

## The phytoextraction potential of *Euterpe oleracea* cultivated in Brazil.

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**Abstract:** This research aimed to characterize the chemical composition in the *Euterpe oleracea* seedlings (upper parts) and in mature trees. The phytoextraction potential the seedlings were determined through method X-ray fluorescence analysis. The Al concentration in the seedlings upper parts was four times higher than preconized as a hyper accumulator species. We also found high concentrations of Fe and Si. The Cu and Ca was lower considered a normal level for the seedlings, but Ca, which may represent an antagonism effect caused by the strong presence of Al and Fe. These results highlight the phytoremediation potential for Al, Fe and maybe Cu. The Si reduces the phytotoxic effects and contributed to enhance the Al and Fe absorption and translocation processes to the upper plant parts. The fast uptake and translocation to the seedlings upper parts highlight the possibility to use this species in phytoextraction of potential toxic elements from the soil.

**Keywords:** phytoremediation, X-ray fluorescence, species of the Brazilian Amazon.

### O potencial da fitoextração de *Euterpe oleracea* cultivada no Brasil.

**Resumo:** Esta pesquisa objetivou caracterizar a composição química nas mudas de *Euterpe oleracea* (partes superiores) e em árvores maduras. O potencial de fitoextração das mudas foi determinado por meio da análise de fluorescência de raios-X do método. A concentração de Al nas partes superior das mudas foi quatro vezes maior do que a preconizada como uma espécie hiperacumuladora. Também encontramos altas concentrações de Fe e Si. O Cu e o Ca foram menores, considerados normais para as mudas, mas Ca, pode representar um efeito antagonismo causado pela forte presença de Al e Fe. Estes resultados destacam o potencial de fitorremediação de Al, Fe e possivelmente de Cu. O Si reduz os efeitos fitotóxicos e contribuiu para melhorar os processos de absorção e translocação de Al e Fe para as partes superiores da planta. A rápida captação e translocação para as partes superiores das mudas destacam a possibilidade de utilizar esta espécie em fitoextração de potenciais elementos tóxicos do solo.

**Palavras Chave:** fitorremediação, fluorescência de raios X, espécies da Amazônia Brasil.

## 1. INTRODUCTION

*Euterpe oleracea* Mart., popularly called "açaí", "açaí-do-pará", among other names, is a Brazilian species naturally occurring in the Pará, Amapá, Maranhão (Calzavara, 1972), Mato Grosso and Amazonas State. They are highly appreciated in food and have health benefits, mainly associated with their antioxidant capacity and phytochemical composition (Portinho et al; 2012). Due to the fact that the *Euterpe oleracea* is settled in flooded regions, their use for phytoremediation can be an alternative for cleaning up contaminated soils. The species may be an option for the



remediation of flooded soils polluted by heavy metals. These systems provide an easy and practical procedure for removal of contaminants rather than excavation and soil replacement. Among the plants used for phytoremediation, only *Oryza sativa* L. (rice) grows well in flooded fields (Sarwar et al; 2017).

The objective of the research was to evaluate the assess possible differences within the chemical compounds in the tree high and the growth period. The phytoextraction potential, we investigated the potential toxic and essential elements concentration in the seedling's upper parts after six months.

## 2. MATERIAL AND METHODS

There were investigated the chemical composition of *Euterpe oleracea* Mart. harvested at sixteen years-old from an agroforestry system in Paraty city, and the seedlings were sampled after six months from a nursery placed at Seropédica city. Both experiments implanted by the Federal University Rural of Rio de Janeiro, Rio de Janeiro State, Brazil. The stipe disk samples were collected from the mature trees. They were separated into three parts: at the base (0.15 cm above the lap), at lower third at the diameter at breast height (DBH, 130 cm above the ground) and at 5 cm below the apical meristem.

### 2.1 Seedlings phytoextraction potential

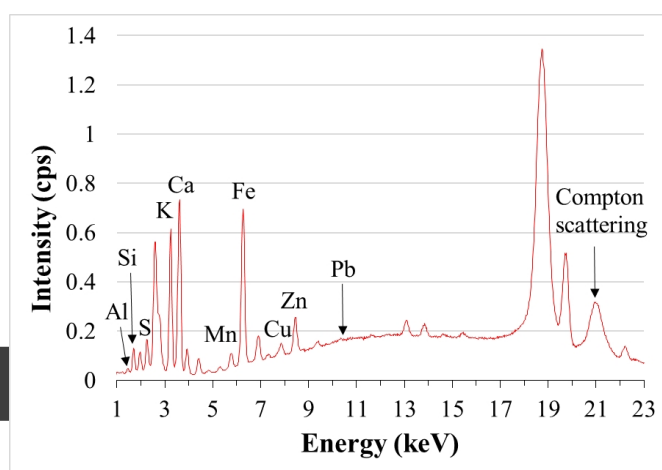
The energy dispersive X-ray fluorescence analysis (EDXRF) was performed at the Nuclear Instrumentation Laboratory, Center of Nuclear Energy in Agriculture, University of São Paulo. The seedlings upper parts were dried in a climatic chamber (60 °C) during 48h. After that, five seedlings stipe and leaves were crushed (Willey mill) and sieved (200 µm). The samples and the standard reference materials (SRM) pressed pellets were prepared using 0.5 g of the sample pressed at 7.5 ton cm<sup>-2</sup> using the press during five minutes. The Al, Si, S, K, Ca, Mn, Fe and Cu concentrations were determined using the EDXRF benchtop spectrometer Shimadzu, model EDX-720, utilizing a Rh X-ray tube operated at 50 kV and 68 µA, a 5 mm diameter collimator and under vacuum (lower than 30 Pa). For Pb determination, it was used the same analysis condition, except the use of Ag filter and without vacuum.

The fundamental parameter (FP) method was used to quantity the elemental concentration in the *Euterpe oleracea* seedlings (Omote et al. 1995). For Si, it was utilized the hay (IAEA-V-10) powder SRM. For Al and Pb, 0.5 g cellulose powder P.A. (Cellulose Binder, Spex) was spiked five and two times separately with Al (10,000 mg kg<sup>-1</sup>) and Pb (20 mg kg<sup>-1</sup>) respectively, then drying at 60 °C in a laboratory oven and homogenized using an agate mortar. Values outside this range

were reported as a semi-quantitative analysis, with the approximate concentrations of the elements in the samples.

### 3. RESULTS

Fig. 1 shows the *Euterpe oleracea* seedlings XRF spectrum. It presents the Al, Si, S, K, Ca, Mn, Fe, Cu and Pb peak intensities.



**Fig. 1** XRF spectrum from the *Euterpe oleracea* sample. The Al, Si, S, K, Ca, Mn, Fe, Cu, Zn and Pb are indicated in the spectrum.

There were observed acceptable ranges for elemental recovery of the standards for K, Ca, S, Fe, Mn, Cu and Pb ranged from 82.77-109.61%. The recovery values for those elements ranged from 54.51-55.72% outside the given range (80-120%), therefore, the results represent approximate concentrations (table 1).

**Table 1** Recovery values for the element's concentrations determined by Fundamental Parameter method in the Standard Reference Materials

SRM	NIST 1515 (apple leaves)				
Analyte	K	Ca	S	Fe	Mn
C (mg kg <sup>-1</sup> )	16355.33	14814.11	1972.90	83.96	51.96
SD	30.43	24.34	12.79	1.17	1.26
RV (mg kg <sup>-1</sup> )	16080	15250	1800	82.70	54.10
R (%)	101.71	97.14	109.61	101.53	96.04
SRM	NIST 1515	IAEA-V-10 (hay)	Spike (cellulose)		
Analyte	Cu	Si	Al	Pb	
C (mg kg <sup>-1</sup> )	4.71	981.25	5572.01	16.61	
SD	0.17	27.40	186.791	0.26	
RV (mg kg <sup>-1</sup> )	5.69	1800	10000	20	
R (%)	82.77	54.51	55.72	83.05	

Where: SRM = Standard Reference Material; C = concentration; SD = standard deviation; RV = reference value; R = recovery.

Fig. 2 shows the elements concentrations in the *Euterpe oleracea* seedlings cultivated at normal conditions harvested after six months.

**Fig. 2** Average of K, Ca, S, Fe, Mn, Cu, Si Al and Pb concentrations in the six months-old *Euterpe oleracea* shoots

#### 4. DISCUSSÃO

The operating conditions used for recording the XRF spectra of the elements range Al - Cu enhanced the background at the Pb La energy peak region at 10.55 keV (Fig.1). The *Euterpe oleracea* seedlings effectively absorbed and translocated Al and Fe to the upper parts (table 1). The Al average concentrations was 4,241 mg kg<sup>-1</sup> of dry weigh (DW), four times above than preconized to be an Al-hyperaccumulator species (Jansen et al. 2002). Al concentration in the *Euterpe oleracea* was twice times higher than found in the fine roots of Spruce and Poplar seedlings with five months of age (Brunner et al. 2008). The Fe and Cu levels were at least five times and twice, respectively, above that found in several species tested for Ni-phytoremediation purposes (Boyd & Jaffré, 2009). The Fe and Cu concentrations were more than six and three times higher (Table 1), respectively, than the normal concentrations in oil palm (*Elaeis* spp.) seedlings (Matos et al. 2016).

The Al and Fe content in the seedlings may be an evidence of the high potential of this species in the absorption, translocation and tolerance of these elements. Essential features to introduce the *Euterpe oleracea* in phytoremediation programs to remove pollutants from contaminated areas (Nakbanpote et al; 2010). High concentration of Si was also observed in the *Euterpe oleracea* seedlings. One of the possible mechanisms involved in tolerance increasing is the compartmentalization of potentially toxic elements in the cell wall and vacuole (Emamverdian et al. 2018). Other mechanisms, such as the Si and Al complexation, were also observed in hyperaccumulator of Al *Faramaea marginata*, which contributes to reduce the phytotoxic effects of the accumulation of Al in the vegetal tissue (Britez et al. 2002).

The K and S concentrations were found within the normal range considering similar species (Fig.2). However, the Ca content was lower, maybe indicating a nutritional disturbance caused by the antagonism between Al, Fe and Cu (Matos et al. 2016). The K was the element with the highest concentration in the *Euterpe oleracea* seedlings. The essential elements content in the *Euterpe oleracea* seedlings followed the descending order of K > Ca > S > Fe > Mn > Cu. Similar results

were observed for Mn concentrations in the leaves of the same species. On the other hand, the authors found lower values for Ca and Cu and higher values for the K and S (Araújo et al. 2016). Similar concentrations of K were reported in the leaflet in an improved *Euterpe oleracea* population (Brasil et al. 2008).

## 5. CONCLUSÕES

The high concentration, fast accumulation and translocation of Al and Fe indicate a potential use of this species to remove these potentially toxic elements from the soil. Values above the recommended as an Al-hyperaccumulator species were observed in the *Euterpe oleracea* seedlings. It is recommended further investigations to assess the potential use of *Euterpe oleracea* for removing Al, Fe, Cu and Pb from contaminated areas.

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