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Application of Moringa in the Removal of Salts from the Desalinator Reject

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Authors' contributions

This work was carried out in collaboration among all authors. Author AJGF performed the experiment as a master's thesis, performed the statistical analysis and wrote the first draft of the manuscript. Authors SCDP and GMCT managed the analysis of the study. Author ASM designed the study and wrote the protocol. All authors read and approved the final manuscript.

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ABSTRACT

This study aims to analyze the reject produced by the desalinators implanted in the semi-arid Pernambuco in contact with the seeds of *Moringa oleifera* Lam. For this, *Moringa* seeds were collected and prepared with the following treatments: reject (control), reject with whole seed with and without husks, reject with crushed seed with and without husks, seed residue with and without husks, in five replicas. Each replica was constituted with doses equivalent to 2.0 g of *Moringa* seeds for 200 mL of reject, with contact time corresponding to 30, 60, 120 and 180 minutes, in a completely randomized design, under laboratory conditions, total of 140 experimental units. The physical-chemical and statistical analyses were performed through analysis of variance (ANOVA), and the F test, at confidence interval of 95%. It has been found through laboratory tests that seeds with crushed or ground Moringa husks are equally effective at adsorbing sodium from 1,868,0 mg/L to 24,6 mg/L (98,7 %), calcium from 1,005.0 mg/L to 894.6 mg/L (11%), magnesium from

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741.0 mg/L to 728.3 mg/L (1.7%) and chloride from 6,997.5 mg/L to 6,782.4 mg/L (1.8%). Therefore, Moringa seed can be considered promising in the adsorption of chemical elements of saline water desalinizers.

Keywords: Moringa; desalinators; saline water; Pernambuco semi-arid.

1. INTRODUCTION

One of the major problems in the semi-arid Northeastern region is drought, a recurrent theme with no apparent solution. The surface waters that form the main sources of drinking water on Earth are scarce, especially in the semi-arid region, causing water shortages in rural communities. Therefore, groundwater appears as a viable alternative to ensure that these communities have access to water. However, these water sources, in most cases, present restrictions of use for human, animal and agricultural consumption due to their high concentrations of mineral salts [1]. The treatment widely used to reduce the concentration of salts of these waters has been the desalination, by the process of reverse or contrary osmosis. However, it is necessary to consider the environmental risks inherent in this technique, because in the desalination process, besides drinking water, the wastewater (reject) is produced highly saline and with a high risk of environmental contamination. This reject has not received any treatment and thus is released into the soil, providing a high accumulation of salts in its superficial layers, which will give rise to serious environmental problems in the short and medium term for the populations that are favored by this technology [2].

Therefore, the need to use the ecologically correct and economically feasible way of the reject is imperative, since water flows and soil are almost always the main environments for their disposal. Salinity reduces the soil's water potential due to its specific toxic effects and correlated to this is the gradual loss of fertility and also the problems of soil permeability [3,4].

The use of *Moringa oleifera* as a natural coagulant, due to its effectiveness in the adsorption of salts, is one of the sustainable alternatives that have been used in the northeastern region, especially in the semiarid region, where water scarcity represents the greatest difficulty for the population. The treatment with the crushed seed of this plant can be used *in situ*, and at low cost and without the use of electric energy [5].

Thus, several researches have proved that these seeds are biocoagulants, that is, they produce improvement in the physical-chemical properties of brackish or contaminated water, through the mechanism of adsorption and neutralization [6].

Therefore, the objective of this work was to evaluate the *Moringa oleifera* Lam. as adsorbent for the removal of salts present in the reject from desalinators from the semi-arid Pernambuco.

2. MATERIALS AND METHODS

The seeds of *Moringa oleifera* were collected and dried in an oven at 45ºC for 24 hours, up to constant weight. After temperature stabilization, they were prepared according to the following treatments: whole seeds with and without husks.

Then one part of the seeds was crushed, and the other part was ground and both passed into a 14 mesh sieve (4.76 mm), thus: whole seeds with husks (CCI), crushed seeds with husks (CCT) and ground seeds with husks (CCM); whole seeds without husks (SCI), crushed seeds without husks (SCT) and ground seeds without husks (SCM).

Subsequently, 200.0 mL of the desalinator's reject and 2.0 grams of freshly prepared seeds (treatments) were added to plastic containers with five replicas of each treatment. The tests had a duration of 30, 60, 120 and 180 minutes of contact between the reject and the seeds of *Moringa.* The physicochemical analysis of the desalinator's reject was performed at the IPA Plant, Ration and Water Analysis Laboratory - LAPRA with the following characteristics: electrical conductivity = 11.541 dS/cm at 25ºC, Ca^{+2} = 403 mg/L, Mg^{+2} = 393.09 mg/L, Na^{+} = 200 mg/L and K^{+} = 40 mg/L, RAS = 23.67, pH = 7.9, classification for irrigation = C4S4 (very high salinity water and high sodium concentration).

After the contact times, the resulting extracts were submitted to physical-chemical analysis, determining pH, electrical conductivity (EC), sodium, potassium, calcium, magnesium and chloride. pH was determined by pHmetry, electrical conductivity by conductometry, sodium

(Na) and potassium (K) by flame emission spectrophotometry, chloride (Cl) by precipitation titrimetry and calcium (Ca) and magnesium (Mg) by complexation titrimetry.

For the statistical analysis of the data, Sigma Plot 11.0 software (Systat Software, 2008, USA) was used, with a significance level of 5% for all determinations. Before the ANOVA was performed, the normality of the data was tested through the Kolmogorov-Smirnov test and the homogeneity of variances by the Barlett test. ANOVA one way (ANOVA unifatorial) was used for data that presented a normal distribution or homogeneity of variance. When the tests showed significant differences ($p < 0.05$), the means of the treatments were compared and, in relation to the control, by the Dunnett test. The Kruskal-Wallis test was used when the requirements for ANOVA were not achieved.

3. RESULTS AND DISCUSSION

In the experiment it was possible to verify that the seeds of *Moringa oleifera* did not significantly alter the pH and alkalinity. It was observed that the contact time did not significantly modify the pH in the samples tested, but, specifically in the treatments with crushed or ground seeds, the pH reduction was verified, according to Fig. 1. Knowing that the zero load point (PCZ) of Moringa oleifera is between 7 and 8 and the pH of the experiment ranged from 5.1 to 7.6, a percentage variation was observed in the removal of the determined elements: cation adsorption favored at pH above the PCZ as adsorption of anions favored at pH below the PCZ.

Statistical analysis of pH was performed among all treatments of Moringa with and without husks (whole, crushed and ground), according to Table 1. In the variance between the groups and the residual (Table 2), the P-value was less than 5% and revealed that the difference between the groups (treatments) was significant. The Fisher Coefficient (F = 518.093) also showed that there is a significant difference between the groups (Table 2). In the comparison between the factors (Dunnett test) it was verified that the difference between the test and the crushed Moringa with husks (CCT) sample is relevant, the P-value is less than 5% (Table 3), because crushed or ground seeds more easily release the cationic protein from Moringa, enabling the coagulation process.

In relation to the electrical conductivity (Fig. 2), it was observed that all treatments reduced their values, but there were some oscillations, when the seeds were treated with and without peels, during the time of exposure.

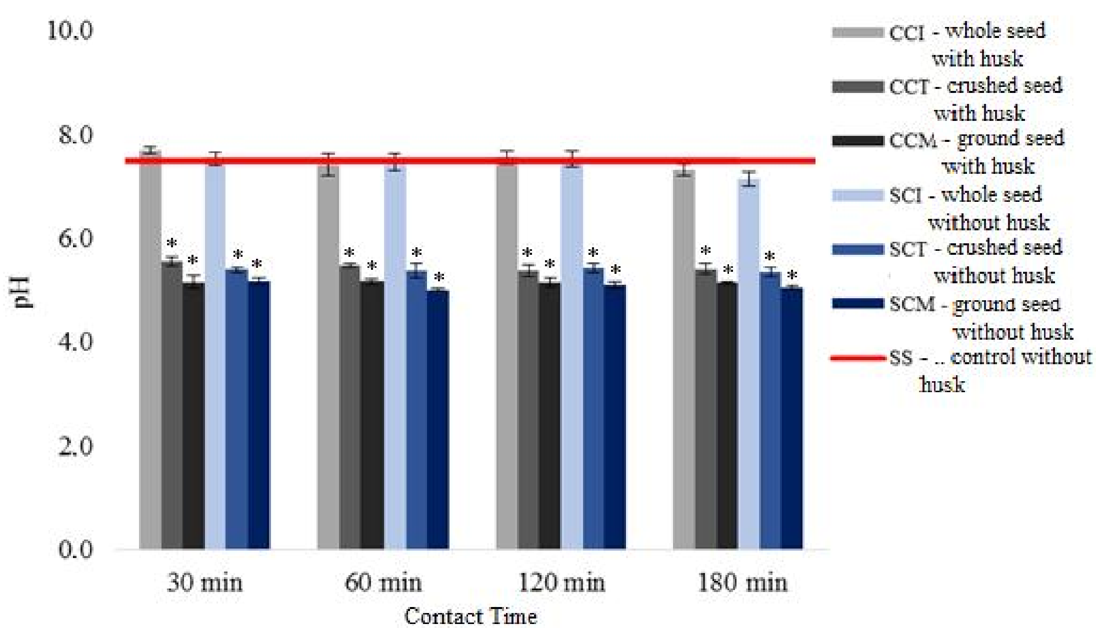

Fig. 1. pH of the extracts obtained with the reject in contact with the seeds of *Moringa oleifera*
(= significant difference)*

Table 1. pH of the extracts obtained with the reject in contact with the seeds of *Moringa oleifera (Moringa* with and without husk)*

Group Name	N	Absence	Mean	Standard Deviation	SEM
TEST	5	0	7.488	0.219	0.0981
CCI	5	0	7.688	0.0653	0.0292
CCT	5	0	5.554	0.0953	0.0426
CCM	5	0	5.156	0.132	0.0591
SCI	5	0	7.532	0.119	0.0531
SCT	5	0	5.388	0.0563	0.0252
SCM	5	0	5.17	0.0561	0.0251

**Whole with husk (CCI) / crushed with husk (CCT) / ground with husk (CCM) / crushed without husk (SCT) / ground without husk (SCM) / whole witout husk (SCI). TEST = Witness*

Table 2. Analysis of pH variance (groups vs. residual)

Source of Variation	DF	SS	MS	F	P
Between groups	6	44.137	7.356	518.093	<0.001
Residual	28	0.398	0.0142		
Total	34	44.535			

Table 3. pH – Comparison control vs. samples (*Moringa* with and without husk)*

Comparison	Difference of means	q'	P	P<0.050
TEST vs. CCM	2.332	30.944	--	Yes
TEST vs. SCM	2.318	30.758	--	Yes
TEST vs. SCT	2.1	27.866	--	Yes
TEST vs. CCT	1.934	25.663	--	Yes
TEST vs. CCI	0.2	2.654	--	No
TEST vs. SCI	0.044	0.584	--	No

**Whole with husk (CCI) / crushed with husk (CCT) / ground with husk (CCM) / crushed without husk (SCT) / ground without husk (SCM) / whole witout husk (SCI). TEST = Witness*

Research carried out by [7] showed that the seeds of *Moringa oleifera* contain proteins with low molecular weight and that, when crushed, its powder dissolved in water acquires positive loads (mainly for elements N, Ca and K) that attract negatively charged particles, which corroborates with the results found in the present study with both crushed and ground Moringa seeds (Fig. 2). Also, there is a protein of the seeds of Moringa that was compared, by the Gassenschmidt team, to a cationic synthetic polymer, being characterized as a cationic molecule, isoelectric point in pH10, with flocculant activity similar to that of the polymer cationic.

According to [8], in a comparison of ground seeds of loofah, pumpkin, almond, *moringa*, Algaroba, Umbu, Umburana and Mulungu, it was seen that *Moringa* seeds increase the percentage of adsorption from 60 minutes contact with saline water.

The results obtained in this work were compared with the analyses performed by [9], which used some parameters, which served as reference for this study, such as pH, electrical conductivity, calcium and magnesium. As verified in this analysis, calcium adsorption (11.0%) and magnesium (1.7%) demonstrated the efficiency of Moringa seed in the removal/reduction of these elements. The statistical analysis of the electrical conductivity was also performed (Table 4), where, in the variance between the groups and the residual (Table 5), the P-value was less than 5% and revealed that the difference between the groups (treatments) was significant. The Fisher Coefficient (F = 26.889) showed that there is a significant difference between the groups (Table 5). In the comparison between the factors (by the Dunnett test), the difference between the test and the crushed moringa with husks (CCT) sample is relevant, the P-value is lower than 5% (Table 6).

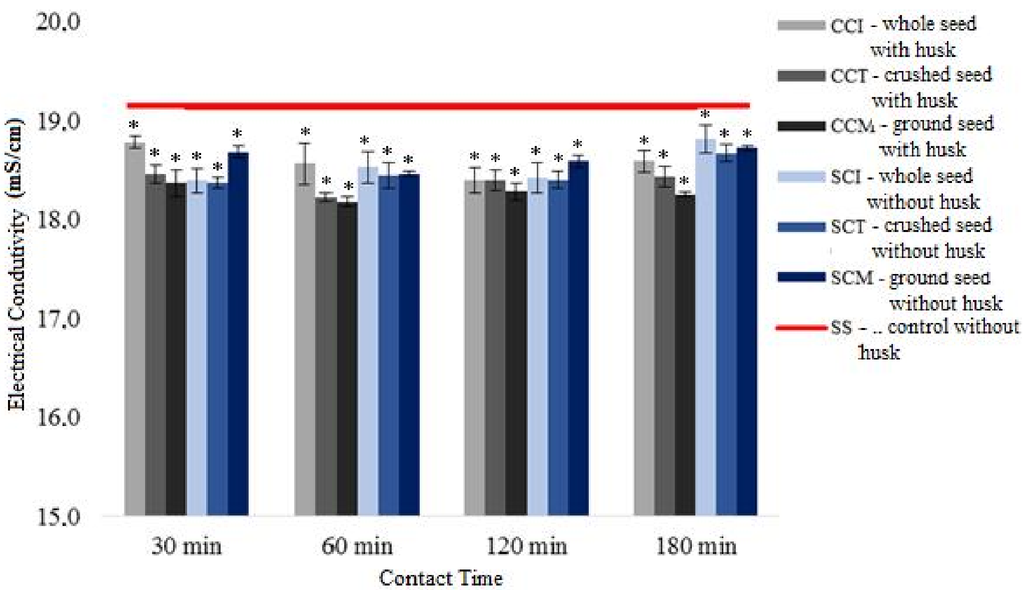

Fig. 2. Electrical Conductivity (E.C.) of the extracts obtained with the reject in contact with the seeds of *Moringa oleifera*

(= significant difference)*

Table 4. Electrical Conductivity (E.C.) of the extracts in contact with the seeds of *Moringa oleifera (Moringa* with and without husk)*

Group Name	N	Absence	Mean	Standard Deviation	SEM
TEST	5	0	19.132	0.0589	0.0263
CCI	5	0	18.784	0.0773	0.0346
CCT	5	0	18.458	0.139	0.062
CCM	5	0	18.37	0.156	0.0699
SCI	5	0	18.394	0.162	0.0723
SCT	5	0	18.37	0.149	0.0667
SCM	5	0	18.686	0.0733	0.0328

**Whole with husk (CCI) / crushed with husk (CCT) / ground with husk (CCM) / crushed without husk (SCT) / ground without husk (SCM) / whole witout husk (SCI). TEST = Witness*

Table 5. Analysis of the variance of E.C. (groups vs. residual)

Source of Variation	DF	SS	MS	F	P
Between groups	6	2.463	0.411	26.889	<0.001
Residual	28	0.428	0.0153		
Total	34	2.891			

Table 6. Electrical Conductivity (E.C.) - Comparison control vs. samples (*Moringa* with and without husk)*

Comparison	Difference of means	q'	P	P<0.050
TEST vs. CCM	0.762	9.75	--	Yes
TEST vs. SCT	0.762	9.75	--	Yes
TEST vs. SCI	0.738	9.443	--	Yes
TEST vs. CCT	0.674	8.624	--	Yes
TEST vs. SCM	0.446	5.707	--	Yes
TEST vs. CCI	0.348	4.453	--	Yes

**Whole with husk (CCI) / crushed with husk (CCT) / ground with husk (CCM) / crushed without husk (SCT) / ground without husk (SCM) / whole witout husk (SCI). TEST = Witness*

In the present study it was observed that 30 minutes contact of the reject with the crushed or ground seeds of moringa with husks was sufficient to reduce the concentration of sodium in the collected extract. It should be noted that this effective reduction of sodium (Na) occurred in all treatments that used seeds with husks during the periods of exposure, unlike the treatments with seeds without husks, as shown in Fig. 3. This sodium behavior can be attributed to the available Exchange sites present in the Moringa bark for the adsorption occurrence.

In relation to the sodium present in the reject, the adsorption of the ground seed of *M. oleifera* caused a significant reduction in the concentration of this element in the whole process when compared to the control (Fig. 3). This fact was also proven by [8], who researched ten different types of biological materials, among them the *M. oleifera* seed and observed the existence of proteins that act as natural organic polymers that, in contact with the brackish water, increase the sodium adsorption, mainly in 60 minutes of contact.

In relation to potassium, it was verified that in all the treatments, when compared with the control (only reject), there was no effectiveness of the moringa adsorption, as shown in Fig. 4.

In relation to potassium (K), there was no reduction in its content in the reject, but an increase in its concentration. It can be verified that all the treatments presented values above the control (Fig. 4). Therefore, it is concluded that the *M. oleifera* seed was unable to adsorb this chemical in the 180-minute period, corroborating the results obtained by [10], who also did not find evidence of potassium's harmful effect to the coagulation provided by the Moringa seed extract. The strength with which a cation is retained depends on its properties such as valence and size, as well as the concentration of the same in solution, what happens in this experiment, where the amount of sodium is higher than that of potassium.

Regarding calcium, it was observed that the time had a positive influence on its adsorption. In the case of the contact of the reject with the whole Moringa seed with husk (CCI) there was greater adsorption within 60 minutes of contact. However, whole without husk (SCI), the highest adsorption occurred with 120 minutes of contact, as shown in Fig. 5.

In the case of Calcium and Magnesium, the experiments carried out showed that there was a reduction in their contents when confronted with the control (Figs. 4 and 5). These results confirm the study by [11], which proved that the Moringa seeds interact with the organic material of the water, destroying the colloidal stability and facilitating its removal by sedimentation, as well as reducing the water hardness. Moringa powder in contact with well water reduced the hardness in 24 h.

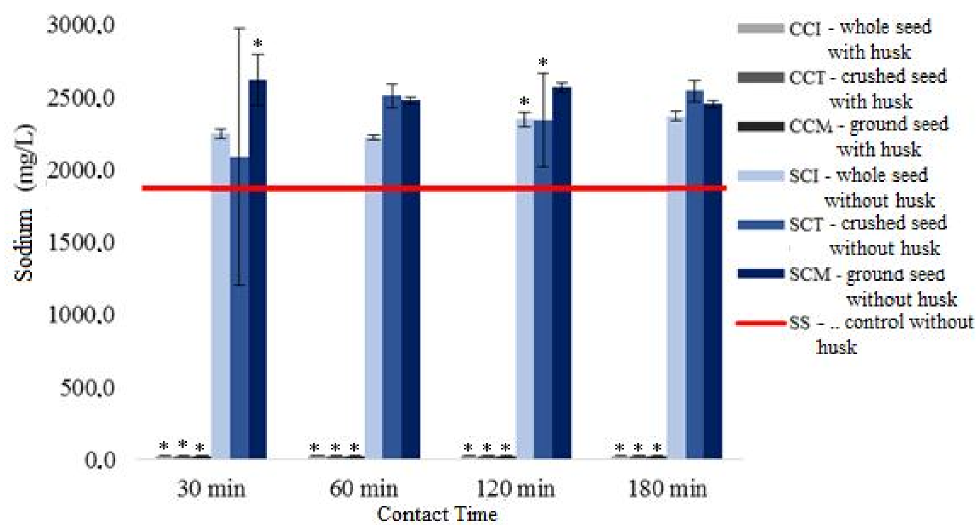

Fig. 3. Sodium (Na) of the extracts obtained with the reject in contact with the seeds of *Moringa oleifera*
(= significant difference)*

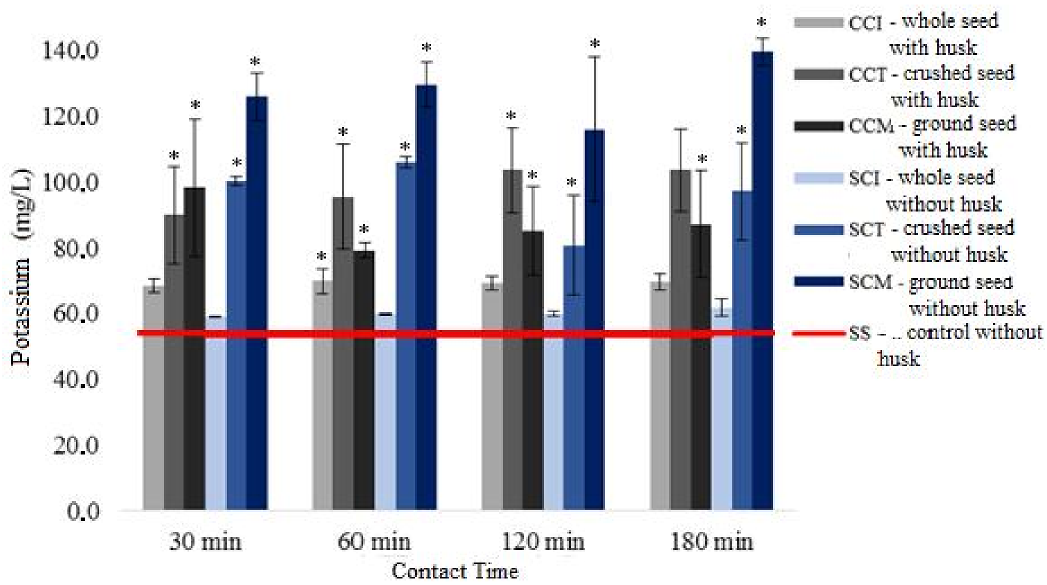

Fig. 4. Potassium (K) of the extracts obtained with the reject in contact with the seeds of *Moringa oleifera*

(= significant difference)*

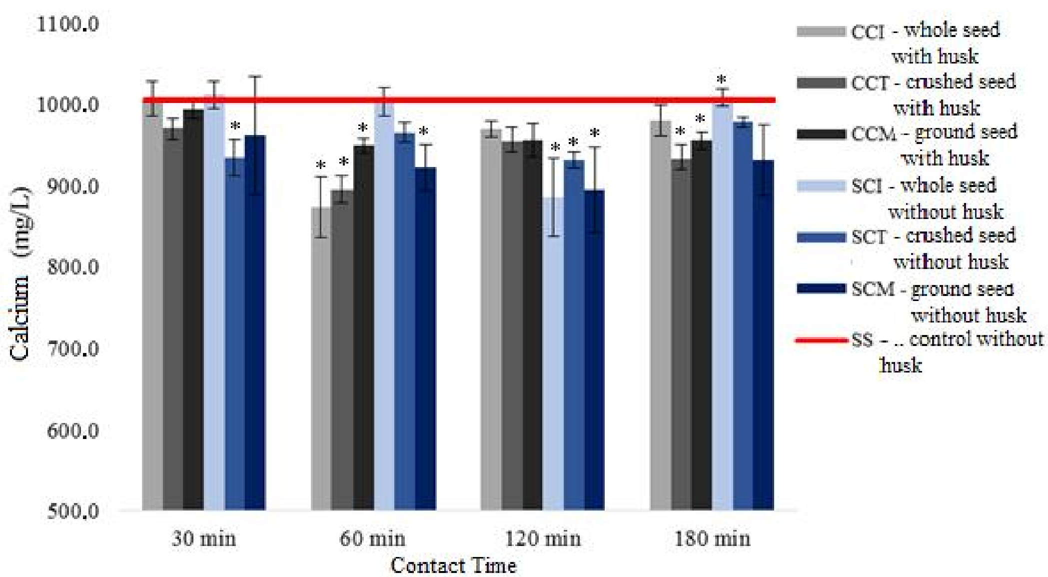

Fig. 5. Calcium (Ca) of the extracts obtained with the residue in contact with the seeds of *Moringa oleifera*

(= significant difference)*

Furthermore, it was observed that the time determined a significant adsorption of magnesium in the crushed seeds with husks and the whole ones without husks with 30 minutes of contact, as well as in the whole seeds with husks with 120 minutes of contact, in relation to the control, as shown in Fig. 6.

The results obtained in this experiment between the *M. oleifera* seed and the chloride ion (Cl) reveal the reduction in the concentration of this element in the reject, when compared to the control (Fig. 6). This same phenomenon was observed in a survey carried out by [12] with open water wells in Kolhapur (India), which showed the reduction of chloride ions from 12 to 5 mg/L for water in contact with the Moringa seed . This occurred due to the chemical attraction of the cationic substance present in the seed with anionic ions of the chlorides present in the water.

Concerning the adsorption of chloride, it was verified that the ground or crushed seeds altered the level of adsorption, in relation to the time of exposure. The highest adsorption occurred in the treatment of the crushed seed without husk in 60 minutes of contact, shown in Fig. 7. A possible explanation for this fact is that the adsorption process of the chloride ion obeys the kinetic law of 2[a] order, spontaneous and exothermic, favoring the physical adsorption and signaling interferences of dissolved organic material or other types of interferents, subject to further research.

Statistical analysis was also carried out regarding the salts present in the reject in contact with the Moringa. In general, it was observed that there is significant difference between the groups, in the same way as in the Fisher's Coefficient (Tables 7 to 20).

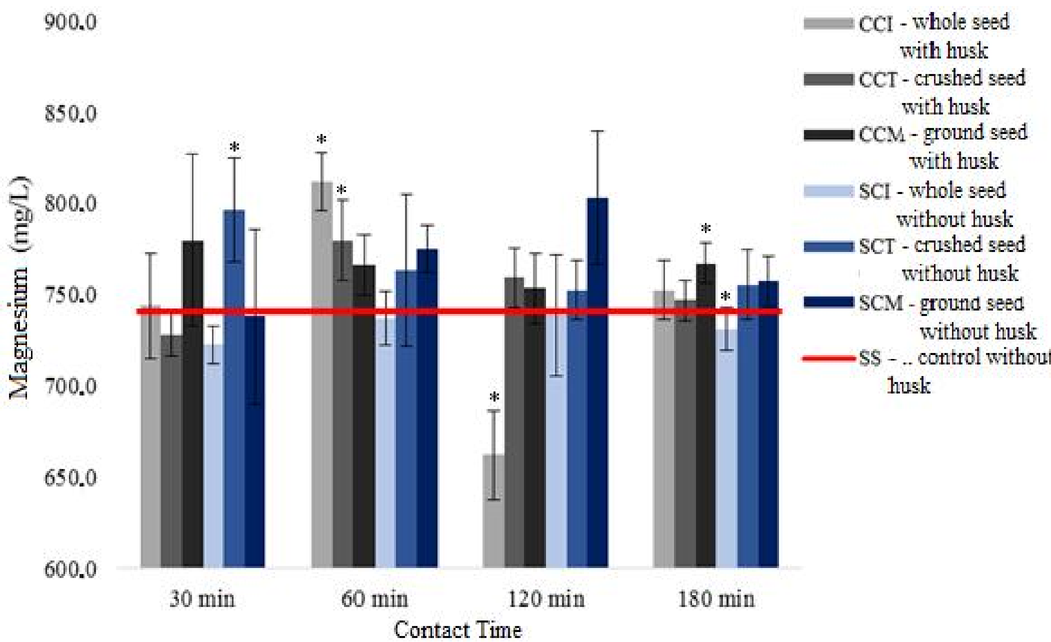

Fig. 6. Magnesium (Mg) of the extracts obtained with the reject in contact with the seeds of *Moringa oleifera*
(= significant difference)*

Table 7. Sodium of the extracts obtained with the reject in contact with the seeds of *Moringa oleifera (Moringa* with and without husk)*

Group Name	N	Absence	Mean	Standard Deviation	SEM
TEST	5	0	1868	59.749	26.721
CCI	5	0	25.26	0.195	0.0872
CCT	5	0	26.54	0.305	0.136
CCM	5	0	26.4	0.316	0.141
SCI	5	0	2250	30.822	13.784
SCT	5	0	2090.8	888.523	397.36
SCM	5	0	2622	175.699	78.55

**Whole with husk (CCI) / crushed with husk (CCT) / ground with husk (CCM) / crushed without husk (SCT) / ground without husk (SCM) / whole witout husk (SCI). TEST = Witness*

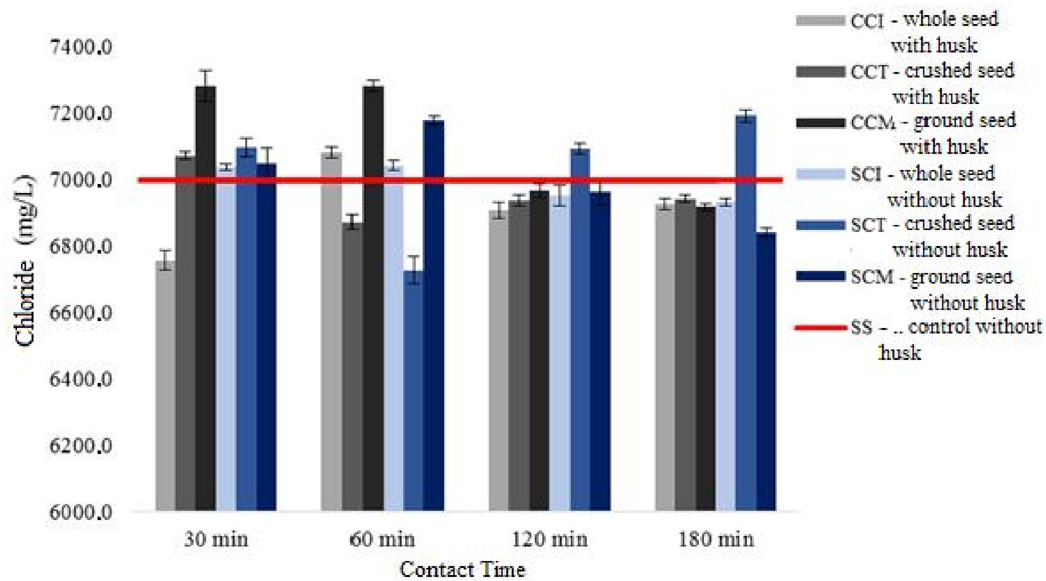

Fig. 7. Chloride (Cl) of the extracts obtained with the reject in contact with the seeds of *Moringa oleifera*
(= significant difference)*

Table 8. Analysis of Sodium variances (groups vs. residual)

Source of Variation	DF	SS	MS	F	P
Between groups	6	42308402	7051400	59.84	<0.001
Residual	28	3299454	117837.6		
Total	34	45607856			

Table 9. Sodium (Na) – Comparison control vs. samples (*Moringa* with and without husk)*

Comparison	Difference of means	q'	P	P<0.050
TEST vs. CCI	1842.74	8.488	--	Yes
TEST vs. CCM	1841.6	8.482	--	Yes
TEST vs. CCT	1841.46	8.482	--	Yes
TEST vs. SCM	754	3.473	--	Yes
TEST vs. SCI	382	1.76	--	No
TEST vs. SCT	222.8	1.026	--	No

**Whole with husk (CCI) / crushed with husk (CCT) / ground with husk (CCM) / crushed without husk (SCT) / ground without husk (SCM) / whole witout husk (SCI). TEST = Witness*

Table 10. Potassium of the extracts obtained with the reject in contact with the seeds of *Moringa oleifera (Moringa* with and without husk)*

Group Name	N	Absence	Mean	Standard Deviation	SEM
TEST	5	0	53.4	1.317	0.589
CCI	5	0	68.42	2.027	0.906
CCT	5	0	90	14.765	6.603
CCM	5	0	98.4	20.804	9.304
SCI	5	0	59.04	0.329	0.147
SCT	5	0	100.3	1.245	0.557
SCM	5	0	126	7.071	3.162

**Whole with husk (CCI) / crushed with husk (CCT) / ground with husk (CCM) / crushed without husk (SCT) / ground without husk (SCM) / whole witout husk (SCI). TEST = Witness*

Table 11. Analysis of variance of potassium (groups vs. residual)

Source of Variation	DF	SS	MS	F	P
Between groups	6	20334.92	3389.153	33.494	<0.001
Residual	28	2833.2	101.186		
Total	34	23168.12			

Table 12. Potassium (K) – Comparison control vs. samples (*Moringa* with and without husk)*

Comparison	Difference of means	q'	P	P<0.050
TEST vs. SCM	72.6	11.412	--	Yes
TEST vs. SCT	46.9	7.372	--	Yes
TEST vs. CCM	45	7.073	--	Yes
TEST vs. CCT	36.6	5.753	--	Yes
TEST vs. CCI	15.02	2.361	--	Yes
TEST vs. SCI	5.64	0.887	--	No

**Whole with husk (CCI) / crushed with husk (CCT) / ground with husk (CCM) / crushed without husk (SCT) / ground without husk (SCM) / whole witout husk (SCI). TEST = Witness*

Table 13. Calcium from the extracts obtained with the reject in contact with the seeds of *Moringa oleifera (Moringa* with and without bark)*

Group name	N	Absence	Mean	Standard Deviation	SEM
TEST	5	0	1005.206	13.412	5.998
CCI	5	0	1006.81	21.658	9.686
CCT	5	0	971.54	10.452	4.674
CCM	5	0	993.984	11.337	5.07
SCI	5	0	1011.606	17.359	7.763
SCT	5	0	934.666	21.658	9.686
SCM	5	0	961.92	72.146	32.265

**Whole with husk (CCI) / crushed with husk (CCT) / ground with husk (CCM) / crushed without husk (SCT) / ground without husk (SCM) / whole witout husk (SCI). TEST = Witness*

Table 14. Analysis of calcium variance (groups vs. residual)

Source of variation	DF	SS	MS	F	P
Between groups	6	24538.24	4089.707	4.172	0.004
Residual	28	27448.65	980.309		
Total	34	51986.9			

Table 15. Calcium (Ca) - Comparison control vs. samples (*Moringa* with and without barks)*

Comparison	Difference of mean	q'	P	P<0.050
TEST vs. SCT	70.54	3.562	--	Yes
TEST vs. SCM	43.286	2.186	--	No
TEST vs. CCT	33.666	1.7	--	No
TEST vs. CCM	11,222	0.567	--	No
TEST vs. SCI	6.4	0.323	--	No
TEST vs. CCI	1.604	0.081	--	No

**Whole with husk (CCI) / crushed with husk (CCT) / ground with husk (CCM) / crushed without husk (SCT) / ground without husk (SCM) / whole witout husk (SCI). TEST = Witness*

Table 16. Magnesium from the extracts obtained with the reject in contact with the seeds of *Moringa oleifera (Moringa* with and without husk)

Group name	N	Absence	Mean	Standard Deviation	SEM
TEST	5	0	740.97	17.729	7.929
CCI	5	0	743.886	28.61	12.862
CCT	5	0	728.33	12.106	5.414
CCM	5	0	779.864	47.338	21.17
SCI	5	0	722.492	10.083	4.509
SCT	5	0	796.392	28.224	12.622
SCM	5	0	738.05	47.81	21.382

**Whole with husk (CCI) / crushed with husk (CCT) / ground with husk (CCM) / crushed without husk (SCT) / ground without husk (SCM) / whole witout husk (SCI). TEST = Witness*

Table 17. Analysis of Magnesium variance (groups vs. residual)

Source of Variation	DF	SS	MS	F	P
Between groups	6	22660.4	3776.733	3.938	0.006
Residual	28	26852.36	959.013		
Total	34	49512.76			

Table 18. Magnesium (Mg) - Comparison control vs. sample (*Moringa* with and without barks)*

Comparison	Difference of mean	q'	P	P<0.050
TEST vs. SCT	55.422	2.83	--	Yes
TEST vs. CCM	38.894	1.986	--	No
TEST vs. SCI	18.478	0.943	--	No
TEST vs. CCT	12.64	0.645	--	No
TEST vs. SCM	2.92	0.149	--	No
TEST vs. CCI	2.916	0.149	--	No

**Whole with husk (CCI) / crushed with husk (CCT) / ground with husk (CCM) / crushed without husk (SCT) / ground without husk (SCM) / whole witout husk (SCI). TEST = Witness*

Table 19. Chloride of extracts obtained with the reject in contact with the seeds of *Moringa oleifera (Moringa* with and without husk)*

Group name	N	Absence	Mean	Standard Deviation	SEM
TEST	5	0	6997.548	57.614	25.766
CCI	5	0	6757.29	155.289	69.447
CCT	5	0	7072.628	97.893	43.779
CCM	5	0	7282.856	405.486	181.339
SCI	5	0	7037.594	100.733	45.049
SCT	5	0	7097.658	285.68	127.76
SCM	5	0	7047.604	253.748	113.48

**Whole with husk (CCI) / crushed with husk (CCT) / ground with husk (CCM) / crushed without husk (SCT) / ground without husk (SCM) / whole witout husk (SCI). TEST = Witness*

Table 20. Analysis of Chloride variance (Groups vs. residual)

Source of Variation	DF	SS	MS	F	P
Between groups	6	725669.9	120945	2.368	0.056
Residual	28	1430337	51083.46		
Total	34	2156007			

4. CONCLUSION

From the experiments carried out, it was possible to demonstrate that the *Moringa oleifera* Lam. seed has significant potential in the treatment of the reject of desalinators.

The pH and electrical conductivity (EC) presented indices that demonstrate the efficiency of *Moringa* in the reduction of these values, highlighting the treatments without husk of 7.5 (control) to 5.2 dS/cm (30.6%) and ground with husk 19.1 to 18.2 dS/cm (4.7%) in 60 minutes of contact. Sodium Na^+ (mg/L) obtained relevant indices in all the treatments with the seed with husk, from 1868.0 (control) to 24.7 mg/L, with reduction of (98.7%). In the treatments without husk, the opposite occurred, the indices were above the control. Calcium Ca^{2+} (mg/L) also showed satisfactory results in treatments with whole seeds with husk, which showed a reduction of 1005.2 (control) to 894.6 mg/L (11%), in 60 minutes of contact. Magnesium Mg^{2+} (mg/L) was not reduced in most treatments. Specifically, the 120-minute period was important for adsorption of magnesium in the experiment with seeds with husks, which was reduced from 741.0 to 662.2 mg/L (10.6%), in comparison to the control. Chloride Cl^- (mg/L) had its indices reduced in some of the treatments. Among these, the crushed seeds with and without husks stood out in 60 minutes of contact, as they obtained adsorption levels in this period of 1.8% and 4.1%, respectively. The potassium K^+ (mg/L) was the only element that did not present satisfactory results in relation to the control, indicating that the use of *Moringa oleifera* Lam. in this parameter is not efficient.

In view of the above, the highlight is the experiments that used crushed or ground seeds with husks, mainly due to their relevance in the adsorption of elements such as sodium, calcium, magnesium and chloride.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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