A bibliographic review on Paricá (*Schizolobium amazonicum* Huber ex Ducke) and its relationship with the phytoremediation of environments contaminated by heavy metals

Uma revisão bibliográfica sobre Paricá (*Schizolobium amazonicum* Huber ex Ducke) e sua relação com a fitorremediação de ambientes contaminados por metais pesados

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ABSTRACT
Phytoremediation is a technique that uses plants to increase dispersion or stabilize pollution in the environment, and acts by decomposing and absorbing heavy metals by the rhizosphere. Being propitiated by the low cost, ease of implantation, good public acceptance and, because it is not invasive, it can be applied in situ. Thus, the objective of this work was to identify studies on the phytoremediation of heavy metals with the species *Schizolobium amazonicum* Huber ex Ducke (Paricá) to verify its effective collaboration in minimizing damage caused to nature. The research was developed based on literature reviews to verify if the Paricá plant can be used in areas that require extraction, degradation, and containment or immobilization of contaminants. With this research, it is possible to investigate the need for more studies that can apply phytoremediation with this type of plant in anthropized places.

Keywords: phytoremediation, parica, environment, contamination.

RESUMO
A fitorremediação é uma técnica que utiliza as plantas para aumentar a dispersão ou estabilizar a poluição no meio ambiente, age decompondo e absorvendo metais pesados pela rizosfera. Sendo propiciada pelo baixo custo, facilidade de implantação, boa aceitação pública e, por não ser invasiva, pode ser aplicada in situ. Assim, o objetivo deste trabalho foi identificar estudos sobre fitorremediação de metais pesados com a espécie *Schizolobium amazonicum* Huber ex Ducke (Paricá) para verificar a sua efetiva colaboração na minimização de danos causados à natureza. A pesquisa foi desenvolvida com base em revisões bibliográficas para verificar se a planta Paricá pode ser utilizada em áreas que requerem extração, degradação e contenção ou immobilização de contaminantes. Com esta pesquisa é possível investigar a necessidade de mais trabalhos que possam aplicar a fitorremediação com este tipo de planta em locais antropizados.

Palavras-chave: fitorremediação, paricá, meio ambiente, contaminação.
1 INTRODUCTION

Terrestrial biodiversity has undergone significant changes in the twenty-first century, causing great concern among researchers in the area. The impacts and losses are many for our Biomes and living beings, caused by advances and technological innovations, which is the improvement in processes and products, through investment in technology, which has generated risk to human health and the quality of our ecosystems, because it aims at "progress" to the detriment of planning.

In Brazil, in recent decades, studies such as those by Inácio et al. (2014), carried out in industrial and commercial areas, have signaled the existence of environmental impacts, since these segments are responsible for the production, storage, and disposal of substances harmful to the environment, such as heavy metals. These are found free or associated with other elements in nature almost always in small concentrations, and are of human interest, as they are applied in the manufacture of various products and objects marketed that bring benefits to society.

As we have realized, it is human needs that have driven the industry to appropriate more and more natural resources. In relation to socio-environmental issues, the problem of our society, reveals a mode of production without sustainability. It is a model that aims at profit and does not consider the consequences and is based on continuous industrial production and mass consumption. Therefore, serious environmental impacts can occur, such as the improper disposal of toxic waste, which is also composed of heavy metals.

Due to the critical context of the relationship between man and nature, considering that heavy metals have characteristics of reacting with other chemical substances and because they cannot be modified or destroyed (bioaccumulative), appropriate methods are sought to mitigate environmental effects. Thus, phytoremediation is a bioremediation technique that emerged to mitigate environmental problems, using plant metabolism to extract, degrade, contain, or immobilize pollutants.

In Brazil, studies have been conducted to treat soils contaminated with herbicides through phytoremediation (Galon et al., 2017, Ferreira et al., 2021, Vasconcelo et al., 2020). In these, it was found that there is a diversity of plants capable of acting in this process, among them ornamental specimens, macrophytes, woody trees, agricultural crops, and grasses (Kaushal et al., 2021 apud Bergamo, Daquila, and Conte, 2022).
The phytoremediation technique can be applied in accidents such as the one that occurred in Brumadinho, Minas Gerais, after the rupture of the dam of the Feijão stream mine and others such as Fundão, in Mariana, which occurred in Brazil, since some plant species have the capacity of hyperaccumulation. Plants that remove, degrade or isolate contaminants are economically viable, as they are not expensive and are a natural method (Ferreira et al., 2022).

Thus, it is essential that remediation and/or isolation measures capable of protecting water resources and soils are studied and adopted to mitigate environmental impacts (Moritta and Moreno, 2021). Therefore, the objective of this work is to describe studies that were carried out on the Paricá (*Schizolobium amazonicum* Huber ex Ducke) and its relationship with phytoremediation, to minimize possible damage caused to the environment through heavy metals.

2 METHODOLOGY

In the search for references, searches were used on platforms such as Scielo, Pubmed, and Google Scholar. For the selection of the descriptors used, we used the following terms: contaminated soils, heavy metals, phytoremediation, Paricá (*Schizolobium amazonicum* Huber ex Ducke), and Biochemistry (Figure 01) in the title or throughout the text and have been published, preferably between the years 2017 and 2022, in Portuguese or English. Next, the researches were read, which were analyzed and discussed later.

The literature review was the narrative, which consists of the systematized way of reviewing the works that exist on the process of phytoremediation of heavy metals, focusing on Paricá. This review model is important to seek updates on a particular subject giving the reviewer theoretical support in a short period. It can also be useful in describing the state of the art of a specific subject, from a theoretical or contextual point of view (Tessmer et al., 2020).
3 RESULTS AND DISCUSSION

3.1 SOILS CONTAMINATED BY HEAVY METALS

Soils are reservoirs of heavy metals important for terrestrial ecosystems. Consequently, understanding the behavior of these elements in the pedosphere is essential to maintain the quality of the environment (Fernandes and Carvalho, 2021).

With this, many studies on environmental contamination, aim to observe the effects of heavy metals and metalloids in soils, plants, animals, and humans. In contaminated soil these substances accumulate in plants, making them inappropriate for human and animal consumption, and are harmful to health and development (Costa et al., 2021).

It is known that activities that use agrochemicals in large quantities and the disposal of urban and industrial waste irregularly, change the levels of heavy metals that exist naturally in the environment, causing soil contamination (Freitas et al., 2020).

Thus, in recent years many remediation technologies (phytotechnologies), including physical, chemical, biological, and combined methods, have been proposed and adopted to mitigate soil contamination. In phytoextraction technology, selecting the appropriate plant species is one of the most important considerations (Venegas-Rioseco, Ginóquio, and Ortiz-Calderón, 2022).
Technological advances, and some changes in the industrial sector, cause impacts on surface and groundwater, soils, and air. However, there are certain species of plants, known as hyperaccumulators that have specific mechanisms to adapt in highly polluted environments, being used to recover and remediate affected areas, this is a biological technique called phytoremediation for contaminated soils (Nawaz et al., 2022).

3.2 EFFECTS OF HEAVY METALS ON SOIL

Heavy metals are naturally present in the soil, meaning they pose no risk to the environment. However, the technological increase and urbanization of recent years have caused a gradual excess of discharge of chemical elements, potentially toxic, which can cause environmental problems of great proportions such as the loss of vegetation, surface water, and contaminated aquifers and direct action on animals (Cogo, Lopes, and Vielmo 2020).

Through industrial, agricultural, and urban processes arise waste, material that has heavy metals in its composition, which is disposed of inappropriately and stays in the environment for decades. Unlike biodegradable pollutants, recalcitrant substances (such as heavy metals) need to be removed, as at high rates they are toxic to living things (Araujo et al., 2019).

For this reason, contamination by heavy metals is a topic of great relevance and brings dangers to living beings. Thus, remedying or minimizing these risks in the environment is important to understand these pollutants and their effects on nature and organisms, which can be indicators of this environmental degradation (Souza, Morassuti, and Deus, 2018).

Thus, in order to remedy soils contaminated by heavy metals, various techniques such as those that depend on the contaminated matrix, the nature of the contaminant, the level of contamination, and the availability of resources have been presented over the years to reduce the levels of these pollutants at environmentally safe levels.

Contamination of areas by heavy metals is common, as a society depends on greater demands for fossil fuels, pesticides, and fertilizers. Traditional methods of recovering these areas are costly. Therefore, phytoremediation becomes a solution to eliminate these contaminants from the soil, through the collection of cultivated plants that extract the elements from the soil in the affected area (May et al., 2020).

To try to reverse the picture of environmental degradation, some studies point out that the phytoremediation technique that uses plants to treat soils contaminated with heavy metals is a
promising and natural alternative for the environment because, in addition to recovering the contaminated area, it promotes the revegetation of the site. This technique is also considered low-cost and easy to perform.

3.3 PHYTOREMEDIATION OF ENVIRONMENTS CONTAMINATED BY HEAVY METALS

Phytoremediation is a biological technique that consists of the removal of heavy metals from contaminated soils. Its use is linked to the ability that certain plants must absorb these chemical elements, making them less harmful. It is a sustainable and economically viable alternative to traditional soil decontamination methods.

Knowledge about phytoremediation emerged from studies on contaminated soils and water. With this technique, we get to know better the species of plants that have the capacity for remediation. The phytoremediation process depends on the characteristics of the contaminant (Morita and Moreno, 2022).

In Brazil, the phytoremediation technique has gained interest and obtained important advances in the field of research. Some studies have applied the technique to treat soils contaminated with herbicides and have observed that various types of plants can be used for this purpose, such as ornamental specimens, macrophytes, woody trees, agricultural crops, and grasses (Bergamo, Daquila, and Conte, 2022).

Although phytoremediation studies use plants with an annual cycle, it is worth highlighting the potential of forest species in programs of this nature and that also, the depth of the root is important to allow the plant to meet the contaminant to clean it later. The different processes involved in the technique rely on the morpho-physiological characteristics of the species and differ from species to species (Silva et al., 2019).

In contaminated soils, phytoremediation may be more conducive to plants that combine remedial capacity with agronomically desirable characteristics, such as rapid growth, easy control, propagation, or eradication. It is a relevant technology for the national reality, as it combines the economic benefits already listed with social and environmental benefits, such as the reduction of interference in ecosystems, the prevention of soil erosion, and the leaching of soil leaching pollutants (May et al., 2020).
3.4 PARICÁ (SCHIZOLOBIUM AMAZONICUM HUBER EX DUCKE)

The Paricá, belonging to the family Fabaceae (Leguminosae), subfamily Caesalpinoideae, species *Schizolobium amazonicum* Huber ex Ducke (Barneby, 1996 Apud Bardiviesso et al. 2019). It is popularly known as bandarra or guapuruvu-da-amazônia is a forest species, present throughout the Amazon region, measuring from 20 to 30 m in height and up to one meter in diameter. It can be used in commercial crops, agroforestry systems, and reforestation of degraded areas, due to its rapid growth and suitable raw material for obtaining cellulose, it has high commercial value (Monteiro et al., 2018 Apud Melo, 2017).

In the State of Pará, the Paricá has a good performance in silvicultural systems. However, it may present variations in the increment in height and diameter, depending on the management adopted (Silva and Sales, 2018). The plantations for its commercialization are concentrated, mainly in the region of Paragominas (Carvalho et al., 2013).

The species *Schizolobium amazonicum* Huber ex Ducke is important for reforestation in the Amazon. This can be demonstrated through the growth of the production of forest species for the recovery of degraded areas and commercial plantations, requiring the use of seedlings with high quality to occur in the forest stand. In this process, it is necessary to evaluate the effects of environmental factors such as light on the behavior of species of different successional groups. It is also important to study the anatomical and physiological parameters of the seedlings of this species under shading that is not yet fully understood (Santos et al., 2022).

The Paricá presents rapid growth, the wood has a high price in the market and is in an intense process of cultivation by the loggers, and can be used to recover immense areas of degraded pastures, as it is possible to analyze in Silva et al. (2022), in this study the results showed a significant development of the species, considered promising for use in the forest restoration process in the Amazon Biome.

3.5 BIOCHEMISTRY

Near industrial complexes and mining areas, the soils are prone to high concentrations of heavy metals, which can cause contamination of agricultural foods, affect the health of the population, and harm the environment by bioaccumulation. Due to the easy flow of metals through the environment, the practice of agriculture can lead to contamination and entry of these into the food chain (Sousa et al., 2021).
Some metals such as Arsenic (As), Cadmium (Cd), Mercury (Hg), Lead (Pb), and Chromium (Cr) even in low concentrations are toxic, bringing problems to agriculture and consequently to human health.

Cadmium is a metal used by many industries and has great soil-plant mobility, which can mess with the physiological and growth parameters of plants. One species that can be affected by cadmium is the Paricá, a tree native to the Amazon region with great social, economic, and environmental potential.

When studying Paricá, Monteiro et al. (2018) under the effect of cadmium, found that the concentrations of this element can be different in their leaf and root organs and that also the absorption of nitrogen can be affected. However, osmoregulatory substances, such as proline, are a strategy to reduce the negative effects of this element. It is possible that the bioaccumulation of the metal is in the root system, but studying the genetic characteristics may be important to understand how the plant resists cadmium in its tissues.

In another research conducted by Merces et al. (2018), the behavior of Paricá was also tested before the effect of different doses of cadmium and corroborates with the results previously described, showing that the Paricá absorbed the metal in the roots, reducing its translocation to the shoot, which contributed to its high tolerance.

Nogueira et al. (2019) in their results obtained data on how cadmium in high concentration can affect several variables of Paricá such as photosynthesis, stomatal conductance, and transpiration. In the plant, the intrinsic efficiency of water use (EiUA) was the variable most affected by water stress, suffering from high concentrations of cadmium in environments with little water. This metal decreased the height, diameter, and number of leaves and leaflets, reaching the synthesis of photoassimilates. The root was the structure with the highest accumulation, but the metal was also found in the shoot, which suggests that plants may have a phytoextractive characteristic in relation to this phytotoxic element.

These studies are important for monitoring cadmium levels in agricultural and industrial environments, to reduce the bad effects of this metal on plants and, consequently, on food production.

The research of Nascimento et al (2018) differently from the others described in this work, made an analysis of the biochemical variables of Paricá in contact with various concentrations of aluminum. Where they observed that in the dosages and time studied there was sensitivity to the
toxicity of the element and that the dose of 75 mg·L$^{-1}$ of aluminum chloride hexahydrate 95% (AlCl$_3$·6H$_2$O) significantly interfered with the biochemical variables. Despite this, there was the resistance of the plant in the 23 days in which it was submitted to aluminum stress, in addition to presenting defense mechanisms that prolonged its physiological activities during exposure to stress.

The research carried out with Paricá is important, since this plant is widely used in the timber industry. With this research it is possible to improve techniques of cultivation and management of plants, aiming at their protection against the toxicity of metals.

4 FINAL CONSIDERATIONS

Phytoremediation is a low-cost technique that has been widely used in environmental contamination processes, but it depends on the choice of plant that among other characteristics must have accelerated growth, pollution tolerance, rapid biomass production, high nutrient absorption capacity, high ecological competitiveness, high translocation rate, accumulate large amounts of reserve substances, be adaptable to climate and soil, have high transpiration capacity and be easily acquired. Thus, it is concluded that although the species *Schizolobium amazonicum* Huber ex Ducke (Paricá) has rapid growth, and that it is promising for use in the forest restoration process in the Amazon Biome. More research is still needed to complement the few existing studies.

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