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Use of Coconut Powder for Adsorption of the Sodium, Potassium and Chloride from Mangrove Sediment

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ABSTRACT

The husk of green coconut can be crushed, and its powder can be added to the soil to retain water and as an organic compound. This is also an environmentally friendly and suitable alternative to an agricultural substrate. In addition, coconut powder can become an alternative to replace turf, fossilized organic material, whose exploitation has been affecting the ecosystem. This article describes an experimental activity involving mangrove sediment and coconut powder packed in PVC tubes, with the objective of adsorbing sodium, potassium and chloride present in the mangrove sediment irrigated with desalination waste. Percolates were collected every 15 days, up to 60 days. After the electrical conductivity, Na^+, K^+ and Cl^- determinations in each collection and the corresponding statistical analysis, it was noticed that when the coconut powder was used on the surface, in determining the percolate, the electrical conductivity showed 14 mS/cm and chloride 412mg/l, at 30 days of contact with the mangrove sediment. At 60 days of contact, the result for sodium with coconut powder on the surface was 2,320.0 mg/l and for potassium with coconut powder incorporated in the mangrove sediment it was 373.0 mg/l. These results indicate that coconut powder, preferably on the surface of the mangrove sediment, is a biosorbent alternative for chemical elements.

Keywords: *Biosorbent. Sediment. Saline water. Residues.*

INTRODUCTION

Sediments are active particles in water resources due to their varied physical and chemical characteristics, which can favor the adsorption of contaminants, being carriers and final destination of many xenobiotics and potentially toxic elements such as some metals[1].

Sediments are formed by the deposition of particles of various types and origins, accumulating organic and inorganic substances. With this, the analysis of the sediments can indicate the contamination that a drainage basin presents and, also, detect the pollution over the years, depending on the particle size and depth in which it is found, among other factors, for example, nature of the particles and hydrological conditions [2, 3].

In Brazil, according to[4],the mangrove ecosystem occurs along the coast, from Cabo Orange, Amapá, to the municipality of Laguna in Santa Catarina, covering an area of 25,000km². Brazil, Indonesia and Australia are the most abundant countries in mangrove ecosystems, covering 400,000 hectares [5].

The mangrove that is the object of this study is located in the municipality of Rio Formoso, located in the physiographic region of the Southern Meridional of the state of Pernambuco, 92km from the capital Recife.Part of its territory is included in an Environmental Protection Area - APA (State Decree No. 19,635, of March 13, 1997), called APA de Guadalupe, which is located in the southern portion of the southern coast of the state of Pernambuco, covering part of of the municipalities of Sirinhaém, Rio Formoso, Tamandaré and Barreiros[6].

The Formoso River is 12km long and rises in the northwest portion of the municipality of the same name. Close to the mouth, located between the Guadalupe point and the Carneiros beach, it receives Ariquindá and its affluent União, two important components of its basin. Along its route, it receives domestic waste and residues from the sugar agribusiness[7].

The excess of salts and sodium is one of the main factors responsible for soil degradation, causing negative impacts on agricultural production and on the sustainability of ecosystems, especially in arid and semi-arid regions. [8,9,10].

In the Pernambuco semiarid region, crystalline basement predominates, with groundwater being an important source that contributes to meeting water demand, playing a prominent role in solving the problems of lack of water for human consumption in this region of the State.[11]. In this way, new technologies to complement the low availability of water in a sustainable way are desired.The main method used for desalination of saline water in northeastern Brazil is based on reverse osmosis. However, this process has the disadvantage of generating wastewater (reject), which ends up impacting soil and ground water [12, 13, 14].

Coconut powder is an excellent organic material for substrate formulations due to its water retention properties, aeration of the cultivation medium and rooting stimulator, showing the possibility of using this residue as an agricultural substrate [15]. However, the high salinity present in coconut powder can lead to high electrical conductivity.The unwashed coconut fiber, in addition to delaying germination, provides less seedling growth, however, salinity tolerance varies between species and, even within the species, between development stages [16]. Salinity also interferes with the mineral composition of leaves with interference with physiological processes[17].

This work's objective was to evaluate the efficiency of adsorption of the sodium, potassium, and chloride of the mangrove sediment, using coconut powder.

MATERIALS AND METHODS

The experiment was conducted at the Analytical Chemistry Laboratory, on the 8^{th} floor of Block D, at the Science and Technology Center at Catholic University of Pernambuco, Recife, Pernambuco, Brazil, with average temperature of 20ºC.

Five subsamples of mangrove sediment were collected in the municipality of Rio Formoso, Pernambuco, at coordinates 8º41'17"S and 35º06'30.1"W, under the SIRGAS 2000 reference system, located in the mesolitoral region, with little water.

These subsamples were mixed to form a composite sample , with the following characteristics: Apparent density = 1.05g/cm^3; Real density = 2.49g/cm^3; Degree of flocculation = 32%; Texture class = clay loam; Natural clay = 25%; Residual humidity = 2.75%; Humidity 0,33atm = 56.80%; Humidity 15atm = 28.14%; Available water = 28.66%; pH (H_2O) = 5.70; Ca^{2+}= 4.00cmol$_c$ / dm^3; Mg^{2+} = 1.10cmol$_c$ / dm^3; Na^+ = 0.34cmol$_c$/dm^3; K^+ = 0.20cmol$_c$/dm^3; Sum of Exchangeable Bases (S) = 5.60cmol$_c$ / dm^3; Cation Exchange Capacity (CEC) = 10.3cmol$_c$ / dm^3; Base Saturation (V) = 55%, according to the methodology of the Brazilian Agricultural Research Corporation.

The desalinator reject for irrigation was obtained from the desalinator located in the municipality of Riacho das Almas, Pernambuco, Brazil. The physicochemical analysis was performed at the Agronomic Institute of Pernambuco (IPA) Plant, Ration and Water Analysis Laboratory - LAPRA with the following characteristics: electrical conductivity = 11.541µS/cm at 25ºC, Ca^{2+} = 403mg/l, Mg^{2+} = 393.09mg/l, Na^+ = 200mg/l; K^+ = 40mg/l, RAS = 23.67, pH = 7.9, classification for irrigation = C4S4 (very high salinity water and high sodium concentration).

The physicochemical analysis of coconut powder was performed at the Agronomic Institute of Pernambuco (IPA) Plant, Ration and Water Analysis Laboratory - LAPRA with the following characteristics: pH = 6.15; EC = 4.74dS/m; Ca^{2+} = 4.8 mg/l; Mg^{2+} = 2.7 mg/l; Na^+ = 35.9 mg/l; K^+ = 71.8 mg/l; Cl^- = 195 mg/l; C = 97.3%; N = 1.11%; C/N ratio = 87.66.

For the installation of the experiment, PVC tubes with 25cm height and 9.8cm internal diameter were used, presenting at the base an opening connected to a 0.7cm diameter flexible hose that allowed the percolating liquid to pass through the sediment into the container collector, with three replications, totaling 12 tubes.

The tubes were filled with 1.5kg of mangrove sediment, enough to obtain a 20cm high column. Shortly thereafter, 300g of the coconut powderwith husk and crushed was applied to the surface (PCS) and incorporated (PCI) into the sediment, in addition to the control (TEST), with irrigation with the desalinator reject twice a week.

The percolate in each tube was collected in a 250ml conical flask, at intervals of 15 days, up to 60 days, with the hydrogen potential being determined - electrical conductivity - EC (conductivity measurement), Na^+ and K^+ (flame emission spectrophotometry), and Cl^- (precipitation titrimetry - Mohr method), for later statistical analysis, using the Minitab 19 software.

RESULTS AND DISCUSSION

The results obtained for the determinations of electrical conductivity, Na^+, $K^+$and $Cl^-$are shown in Figures 1 to 4.

The electrical conductivity - EC is one of the parameters used to express the concentration of soluble salts in the solution.The values presented in Fig.1 show that at 15 days of contact between the mangrove sediment and the coconut powder on the surface (CPS) the EC of the percolate was 23mS/cm and when incorporated (ICP) it was 21 mS/cm; at 30 days CPS was equal to 14 mS/cm and ICP equal to 16 mS/cm.At 45 and 60 days of contact, the EC presented 15 mS / cm for both CPS and ICP.All values for EC were lower than the control (TEST) at all times of contact between mangrove sediment and coconut powder.

According to [18], the EC declines as the collection time approaches 60 days.It is noticed that the moringa incorporated in the mangrove sediment registered in the percolate, at 15 days, EC equal to 37.4 mS/cm and, at 30 days, 28.6 mS/cm.*Moringa oleifera* on the surface of the sediment showed 18.3mS/cm and 13.1mS/cm in the percolate EC, respectively at 45 and 60 days of contact.

Fig1. *Average values of electrical conductivity (EC) of percolate collected at 15, 30, 45 and 60 days for the control (TEST), coconut powder on the surface (CPS) and incorporated (ICP) in the mangrove sediment.*

Fig.2 shows that sodium in the ICP percolate showed a value of 4.020.0mg/l and in the PCS 3.440.0 mg/l at 15 days, decreasing its values as the time of contact with the mangrove sediment increases, up to 60 days, indicating greater sodium adsorption, clearly when coconut powder was incorporated (ICP), at 30 days (2,617.0 mg/l). The values found in the percolate of the experiment by [18] with mangrove sediment and shelled and crushed seed of *Moringa oleifera* indicate that there is a tendency for sodium adsorption after 30 days of contact, namely: Na^+in the percolate at 30 days (MS = 3,620.0mg/l; MI = 3,246.7mg/l), Na^+in the percolate at 45 days (MS = 2,746.7mg/l; MI = 2,880.0mg/l), and Na^+in the percolate at 60 days (MS = 2,533.3mg/l; MI = 2,410.0mg/l).

Fig2. *Average percolate sodium values collected at 15, 30, 45 and 60 days for the control (TEST), coconut powder on the surface (CPS) and incorporated (ICP) in the mangrove sediment.*

The behavior of potassium in the percolate (Fig.3) was decreasing from 30 days to 60 days of contact of mangrove sediment with coconut powder on the surface (CPS) and incorporated (ICP), as well as in the control (TEST).However, at 15 days, higher values were obtained for CPS (1,100.0mg/l) and for ICP (1,167.0mg/l).

According to [18] the moringa incorporated in the mangrove sediment presented the highest K^+ values in the percolate, for all contact times: 15 days (1,166.7mg/l), 30 days (970.0mg/l), 45 days (1,036.7mg/l) and 60 days (786.7mg/l). Therefore, the moringa on the surface favors more potassium adsorption. In contrast, the values that showed less potential for adsorption, in all contact times, were moringa control (TEST): 15 days (683.3mg/l), 30 days (576.7mg/l), 45 days (523.3 mg/l) and 60 days (300mg/l).

Fig3. *Average percolate potassium values collected at 15, 30, 45 and 60 days for the control (TEST), coconut powder on the surface (CPS) and incorporated (ICP) in the mangrove sediment.*

Fig.4 shows that the chloride values in the percolate range from 15 to 45 days of contact of the mangrove sediment with the coconut powder on the surface (CPS) and embedded (ICP), as well as in the control (TEST). Values are stable after 60 days of contact for TEST = 479mg/l, CPS = 490mg/l andICP = 495mg/l. It can also be seen in Fig.4 that at 30 days of contact the lowest value for chloride was obtained with CPS (412mg/l), indicating greater adsorption of this element.

The chloride ion showed lower values in the percolate when [18] used the moringa incorporated in the mangrove sediment at 15 days (797.0mg/l), 30 days (540.8mg/l), 45 days (485.2mg/l) and 60 days (470.0mg/l) of contact.This behavior was more effective in adsorbing Cl^- in relation to the moringa on the surface.

After statistical analysis of the extracts collected and analyzed at seven and 15 days, it was noticed that the results presented demonstrated that the adsorption of sodium and potassium was more effective at eight days of contact of the sediment with the rice husk, water hyacinth and barley [19].

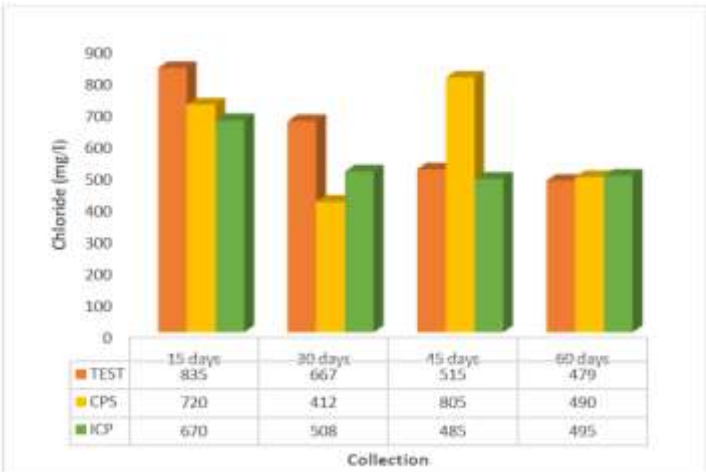

Fig4. *Average percolate chloride values collected at 15, 30, 45 and 60 days for the control (TEST), coconut powder on the surface (CPS) and incorporated (ICP) in the mangrove sediment.*

Conclusion

This experiment presented an alternative to use coconut powder, making it possible to reduce the disposal of this solid waste in inadequate areas, contributing to the reduction of environmental and public health problems.

Therefore, it wasfound that the electrical conductivity showed 14mS/cm and the chloride 412mg/l, after 30 days of contact of the coconut powder with the mangrove sediment.At 60 days of contact, the result for sodium with coconut powder on the surface was 2,320.0 mg/l and for potassium with coconut powder incorporated in the mangrove sediment it was 373.0mg/l.These results indicate that coconut powder, preferably on the surface of the mangrove sediment, is a biosorbent alternative for chemical elements.

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