oleifera seeds, the electrical conductivity values increased with increasing proportion of MO seeds.

4 CONCLUSIONS

Moringa oleifera seeds are efficient in water treatment, in addition to reaffirming their viability, owing to their sustainability and low cost. The greatest treatment efficiency was observed with 2 hours of sedimentation and 60 *Moringa oleifera seeds* in a 500 mL water sample collected in a small reservoir in the municipality of Queimadas, Paraíba.

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