Aplication of *Moringa oleifera* Seeds' Dust in the Treatment of Water Turbidity

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Abstract

The present study aimed to assess the best concentration of Moringa oleifera Lam. and the best sedimentation time in order to remove turbidity from water extracted from the Capibaribe River, in the city of Recife, Pernambuco, Brazil. The proposed treatments consisted of zero, 50, 100, 200, 250 and 300mg of moringa dust / 200mL of water, with a exposure/sedimentation time of zero, 1, 2, 4 and 6 hours, adjusted by a CCD experimental plan. Before and after the application of each treatment, turbidity, pH and electric conductivity were measured. The obtained results were analyzed through an ANOVA table and a Pearson graphic with a significance level of 5% and correlation between variables. The essay results have shown a reduction of up to 100% of turbidity, at a 200mg concentration of moringa dust with the sedimentation time of 2 hours as well as a reduction of the other physicochemical parameters measured.

Keywords: Moringa seed, Biological Coagulant, Water clearing.

1. Introduction

Throughout human history the major health problems faced had a close relationship with the life in community, for example, the control of infectious diseases, the administration and improvement of the physical space (sanitation), the availability of fresh water and food of good quality in adequate amounts, the provision of health care and the aid to the handicapped and dispossessed. The effort put into each of those problems has oscillated from time to time, albeit their close and intricate relationship with one another (Ribeiro, 2004). In the past decades, the declining of the quantity and quality of water has called the attention of both the population and authorities. Several water systems are routinely contaminated by effluents containing high amounts of substances that lead to changes in water color and turbidity, in turn affecting the photosynthesis process in the water course by increasing the light reflection in the surface (Vaz, 2007). The turbidity, according to Cordeiro (2008), is evidenced by the presence of particles in suspension in colloidal state, which has a strong correlation with biological contamination.

In the majority of developing countries, the water employed in human consumption and domestic usages is collected from the rivers, commonly with elevated turbidity, owing to the presence of high amounts of solids in suspension, mostly during rainfall season, as well as bacteria and other microorganisms. Therefore, optimal removal of such materials is necessary in order to allow consumption of this water safely.

The process of removal is made through adding chemical coagulants in a controlled treatment sequence (Paterniani, 2009). The application of coagulants is considered an important step in water treatment for it is responsible for the removal of the turbid aspect of water as well as the improvement of basic physicochemical parameters: turbidity, pH and alkalinity of crude water (Franco, 2009).

The Water Treatment Stations (ETA's) employ aluminum salts and trivalent iron as chemical coagulants. Aluminum presents a risk to public health, for its presence in water directed to human consumption can cause Alzheimer Dementia as well environmental problems due to the formation of sludge in the process of sedimentation of the flocculated particles. The scientific community has raised a concern, over the past decades, with the presence of residual aluminum, present at the ETAs and its connection with the formation of turbidity at the end of the treatment, impairing the disinfection step and causing increased incidence of neurological conditions such as neurodegeneration, encephalopathy, dialytic dementia and neurobehavioral alterations (Rosalino, 2011; Bezerra, 2004). The employment of biopolymers of *Moringa oleifera* seed, in the process of water treatment, promotes the coagulation of the organic matter with a smaller fraction than that of the chemical coagulants, reduces the formation of sludge, doesn't alter water pH, reduces turbidity and color also contributing to the removal of up to 90% of the bacteria, for the most part of them are aggregated to the particles disseminated in water; and doing so it reduces the amount of chloride in the processes of disinfection, turning the process biodegradable (Santos, 2013; Arantes *et al*., 2012).

The cultivation of moringa is becoming widespread in all the Brazilian northeastern semi-arid, due to its employment in water treatment for domestic use; however, the employment of natural coagulants to clear water is not a new idea, because Ndabigengesere and Narasiah (1996) indicated that *Moringa oleifera* seeds were a viable alternative as a coagulant agent replacing aluminum salts, which were used in water treatment at all Water Treatment Stations – ETA (Santana, 2010). The *Moringa oleifera* is a tree of Indian origin which has become pantropical, meaning it inhabits any regions of the tropics and subtropics. The spreading of this species can be performed through seeds, seedlings or pods, without specific demands for the type of soil in which it is going to be cultivated except for the inability to develop in waterlogged soils (Gallão, 2006). The seeds of *Moringa oleifera* contain low molecular weight proteins and when its dust is dissolved in water they acquire positive charges which attract negatively charged particles such as clays and silts, turning into dense flocks which then deposit, according to Paterninani (2009).

The dried leaves of moringa were found, through different studies, to have 30,3% of crude protein levels and 19 of amino acids, the following contents of minerals: calcium (3,65%), phosphorus (0,3%), magnesium (0,5%), potassium (1,5%), sodium (0,164%), sulfur (0,63%), zinc (13,03 mg/kg), copper (8,25%), manganese (86,8 mg/kg), iron (490 mg/kg) and selenium (363 mg/kg). 17 fat acids were observed being linolenic (44,57%) the highest proportion found followed by heneicosanoic acid (14,41%), g-linolenic (0,20%), palmitic (0,17%) and capric acid (0,07%). Vitamin E had the highest concentration, of 77 mg/100 g of dry leafs, and the concentration of beta-carotene was 18,5 mg/100 g of dry leafs. The content in fiber in neutral detergent (FND) (11,4%), in acid detergent (FAD) (8,49%), lignin in acid detergent (LAD) (1,8%) and cellulose in acid detergent (CAD) (4,01%). The condensed tannins were found at a value of 3,2% while the total polyphenols were of 2,02% not presenting toxic symptoms during several usages (Moyo *et al.*, 2013; Valverde *et al*., 2013). This work aimed to assess the efficacy of the *Moringa oleifera* seeds in clearing water collected from the Capibaribe river in the city of Recife, Pernambuco, Brasil, for presenting noticeable turbidity.

1. *Methodology*

2.1 Samples

The crude water employed in the experiment was collected from the Capibaribe River, with its collection point designed as point 4, which is located in the bridge Professor Lima de Castilho on the Abdias de Carvalho Avenue, close to the Chico Science tunnel, in the city of Recife, Pernambuco, Brazil. The pH, electric conductivity and turbidity of the water were measured and resulted in the following values: pH = 8,11; Electric Conductivity = 8,35 mS/cm; Turbidity = 16,62 NTU.

2.2 Preparation of de Seed's dust

Following Ramos (2005) recommendation, the moringa seeds were collected, peeled and dried in an oven at 70ºC for 30 minutes. After the completion of the previous steps, they were grinded until turned into dust and sieved at

14 meshes (modified from RAMOS, 2005). The dust was stored in a plastic recipient with a cover to avoid exposure to humidity.

2.3 Calculation of the Concentration of the Seed's Dust and Sedimentation Time

Following Ramos (2005) suggestions further, the treatments were performed with five repetitions in doses equal to zero, 50, 100, 200, 250 and 300 mg of *Moringa oleifera* seed dust to 200mL of Capibaribe River water, with a exposure/sedimentation time of 1, 2 ,4 and 6 hours. The relationship between moringa dust (mg/L) and sedimentation time (h) was adjusted (Table 1) through a central composite design (CCD) and had its values combined in an experimental matrix (Table 2), generation twelve essays.

2.4 Application of the *Moringa oleifera* seed dust

After the calculation, the seed's dust was weighted in an analytical balance and in sequence applied to 200mL of water from the Capibaribe River according to the preset combination between the sedimentation time and concentration as shown in Table 2.

2.5 Chemical determination of the clarified water

After the sedimentation time set for each sample, the supernatant was filtered and the pH, turbidity (NTU) and electric conductivity were assessed, using the ASTM D1293 - 12, ASTM D6698 - 14 and ASTM D1125 - 14 methods respectively (Table 3)

2.6 Statistical analysis

The data obtained from the treatments was submitted to statistical analysis through an analysis of variance (ANOVA) method, using the F test, with a confidence interval of 95%, building a Pearson graphic, which indicates the influence of the variables over the desired answers, that is, how the concentration of the seeds dust (coagulant agent) and the sedimentation time interacted statistically with the measured parameters (turbidity, electric conductivity and pH).

2.7 Morphologic characterization of the *Moringa oleifera seed*

The morphological characteristics of the *Moringa oleifera* seed were obtained through an Scanning Electron Microscope JEOL JMT-300. The sample was covered with a thin layer of gold and a voltage of 20 kV was applied.

2. *Results and discussion*

Table 1 presents the values suggested by Ramos (2005) to treatments equal to zero, 50, 100, 200, 250 and 300 mg/200mL, with a sedimentation time of zero, 1, 2, 4 and 6 hours, codified and adjusted to the experimental design.

Table 1: Variables employed in the experiment

Codified value	-1.41	-1	0	+1	+1.41
Seed dust concentration	129.5	150	200	250	270.5
Sedimentation time	0.54	1	2	3	3.41

Table 2 presents the 12 combinations between the moringa seeds dust and the exposure time used in the experiment.

Table 2: Experimental matrix

Codified Value-Concentration of the seeds' dust (mg)	Codified Value-Sedimentation time (h)
0 – 200	0 – 2h
0 – 200	0 – 2h
0 – 200	0 – 2h
0 – 200	0 – 2h
(-1) – 150	(-1) - 1h
(-1) – 150	(+1) - 3h
(+1) – 250	(-1) - 1h
(+1) – 250	(+1) - 3h
0 – 200	(-1.41) – 0.59 min
(+1,41) – 270,5	0 – 2h
0 – 200	(+1.41) – 3h41min

Table 3 presents the obtained results, demonstrating the best possible combinations between the concentration of *Moringa oleifera* seeds' dust and the sedimentation time to reduce turbidity, being the treatments 4, 5, 6, 7, 8 and 9 which presented 100% reduction of Capibaribe River water turbidity reduction, in concurrence with the results found by Gallão (2006) and Esnarriaga (2010).

Table 3: Results found to the variables employed in the experiment

	Independent variables		Dependent Variables		
Treatment	**Moringa dust (mg)**	**Exposure time(h)**	**pH**	**EC**	**Turbidity**
1	200	0.54	7.30	7.09	2.04
2	250	1	7.11	7.20	3.29
3	150	1	7.27	6.54	1.72
4	200.1	2	6.79	7.08	0.00
5	200.2	2	6.90	7.12	0.00
6	200.3	2	7.03	7.20	0.00
7	200.4	2	6.99	7.18	0.00
8	270.5	2	7.02	7.00	0.00
9	129.5	2	7.22	7.05	0.00
10	150	3	7.04	6.95	1.57
11	250	3	7.03	7.06	1.72
12	200	3.41	7.11	6.93	0.78

In all treatments employed a reduction of electric conductivity was found which confirms the coagulant ability of *Moringa oleifera* in removing ions in water effluents which was already demonstrated in Coelho (2010). No significant change was found regarding pH, and such fact is explained by a trace singular to coagulants of not changing the water fluid pH, leaving it in a neutral band. Such finding stands as an advantage in comparison to chemical coagulants, such as aluminum sulfate, which in their usage process demand pH corrections, according to Lo Monaco *et al.* (2010).

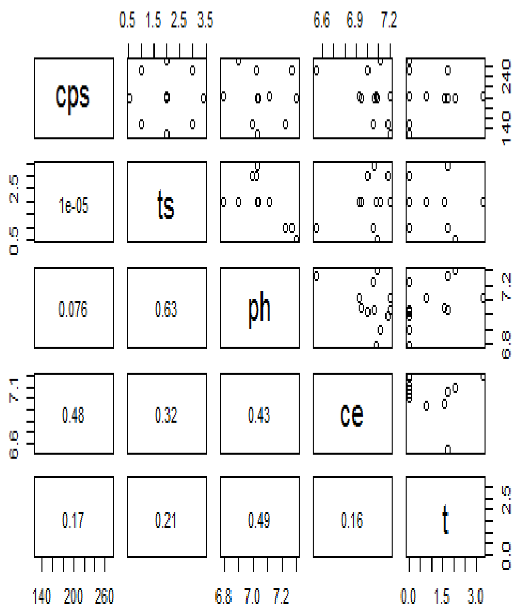
Assuming 5% as a significance level, it has been observed that in both Tables 4 and 5 the hypothesis of significant difference is not rejected, meaning that there are significant differences between the mean values of the variables. It has been concluded that turbidity does present distinct behaviors when it comes to sedimentation time and seeds' dust concentration.

Table 4: Variance Analysis between moringa seeds dust concentration (Cps)

Cps	Sum of squares	Degrees of freedom	Mean square	F	p-value
Between Groups	13891,750	02	6945,875	10,334	0,005
Within Groups	6048,967	09	672,107		
Total	19940,717	11			

Table 5: Variance analysis of exposure/sedimentation time (ST)

Ts	Sum of squares	Degrees of freedom	Mean square	F	p-value
Between Groups	7,866	02	3,933	139,842	0,000
Within Groups	0,253	09	0,028		
Total	8,119	11			



Graphic 1: Pearson correlation between the variables

Where:
cps – Moringa seed dust concentration;
ts – Sedimentation Time;
ph – pH;
ce – Electric Conductivity;
t – Turbidity.

Graphic 1 shows the Pearson correlation between the variables. It is observed that the variable Sedimentation Time is only moderately correlated with pH, with a zero, 63 coefficients. The remaining variables show low correlation being zero, 49 the highest value among them corresponding to Turbidity and pH. It can also be perceived that the dependent variables are not correlated to one another for their correlation coefficient is very close to zero.

Figure 1 represents the electron scanning micrographics of moringa's pulp *in natura* (left) and treated (right). It can be perceived that the biosorbent material presents a complex matrix with a somewhat porous heterogeneous distribution. Regarding the electron scanning micrograph it has been perceived that the treatment of moringa seed increases the porosity of the material, making moringa's pulp more exposed to adsorption. The morphologic change of the treated moringa surface is also a result of the superficial removal of some structural components such as carbohydrates, proteins, and lignin and in smaller proportion, fatty acids. These observations corroborate the hypothesis the treatment can improve de adsorption traits of the moringa (Anwar & Rashid, 2007) associated with the adsorptive characteristic of this biomaterial.

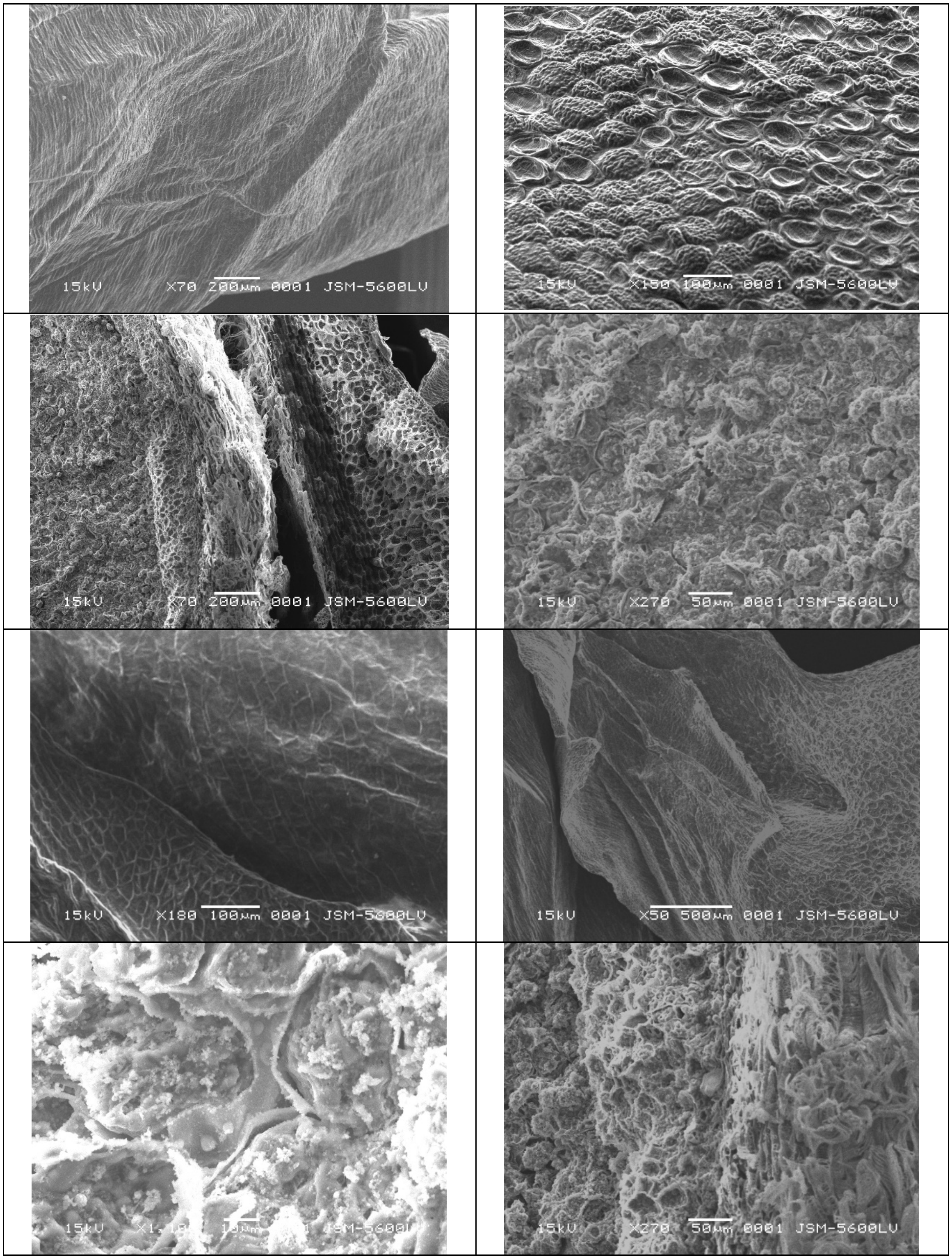


Figure 1: Electron scanning photomicrographs of *Moringa oleifera Lam. "in natura"* (left) and treated (right)

3. Conclusions

The experiment with *Moringa oleifera* seeds presented good results, demonstrating its has high efficacy in the process of turbidity removal from water, as high as the chemical coagulants Such alternative presents as a viable one to be employed in water treatment, due to the results obtained being in conformity to the Decree n. 2914/11of the Brazilian Health Ministry.

It has also been noticed in the experiment that the employment of moringa positively influences other physicochemical parameters such as pH by not significantly altering its value. Therefore, chemical substances would not be needed to its correction towards a neutral band which lowers the treatment cost. The electric conductivity happens due to ions dissolved in the water. This, most often, is represented by ions which are harmful to human health. The experiment has shown that the ability of the coagulant agent present in *Moringa oleifera* seeds in reducing the presence of such ions, demonstrated by the reduction of the electric conductivity

In the electric scanning micrographs of moringa's pulp, both treated and *in natura*, porosities were found in its structure which indicates that it is a material that promotes adsorption, characterizing a coagulant agent. The *Moringa oleifera* employment appears promising, for presenting a number of positive factors such as an economic viable alternative, with comprehensive employment, which turns it into a sustainable alternative that does not offer risk to the humans and the environment.

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