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Saline Waters Treatment Using Activated Carbon Filled Filter

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Authors' contributions

This work was carried out in collaboration among all authors. Author SSAL performed the experiment as a master's thesis, performed the statistical analysis and wrote the first draft of the manuscript. Authors HJBLF designed the desalinizer prototype and together with author SCDP managed the analysis of the study. Author ASM designed the study and wrote the Protocol. All authors have read and approved the final manuscript.

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ABSTRACT

In this paper, we describe an experimental activity involving the water treatment steps using the activated carbon made from coconut fibre and grape pomace packaged in a filter constructed with low-cost material to adsorb chemical elements present in the underground saline water before desalination. The activated carbon (CA) was prepared with grape pomace (P) and coconut fiber (C) mixtures, with coconut/pomace doses of 100/0; 75/25; 50/50; 25/75; 0/100 (the first stage of the experiment). The 50C/50P mixture was statistically considered the most suitable for the production of CA, being chemically activated with $ZnCl_2$, underflow of 100 mL/min, at 550ºC for 60 minutes. To evaluate the efficiency of the filter with the carbon produced, different contact times were used. Tests were performed every 5 minutes totalling 60 minutes. After the pH, EC, Na, K, Ca, Mg and Cl determinations in each collection and the corresponding statistical analysis, it was noticed that in the initial five minutes there was already positive response to adsorption of the determined elements.

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Keywords: Alternative filter; contact time; packaging; coconut fiber; grape pomace; solid waste.

1. INTRODUCTION

In the Brazilian Northeast, vast areas suffer from the lasting problem of low rainfall and periodic droughts, in addition to the continuous occurrence of high levels of groundwater salinization. According to the 2010 Census [1], approximately 61% of the Brazilian population is supplied with groundwater for domestic purposes, with 6% self-supplying from shallow wells, 12% from springs and 43% from deep wells.

According to Gimenes et al. [2], it is clear that the central problem of the water crisis is not only the scarcity of water but the lack of proper water for the population's consumption, as the existing sources are being increasingly polluted.

Desalination is a rapidly expanding form of saline water treatment with a promising future [3]. Part of the estimated increase is mainly due to the great advance in increasingly effective desalination technologies, which allow for a marked reduction in the cost of cubic meter of treated water [4]. Another reason for the expansion of this technique is the constant need to find alternative sources of water due to the increasingly worrying pollution or scarcity of freshwater [5, 6,7].

According to Westphalen et al. [8] activated carbon is normally used as a sorbent that serves as a filtering agent for hydrophobic organic contaminants present in small quantities in water, such as compounds that are responsible for changes in the organoleptic characteristics of water.

Batch adsorption experiments serve to investigate the performance of an adsorbent under certain experimental conditions, as well as to estimate parameters such as process kinetics and thermodynamics. Such information is relevant and may be useful in predicting the performance of a fixed-bed adsorption process [9].

In general, fixed-bed adsorption can be defined as the concentration wave propagation of a chemical species in a column packed with adsorbent solid particles. The fluid phase passes through the stuffed bed with support and transfers heat and mass with it until it reaches saturation, the condition in which the process is completed [10].

Therefore, the purpose of this work was to contribute to minimize a global problem, which is the generation of solid waste and its inappropriate disposal, using coconut fibers and grape pomace, demonstrating the importance of applying and using new alternative sources for the production of activated carbon, contributing to the improvement of quality of life, mainly socioeconomic, prioritizing environmental preservation and proposing technological innovations for saline water treatment.

2. MATERIALS AND METHODS

The test was developed in the Analytical Chemistry Laboratory of the Science and Technology Center of Catholic University de Pernambuco, Recife, Pernambuco, Brazil.

In the first experimental phase, the mixtures of grape pomace (P) and coconut fibre (C) were tested, with doses of 100/0; 75/25; 50/50; 25/75; 0/100. The mixture 50C/50P was considered statistically the most suitable for the production of CA [11], the treatment used in this stage.

For the experiment, a filter made of low cost material was assembled, made up of PVC connections, containing female adapters, joints, male adapters and reducing adapters, and one inch stainless steel mesh (ABNT/ASTM 40) for packing with activated carbon previously produced with coconut fiber and grape pomace, where the best previous result was with the dose of 50% coconut fiber plus 50% grape pomace, in the adsorption of chemical elements [11].

The filter was adapted through connections to a 200-liter reservoir containing desalination reject from the municipality of Riacho das Almas, Pernambuco, Brazil.

Every five minutes, up to a total of 60 minutes, 200 mL of the filter extract filled with activated carbon was collected, with an average flow rate of Q = 0.022L/s to evaluate the parameters: pH and electrical conductivity, using the methods [12,13] respectively, sodium and potassium by flame emission spectrophotometry, calcium and magnesium by complexation titration and chloride by precipitation titration.

The data obtained were submitted to descriptive statistical analysis generated by the Minitab software.

3. RESULTS AND DISCUSSION

Comparing the data shown in Fig. 1, it was observed that there was a reduction in the content of the elements determined in the extract obtained by the filter, especially in the first five minutes of contact.

The onset of adsorption has a higher mass transfer rate, which may be explained by the large availability of active sites. After the initial stage, repulsive forces begin to exist between the adsorbate molecules in the fluid phase and the adsorbent after a certain time.

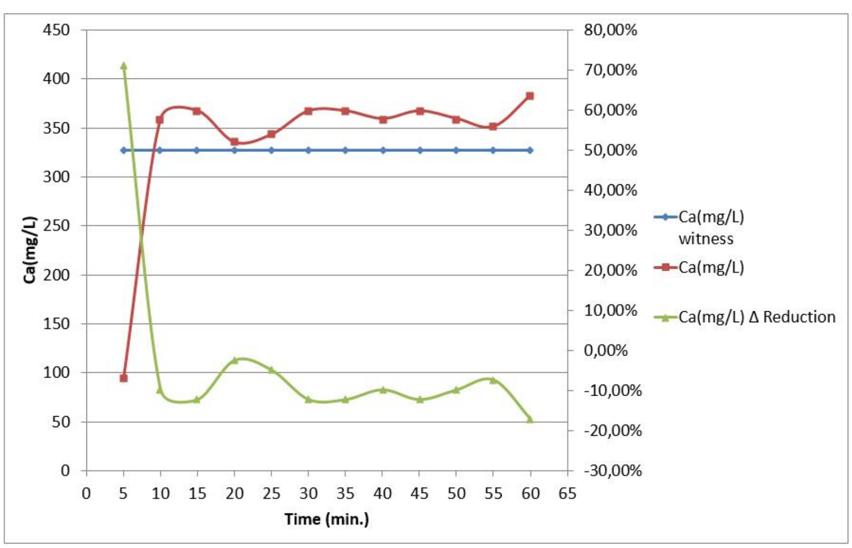
In this last stage, adsorption occurs slower than in the beginning because the process is controlled by decreasing the availability of adsorption sites. As the surface of the solid reaches saturation, the adsorption rate begins to be controlled by the rate of transfer from adsorbate to active sites located within the adsorbent [14].

Also according to Fig.1, it is possible to identify that in the initial five-minute contact range there was a 47.59% reduction of all chemical elements present in the desalinator reject, corroborating the results obtained by Youssef et al. [15], when he observed that the adsorption rate is high at the beginning of the process, which is probably related to the high number of adsorption sites on the carbon surface.

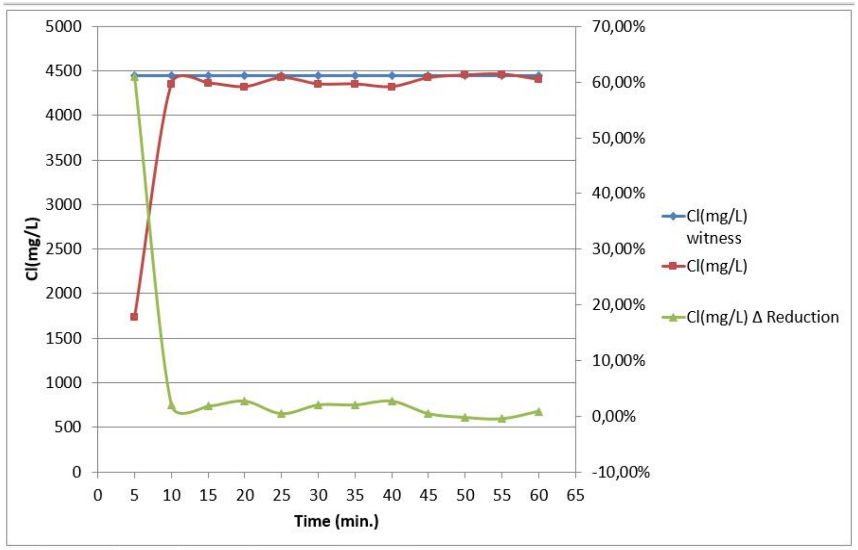
Analyzing the individual values of the determinations shown in Fig. 1, it can be seen that the pH ranged from 7.1 to 7.9 (pH of the witness 8.2 - basic), the electrical conductivity from 5,270 to 10,324 dS/m (EC of the witness 10,440 dS/m); Na from 1,300 to 2,560 mg / L (Na of the witness 2,610 mg / L); K from 38.8 to 72.2 mg / L (K of the witness 73.7 mg / L); Ca from 94.5 to 383.2 mg / L (Ca of the witness 327.05 mg / L); Mg from 277.13 to 442.44 mg/ L (Mg of the witness 476.75 mg / L); and the Cl from 1,736.34 to 4,462.90 mg / L (Cl of the witness 4,442.9 mg / L) every five minutes until 60 minutes of contact.

It is known that pH is considered as an important parameter in the adsorption process, as it directly affects the activity of functional groups on the surface of the adsorbent responsible for element capture [16], as well as modifying the ionic composition of the adsorbate, even with a small variation, as shown in Fig.1. The results found in the experiments proposed in this study showed that the pH did not influence the adsorption of ions present in the desalination reject. In one of his experiments, Sadaf and Bhatti [17] found pH between 6 and 7 in treated water treatments using commercial activated carbon and, after the adsorption process, concluded that there was no significant variation in pH about the initial water.

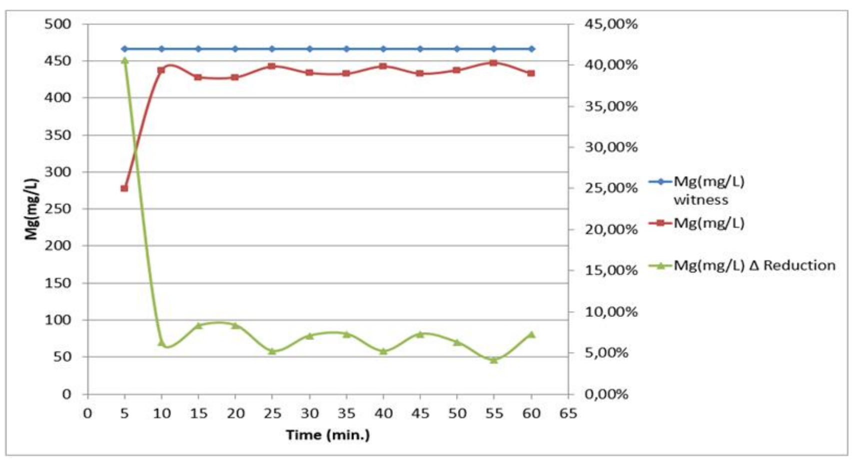
Studies by Cruz et al. [18], which used the orange peel as a precursor material, presented very fast kinetics, reaching equilibrium with only 10 minutes of contact time. Between zero and three minutes a marked transfer occurred, and then, from three to 10 minutes, the increase in adsorption gradually occurred until it reached equilibrium.



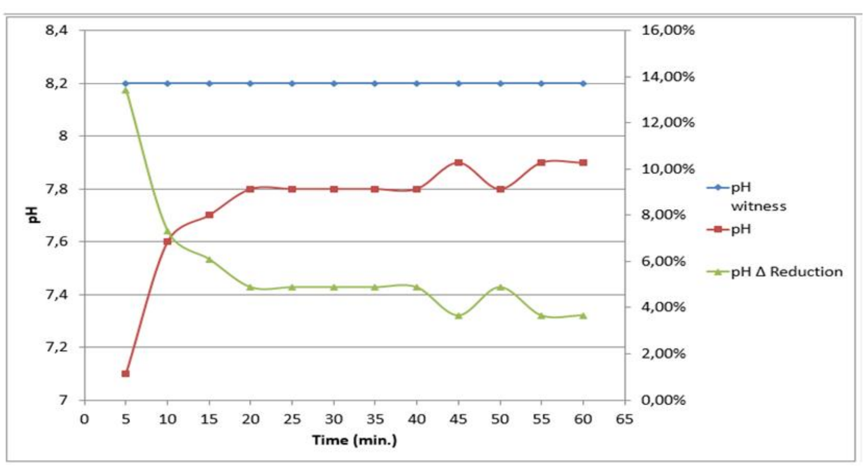
A- Calcium



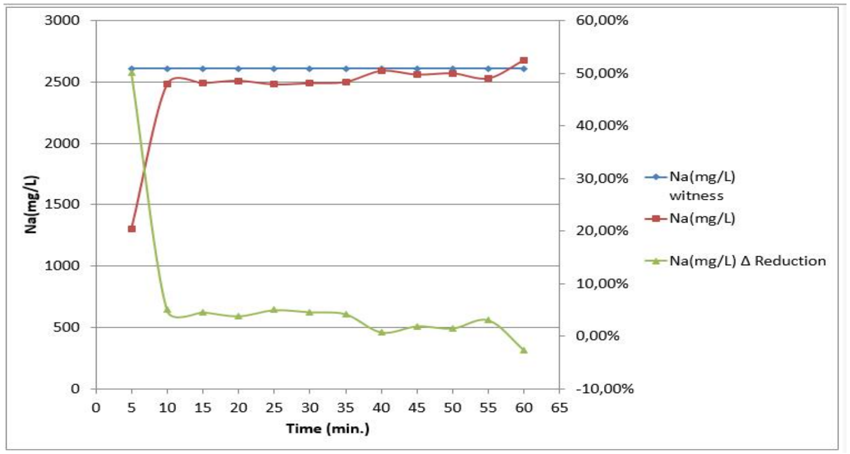
B- Chloride



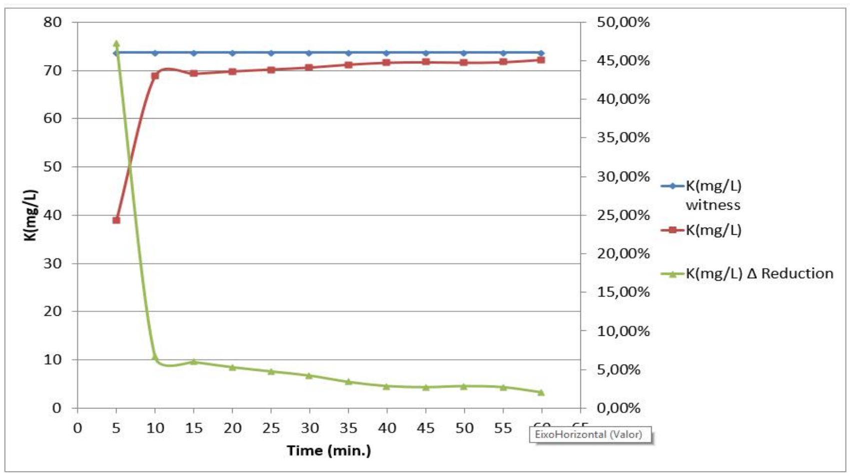
C- Magnesium



D- pH



E- Sodium



F- Potassium

Fig. 1 (A-F). Results obtained for the different contact times of activated carbon with desalination reject in the adsorption of chemical elements

This behavior is expected since, in the initial moments, the adsorption sites are completely available, and in the later moments, the remaining ions are repulsed from ions that have already been adsorbed on the surface of the adsorbent [19].

Also according to Gönen et al. [19], rapid adsorption of pollutants and the establishment of equilibrium over a short period represents the efficiency of the adsorbent for its use in water treatment.

It is perceived that as the time was increasing (over five minutes) there is a greater possibility of the desortive process to be effective for all the elements determined, corroborating with the results obtained by Dural et al. [20].

4. CONCLUSION

Given the results obtained, it can be concluded that the results obtained demonstrated the efficiency of activated carbon in the adsorption of ions, thus making use of coconut fibre and grape pomace. The produced activated carbon, when used as a filter, presented a total efficiency in the first contact times where the values obtained for pH and electrical conductivity, sodium, calcium, chloride and potassium showed significant variations during the first five minutes of contact. Also, due to the chemical characteristics of the activated carbon produced, all the elements in the water dissolve, especially in the early times of system operation. The excess of these ions is minimized to levels suitable for human consumption. It is important to note that the results obtained in this study contribute to the development of technology in the area of chemical engineering, which is characterized by the low cost of implementation, operation and maintenance, enabling a more appropriate use of desalination to reject.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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