Indian Journal of Science and Technology, *Vol 11(9), DOI: 10.17485/ijst/2018/v11i9/121221, March 2018*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Influence of Storage Time of *Moringa oleifera* Seed on the Coagulant Activity Efficiency for Raw Water Treatment

Jhon Jairo Feria Díaz[1]*, Gastón BallutDajud[1] and Juan Pablo Rodriguez Miranda[2]

[1]Department of Civil Engineering, University of Sucre, Cra. 28 #5-267, Puerta Roja, Sincelejo, Colombia; jhon.feria@unisucre.edu.co, gaston.ballut@unisucre.edu.co
[2]Department of Environnmental Engineering, Francisco José de Caldas University, Cra. 7 #40B-53, Bogotá, Colombia; jprodriguezm@udistrital.edu.co

Abstract

Objective: To verify storage and storage time influence of *Moringa oleifera* seeds in coagulant activity when used for natural raw watertreatment. **Methods/Analysis:** Two types of coagulant extracts with high turbidity levels (105, 202, and 410 NTU) were applied to raw water samples taken from Sinú River in Colombia. Coagulant "A" was prepared with *Moringa oleifera* seeds stored and preserved for 6 months and, coagulant "B", prepared with seeds stored for 4.5 years. Three different doses of each coagulant were used (15, 30 and 60 mgL^{-1}) according to a 3^2 experimental design. **Findings**: Although coagulant extracts'physical appearance was different, coagulant activity between the extractsshowed no statistically significant differences. A 30 $mg\ L^{-1}$ optimum dosein raw water allowed for the attaintment of turbidity removals greater than 95%, regardless of coagulant type. As a result, the greater the raw water turbidity, the greater efficiencies achieved with extracts of *Moringa oleifera* seeds. **Application**: Based on results obtained,it is possible to assertthat seeds stored in dry containers and at room temperature can be used as a coagulant in a time period less than or equal to 4.5 years.

Keywords: Coagulant Activity, *Moringa Oleifera*, Raw Water, Seed Storage Time

1. Introduction

At present, natural products are being widely researched due to their effectiveness and use advantages over synthetic products. Research with vegetable coagulants such as *Guazuma ulmifolia, Opuntia ficus, Manihot esculenta, Tamarindus indica, Pithecellobiumsaman,* and *Moringaoleifera* have reported turbidity removal percentages greater than 80%[1]. Fruit husk residues from thecoconut tree, used as a coagulant, can achieve high removals of Total Suspended Solids (up to 76.81 TSS% removal), Biochemical Oxygen Demand (up to 49.10 BOD% Removal) and Chemical Oxygen Demand (up to 59.38 COD % removal)[2]. *Moringa oleifera* seed extracts have antimicrobial effects on *Staphylococcus aureus, Vibrio cholerae, Escherichia coli* and *Salmonella entereti-dis*[3].Similarly, many plant extracts have fungicidal activity[4]. Agricultural waste can be used as an adsorbent material in heavy metals removal for being less expensive, readily available,requiring little processing, and having good adsorption capacity[5,6]. Heavy metals have a persistent nature which makes themsome of the main and most extensive pollutants groups in water[7]. Extracts of *Moringa oleifera* seed are some of the most efficient natural coagulants in the technical literature. They have achieved up to 99% coagulant activity in turbidity removal in raw water treatment from rivers[8,9]. Nonetheless, several researchers agree that coagulant activity efficiency depends onthe initial turbidity of water samples[8–11] and,the solution in which the coagulant is prepared. The use of saline solution in preparation of *Moringa oleifera* coagulantis

*Author for correspondence

advised due to its proven contribution to the coagulant is extract efficiency[10–12].

Advantages of using *Moringa oleifera* seed as a coagulant are mainly due to its high biodegradability, non-toxicity, and natural buffering capacity, thus, pH and alkalinity adjustments are not required during treatment; and because of low production of coagulation sludge compared to residual sludge produced by Aluminum Sulphate[13,14]. Overall, many natural products effectiveness could depend on storage conditions, extraction methods and preservation temperatures[15]. Researchers, such as[16] tested different storage conditions; temperature (open container at 28 °C and closed container at 3°C) and storage times of *Moringa oleifera* seeds (1, 3 and 5 months). They showed that coagulation effectiveness with *Moringa oleifera* is independent of storage temperature and container;still, it decreased as storage duration increased. On the other hand[17], agrees that coagulation effectiveness with *Moringa oleifera* is independent of storage conditions, but asserts that storage time of coagulant solution of *Moringa oleifera* saline extracts does not adversely affect removal efficiency of turbidity and color.This study aimed at verifying the storage effect of *Moringa oleifera* seed for long time periods on the efficiency of the coagulant effect in raw water samples of different turbidity.

2. Materials and Methods

2.1 Samples of Raw Water

Raw water samples were taken from the Sinú Riverpassing alongside the Mocari neighborhood in the Monteria municipality, department of Córdoba, Colombia, between February and July 2017. Turbidities were 105, 202 and 410 NTU of the three samples respectively.

2.2 Coagulant Extract Preparation

Two types of *Moringa oleifera* seed coagulants were prepared. Type a Coagulant, prepared from seeds with a 6 months storage time and, type Bcoagulant, prepared from seeds with a 4.5 years storage time. Seeds stored at room temperature (30°C) and in a dry container were ground in a Corona hand mill, obtaining a fine powder later sieved in a 0.6 mm mesh Grain Test (Number 30 according to Tyler ATSM series E-11/2004). Then, 10.0 grams of seeds type A and type B were taken and dissolved in two different containers with 1.0% saline solution (w/v) up to1 liter. Solutions were initially mixed for 1 hour with a magnetic stirrer Schott E and Q AMPC-1, then filtered using cellulose filter paper[8,9]. The filtrate was labeled as a coagulant salt extract (SCE 10,000 mg L^{-1}) and kept refrigerated at 4°C[18].

2.3 Jar Test

Moringa oleifera seed extract was applied as a coagulant in 15, 30 and 60 mg L^{-1} doses to each raw water sample. This procedure was carried out for both type A and type B coagulants. EyQ F6-300-T jar test equipment was used and set up with six rotating blades and the same number of beakers (1000 mL each). Rapid mixture rotational speed was 200 rpm per 1 minute (170 s^{-1} speed gradient), followed by a slow mixture of 40 rpm per 20 minutes (22 s^{-1} speed gradient) and a 30 minute sedimentation time[9,19]. A blank was used to verify the natural coagulants activity and the turbidity removal in all jar tests.This was calculated using the following equation[18,20,21].

$$\% \text{ Coagulant Activity} = \frac{ResidualTurbidity_{blank} - ResidualTurbidity_{sample}}{ResidualTurbidity_{blank}} * 100$$

Equation (1)

2.4 Experimental Design

A 3^2 factorial design was applied to the experimental design. Two factors were evaluated at three levels each, for a total of 18 tests (9eachfor both types of coagulants) plus 3 controls. The initial turbidity of raw water and applied doses of coagulant were thefactors analyzed based on *Moringa oleifera* seeds. This design was done to determine each factoreffect, i.e., change in response (in this case, the coagulant activity of *Moringa oleifera*), produced by a change in factor level. The Analysis of Variance (ANOVA) was the statistical tool implemented for data analysis, using R program and the Statgraphics Centurion XVI (Version 16.0.07). The statistical significance level was set up at $p<0.05$for all statistical analyzes[21].

3. Results and Discussion

Visual characteristics of the two types of coagulant, prepared with seed from the different storage time periods, are shown in Figure 1. The study showed that type B coagulant, i.e., prepared with seeds with a 4.5 years storage time, had a less turbid and less lumpy appearance than type A coagulant extract. That proves the maturity of the

seeds drying used for this extract. Nonetheless, coagulant type A has a fresh and more whitish appearance than type B coagulant. Table 1 presents the results of the experimental design according to the proposed methodology. Highest turbidity removal efficiencies, due to coagulating activity of *Moringa oleifera* seed extracts, were observed when initial turbidity of raw water samples was 202 NTU and 410 NTU. Nonetheless,the best dose or optimum dose was achieved at 30 mg L^{-1} for all raw water turbidities;with a coagulant activity higher than 95% in all tests, regardless of coagulant type used. These results are analogous to those reported by other authors, both for raw natural water[8-14,17,18,22] and wastewater[23]. The coagulant extract effectiveness of *Moringa oleifera* seeds in the water treatment of high turbidity was proven again. Although there are no appreciable differences in coagulant activity of extracted seeds of *Moringa oleifera* for the treatment of raw water samples,an analysis of variance was applied between the results found for both types of coagulants. The aim is to check if there are statistically significant differences between the use of coagulant type "A" and type "B"; to confirm if the seed storage time influences the efficiency of the coagulant. Once assumptions compliance of normality, variances homogeneity and independence of ANOVA residuals calculated for the coagulating activity was verified, the analysis of variance was subsequently verified[24]. Results are shown in Table 2. It was found that P-value of Table 2 is equal to 0.90, therefore greater than 0.05, indicating that there is no statistically significant difference between averages of the coagulant activity from type "A" and type "B" coagulants with a 95% confidencelevel[25].

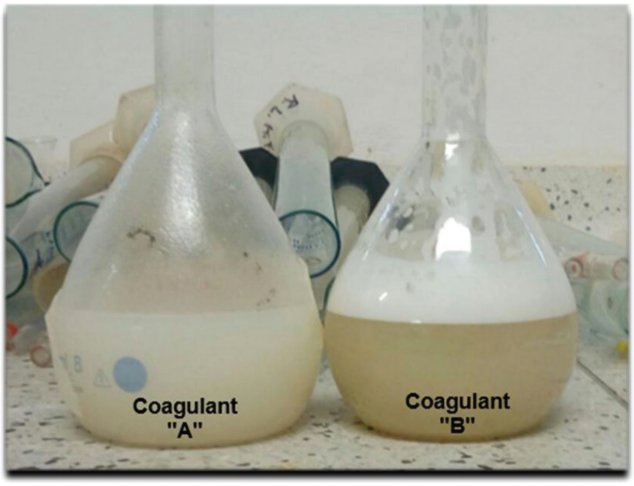

Figure 1. Visual characteristics of the two types of coagulant based on *Moringa oleifera* seeds.

Table 1. Experimental design results (Jar test)

Factors		Response: Coagulant Activity (%)	
Turbidity (NTU)	Dosage (mg/L)	Coagulant"A"	Coagulant"B"
105	15	80.87	78.38
	30	95.08	96.04
	60	93.28	94.75
202	15	82.51	78.30
	30	96.26	97.10
	60	94.88	95.48
410	15	88.83	93.41
	30	96.54	98.55
	60	98.74	99.12

Table 2. Results of ANOVA for coagulant activity of *Moringa oleifera*

Source	Sume of Squares	Degrees of Freedom	Average Squared	F-Ratio	P-Value
Between Groups	0.95	1.00	0.95	0.02	0.90
Inside the Groups	857.25	16.00	53.58		
Total	858.21	17.00			

4. Conclusion

Even though visual characteristics from the two coagulants are different, both extracts prepared with preserved seeds with different storage times showed no difference in the coagulating activity effectiveness; in a statistically significant way and with a 95% confidence level. Correspondingly, both coagulants are more efficient depending on initial raw water turbidity. The greater the turbidity, the greater the efficiency of coagulating extracts; regardless of time in which seed is stored, as long as the storage period is the same or less than 4.5 years and, the container is in dry environmental conditions.

5. Acknowledgements

The author J.J. Feria thanks,Lieth Johana Prasca Ramos and Jesus David Vergara Barreto, Civil Engineering students fromUniversity of Sucre for their valuable contribution providedon this project.

6. References

1. López S, Matías CA, Matías D, García IA. Vegetable coagulants as alternative for treatment of wastewater in Mexico. Journal of Negative and No Positive Results. 2017 Dec; 2(12);687–94.
2. Dange PS, Lad RK. Vascular bundle of wasted leaf stalk of coconut tree as a natural coagulant to treat sewage water. Indian Journal of Science and Technology. 2016 Nov; 9(44):1–6. Crossref.
3. Fernandez GH, Alves J, Angelo AM, Albuquerque R, Silva dos Fernandes RH. Antibacterial effect (in vitro) of Moringa oleifera and Annona muricata against Gram positive and Gram negative bacteria. Journal of the São Paulo Institute of Tropical Medicine. 2010 May-Jun; 52(3):129–32. Crossref.
4. Bobbarala V, Kumar P, Chandrasekhar K, Penumajji S. Antifungal activity of selected plant extracts against phytopathogenic fungi Aspergillus niger F2723. Indian journal of Science and Technology. 2009 Apr; 2(4):87–90.
5. Kaur A, Sharma S. Removal of heavy metals from waste wáter by using various adsorbents- A review. Indian Journal of Science and Technology. 2017 Sep; 10(34):1–14. Crossref.
6. Rungrodnimitchai S. Modification of rice straw for heavy metal ion adsorbents by microwave heating. Macromolecular Symposia. 2010 Sep; 295(1):100–6. Crossref.
7. Nasirian H, Nazmara S, Hossein A, Hosseini M, Shiri L, Vazirianzadeh B. Assessment of some heavy metals in the Shadegan and Hawr Al Hawizea wetland waters from Iran. Indian Journal of Science and Technology. 2015 Dec; 8(33):1–9. Crossref.
8. Rodi-o J, Feria JJ, Paternina R, Marrugo J. Sinú River raw water treatment by natural coagulants. Revista Facultad de Ingeniería Universidad de Antioquia. 2015 Jul-Sep; (76):90–8.
9. Feria JJ, Bermúdez S, Estrada AM. Eficiencia de la semilla Moringa oleífera como coagulante natural para la remoción de la turbidez del río Sinú. Producción + Limpia. 2014 Jan-Jun; 9(1):9–22.
10. Scaramal G, Guilherme I, Jurca V, De Abreu Alves B, Fagundes M, Bergamasco R. Evaluation of extracts of Moringa oleifera lam seeds obtained with NaCl and their effects on water treatment. Acta Scientiarum. Technology. 2012 Jul-Sep; 34(3):289–93.
11. Scaramal G, Bordini G, Marquetotti A, Nishi L, Cordeiro K, Bergamasco R. Study of the effect of saline solution on the extraction of the moringa oleifera seed's active component for water treatment. Water, Air, and Soil Pollution. 2010 Sep; 211(1-4):409–15. Crossref.
12. Okuda T, Baes AU, Nishijima W, Okada M. Isolation and characterization of coagulant extracted from Moringa oleifera seed by salt solution. Water Research. 2001 Feb; 35(2):405–10. Crossref.
13. Sulaiman M, Andrawus D, Mohammed K, Mohammed D, Aliyu B, Abd Manan F. Moringa oleifera seed as alternative natural coagulant for potential application in water treatment: A review. Journal of Advanced Review on Scientific Research. 2017 Jan; 30(1):1–11.
14. Sánchez J, Beltrán J, Peres JA. Improvement of the flocculation process in water treatment by using Moringa oleifera seeds extract. Brazilian Journal of Chemical Engineering. 2012 Jul-Sep; 29(3):495–502. Crossref.
15. Yogeswari M, Sham B, Ganesan P. Effect of room temperature storage on the physicochemical and antioxidant properties of oven dried young tamarind leaves (Tamarindus Indica) Chutney powder. Indian Journal of Science and Technology. 2016 Dec; 9(48):1–8. Crossref.
16. Katayon S, Noor MJ, Asma M, Ghani LA, Thamer AM, Azni I, Ahmad J, Khor BC, Suleyman AM. Effects of storage conditions of Moringa oleifera seeds on its performance in coagulation. Bioresource Technology. 2006 Sep; 97(13):1455–60. Crossref. PMid:16213137
17. Salazar LL, Luna M, Salazar R. Effect of storage and preparation methods of Moringa oleifera seeds during the coagulation process. Desalination and Water Treatment. 2016 Jul; 57(35):16376–83. Crossref.
18. Feria JJ, Rodi-o JP, Gutierrez GE. Behavior of turbidity, pH, alkalinity and color in Sinú river raw water treated by natural coagulants. Revista Facultad de Ingeniería Universidad de Antioquia. 2016; (78):119–28.
19. American Society for Testing and Materials International (ASTM). Standard Practice for Coagulation-Flocculation Jar Test of Water. Standard ASTM D2035-08; 2008. p. 1–4.
20. Antov MG, Sciban MB, Prodanovic JM. Evaluation of the efficiency of natural coagulant obtained by ultrafiltration of common bean seed extract in water turbidity removal. Ecological Engineering. 2012 Dec; 49:48–52. Crossref.
21. Feria JJ, Tavera MJ, Perna O. Extraction and efficiency of Chitosan from Shrimp Exoskeletons as coagulant for lentic water bodies. International Journal of Applied Engineering Research. 2018 Jan; 13(2):1060–7.
22. Baptista ATA, Silva MO, Guttierres R, Bergamasco R, Vieira MF, Vieira AMS. Protein fractionation of seeds of Moringa oleifera Lam and its application in superficial water treatment. Separation and Purification Technology. 2017 Jun; 180:114–24. Crossref.
23. De Paula HM, De Oliveira MS, Sarmento AP, Andrade LS. Dosage optimization of Moringa oleifera seed and traditional chemical coagulants solutions for concrete plant wastewater treatment. Journal of Cleaner Producction. 2018 Feb; 174:123–32. Crossref.
24. Herramientas estadísticas-comparación de más de dos muestras: ANOVA. Available from: http://web.cortland.edu/matresearch/ANOVA-I.pdf
25. Lomax R, Hans-Vaughn DL. An introduction to statistical concepts 3th ed. International Ststistical Review. 2012 Dec; 80(3):489–91.