



PHYTOREMEDIATION OF MERCURY IN SOIL: ANALYSIS OF THE RESPONSES OF *Mimosa pudica* L. AND *Jatropha curcas* L.

Diego Ribeiro Domiciano¹
Lais Palugan Corrêa²
Lucas Rodigheri Hirt Matos³
Michael Renken⁴
Nelson Consolin Filho⁵
José Hilton Bernardino De Araújo⁶

ABSTRACT

Objective: The objective of this work was to investigate the performance of these species in soils contaminated with different concentrations of mercury, evaluating parameters such as germination, stem growth, leaf development, and root characteristics.

Method: The experiment was conducted in the laboratories of Block E of the Federal Technological University of Paraná (UTFPR), Campo Mourão Campus. The soil used was collected near the university, sieved and dried, ensuring uniformity in the substrate.

Results and Discussion: The results obtained demonstrate that the presence of mercury (HgO) in the soil significantly influences the growth of *Mimosa pudica* L. and *Jatropha curcas* L.

Final Considerations: The results obtained indicate that mercuric oxide (HgO) has a specific negative impact on the growth and development of the proven plants, *Mimosa pudica* L. and *Jatropha curcas* L., especially at higher concentrations. These results are in agreement with previous studies, such as that of Sharma et al. (2018), which report that mercury directly interferes with plant physiology, reducing the absorption of essential nutrients and causing oxidative stress.

Keywords: Phytoremediation, Mercury, *Mimosa pudica* L., *Jatropha curcas* L.

FITORREMEDIAÇÃO DE MERCÚRIO NO SOLO: ANÁLISE DAS RESPOSTAS DE *Mimosa pudica* L. E *Jatropha curcas* L.

RESUMO

Objetivo: O objetivo do trabalho foi investigar o desempenho dessas espécies em solos contaminados com diferentes concentrações de mercúrio, avaliando parâmetros como germinação, crescimento do caule, desenvolvimento foliar, e características radiculares.

¹ Universidade Tecnológica Federal do Paraná (UTFPR CM), Campo Mourão, Paraná, Brazil.
E-mail: diegodomiciano@alunos.utfpr.edu.br

² Universidade Tecnológica Federal do Paraná (UTFPR CM), Campo Mourão, Paraná, Brazil.
E-mail: laispalugan@alunos.utfpr.edu.br

³ Universidade Tecnológica Federal do Paraná (UTFPR CM), Campo Mourão, Paraná, Brazil.
E-mail: lucasrodigheri@alunos.utfpr.edu.br

⁴ Universidade Tecnológica Federal do Paraná (UTFPR CM), Campo Mourão, Paraná, Brazil.
E-mail: michaelrenken@alunos.utfpr.edu.br

⁵ Universidade Tecnológica Federal do Paraná (UTFPR CM), Campo Mourão, Paraná, Brazil.
E-mail: consolin@utfpr.edu.br

⁶ Universidade Tecnológica Federal do Paraná (UTFPR CM), Campo Mourão, Paraná, Brazil.
E-mail: jaraujo@utfpr.edu.br



Método: O experimento foi conduzido nos laboratórios do Bloco E da Universidade Tecnológica Federal do Paraná (UTFPR), Câmpus Campo Mourão. O solo utilizado foi coletado nas proximidades da universidade, peneirado e seco, garantindo uniformidade no substrato.

Resultados e Discussão: Os resultados obtidos demonstram que a presença de mercúrio (HgO) no solo influencia significativamente o crescimento da *Mimosa pudica* L. e da *Jatropha curcas* L.

Considerações Finais: Os resultados obtidos indicam que o óxido de mercúrio (HgO) tem um impacto negativo específico no crescimento e desenvolvimento das plantas comprovadas, *Mimosa pudica* L. e *Jatropha curcas* L., especialmente em concentrações mais elevadas. Esses resultados estão de acordo com estudos prévios, como o de Sharma *et al.* (2018), que relatam que o mercúrio interfere diretamente na fisiologia das plantas, reduzindo a absorção de nutrientes essenciais e causando estresse oxidativo.

Palavras-chave: Fitorremediação, Mercúrio, *Mimosa pudica* L., *Jatropha curcas* L.

FITORREMEDIACIÓN DEL MERCURIO EN EL SUELO: ANÁLISIS DE RESPUESTAS A *Mimosa pudica* L. Y *Jatropha curcas* L.

RESUMEN

Objetivo: El objetivo del trabajo fue investigar el comportamiento de estas especies en suelos contaminados con diferentes concentraciones de mercurio, evaluando parámetros como germinación, crecimiento del tallo, desarrollo foliar y características de las raíces.

Método: El experimento se realizó en los laboratorios del Bloque E de la Universidad Tecnológica Federal de Paraná (UTFPR), Campus Campo Mourão. La tierra utilizada fue recolectada cerca de la universidad, tamizada y secada, asegurando uniformidad en el sustrato.

Resultados y Discusión: Los resultados obtenidos demuestran que la presencia de mercurio (HgO) en el suelo influye significativamente en el crecimiento de *Mimosa pudica* L. y *Jatropha curcas* L.

Consideraciones Finales: Los resultados obtenidos indican que el óxido de mercurio (HgO) tiene un impacto negativo específico en el crecimiento y desarrollo de las plantas probadas, *Mimosa pudica* L. y *Jatropha curcas* L., especialmente en concentraciones más altas. Estos resultados están en línea con estudios previos, como el de Sharma *et al.* (2018), quienes reportan que el mercurio interfiere directamente con la fisiología de las plantas, reduciendo la absorción de nutrientes esenciales y provocando estrés oxidativo.

Palabras clave: Fitorremediación, Mercurio, *Mimosa pudica* L., *Jatropha curcas* L.

RGSA adota a Licença de Atribuição CC BY do Creative Commons (<https://creativecommons.org/licenses/by/4.0/>).



1 INTRODUCTION

Soil is one of the most valuable natural resources in the biosphere, playing a fundamental role in sustaining life. It acts as a reservoir of nutrients, harbors a rich microbial biodiversity, regulates the hydrological cycle and contributes to the production of biomass, which is essential for food and other human activities (LONE *et al.*, 2008). In addition, soil plays a critical role in filtering and storing water, sustaining both terrestrial and aquatic ecosystems. Its preservation is essential to ensure environmental balance and quality of life on



the planet.

Despite their importance, soils have been severely impacted by human actions and, to a lesser extent, by natural processes. Activities such as mining, intensive agriculture, improper waste disposal and urbanization have contributed significantly to soil contamination, especially by heavy metals, pesticides and other chemical substances (SHAH, DAVEREY, 2020). These contaminants have altered the physical, chemical and biological structure of the soil, compromising its fertility and ability to support life. In contrast, natural processes such as erosion and leaching can also mobilize pollutants, expanding their reach and environmental impact.

2 THEORETICAL FRAMEWORK

There has been a growing search for effective methods of remediating contaminated soils. Physical and chemical techniques, such as excavation, soil washing and contaminant stabilization, have been widely used, but they are often expensive, invasive and have environmental limitations. In this context, bioremediation has emerged as a sustainable alternative, using living organisms, such as microorganisms and plants, to remove or neutralize emissions in a more natural and lower-cost way (DINIZ *et al.* , 2013).

Bioremediation, which includes techniques such as phytoremediation, offers numerous advantages. This method is economically viable, ecologically sustainable, and capable of remediating large contaminated areas without causing additional damage to the environment (LIU *et al.* , 2018). Among the main phytoremediation mechanisms are phytoextraction, in which plants absorb contaminants through their roots and accumulate them in their aerial parts, phytostabilization, which reduces the mobility of contaminants in the soil, and phytovolatilization, where pollutants are transformed into gases and released into the atmosphere. Despite these advantages, phytoremediation also has limitations, such as the long time required for effective results and the dependence on affected environmental conditions (SUSARLA *et al.* , 2002).

Plants used in phytoremediation need to have specific characteristics to be effective. They must be able to grow quickly, tolerate high levels of contaminants and have extensive root systems. In addition, it is important that they have a high capacity to absorb and accumulate heavy metals in their aerial parts, facilitating their removal from the environment (COUTINHO; BARBOSA, 2007). Studies show that some species accumulate metals at extraordinarily high



levels, and are commonly classified as hyperaccumulative. This ability not only allows soil remediation, but also the possibility of recovering valuable metals for reuse.

Among the most worrying contaminants is mercury. Today, it is still found in high levels in soils around the world due to activities such as artisanal gold mining, use in industrial processes, and application of fungicides (DINIZ *et al.* , 2013). Its presence is extremely toxic to living organisms, impacting soil microbiota and entering the food chain, with adverse effects on human health, such as neurological and kidney problems (SHAH, DAVEREY, 2020). Remediation of soils contaminated with mercury is particularly challenging due to its mobility and persistence in the environment.

The *Jatropha curcas* L. is a plant recognized for its adaptability to adverse conditions, being widely used in phytoremediation studies. Its characteristics include a robust root system, high tolerance to heavy metals and ability to grow in poor and contaminated soils (NUNES *et al.*, 2009). In addition, its biomass can be easily managed after the remediation process, making it a practical and efficient option for environmental decontamination studies.

On the other hand, *Mimosa pudica* L. , also known as dormideira, presents a peculiar behavior of sensitivity to touch, but also has potential for phytoremediation. This plant is capable of growing rapidly in different soil conditions, including in degraded environments. Its high growth rate and adaptability make it a promising species for the study of heavy metal accumulation and recovery of contaminated areas (COUTINHO; BARBOSA, 2007).

The objective of this study was to investigate the performance of these species in soils contaminated with different concentrations of mercury, evaluating parameters such as germination, stem growth, leaf development, and root characteristics. The results of this study contribute to the advancement of phytoremediation techniques and offer alternatives for the management of contaminated areas, promoting environmental sustainability.

3 METHODOLOGY

The experiment was conducted in the laboratories of Block E of the Federal Technological University of Paraná (UTFPR), Campo Mourão Campus. The soil used was collected near the university, sieved and dried, ensuring uniformity in the substrate. The soil was divided into 30 plastic pots, with a capacity of up to 2 kg, containing 1 kg of dry soil each.

For contamination, five different concentrations of mercury were prepared: control (without addition of mercury), 1 g, 5 g, 10 g and 20 g of mercury per pot, in three replicates for each concentration and for each species. The mercury was weighed on an analytical balance,



ensuring precision in the addition of the contaminant to the soil. The mercury was homogeneously mixed with the substrate of each pot, using gloves for protection.

Jatropha seeds curcas L. (Figure 1) were planted at a rate of three seeds per pot, while an equivalent amount of *Mimosa pudica* L. seeds was evenly distributed in each container. Irrigation was standardized with the application of 200 mL of water per pot, carried out twice a week over 50 days. The water was measured with the aid of a beaker, and the pots were placed in natural conditions of light and room temperature.

During the experiment, weekly surveys of the following variables were carried out: number of germinated plants, average stem height and number of leaves per plant. At the end of 50 days, the plants were carefully removed from the soil and evaluated for average root length and weight. Weighing was performed on a semi-analytical balance after removing the samples from their respective pots.

Figure 1

Jatropha curcas L seeds.



4 RESULTS AND DISCUSSIONS

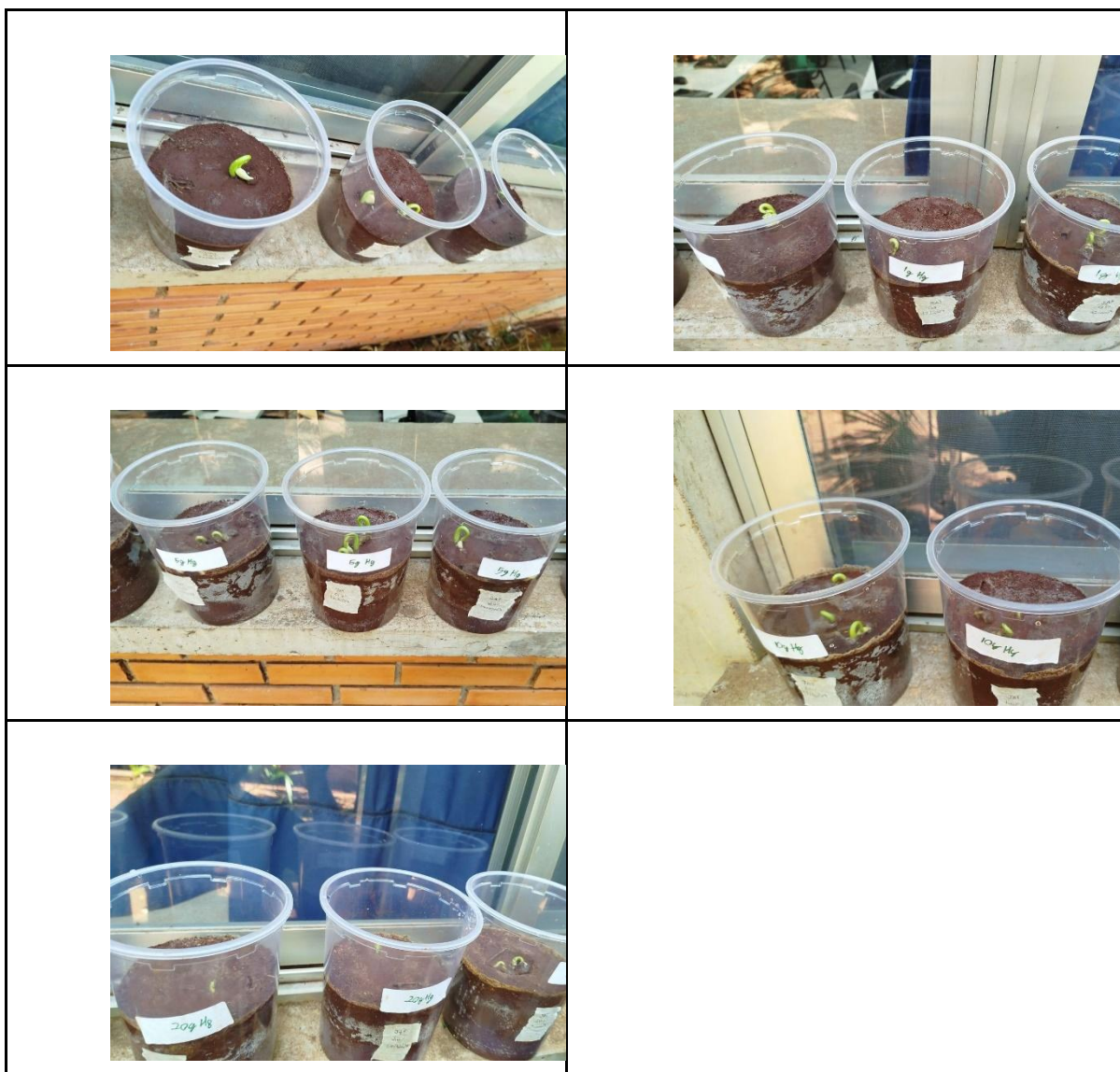
The results obtained demonstrate that the presence of mercury (HgO) in the soil significantly influences the growth of *Mimosa pudica* L. and *Jatropha . curcas* L.

Figures 2 and 3 show the image sets of *Mimosa pudica* L. and *Jatropha curcas* L. .



Figure 2

Set of images from the *Jatropha curcas* L. referent to the day 24 of October of 2024, first week after the planting.



In Table 1, which shows the height of the plants over time, it can be seen that the height of the control samples was always superior the of the plants exposed to the HgO. To *Mimosa pudica* L. , the highest average height at the end of the experiment was 7.33 cm in the control group, while in concentrations of 1 g, 5 g, 10 g and 20 g of HgO, the heights were progressively smaller, with 3.53 cm, 5.47 cm and 2.74 cm, respectively. To *Jatropha curcas* L. , a trend distinct he was observed: the group control reached one height of 14.75 cm, while the groups with 1 g, 5 g, 10 g and 20 g of HgO presented the following measurements being 19.22 cm, 16.66 cm, 12.5 cm and 6.33 cm, respectively. Despite from the reduction node group containing 10 g and 20 g, the *Jatropha curcas* L. it achieved to grow of form relatively satisfactory,



especially in concentrations of 1 g and 5 g, where its height exceeded that of control group.

Figure 3

Set of images from the *Mimosa pudica* L. referent to the day 24 of October of 2024, first week after the planting

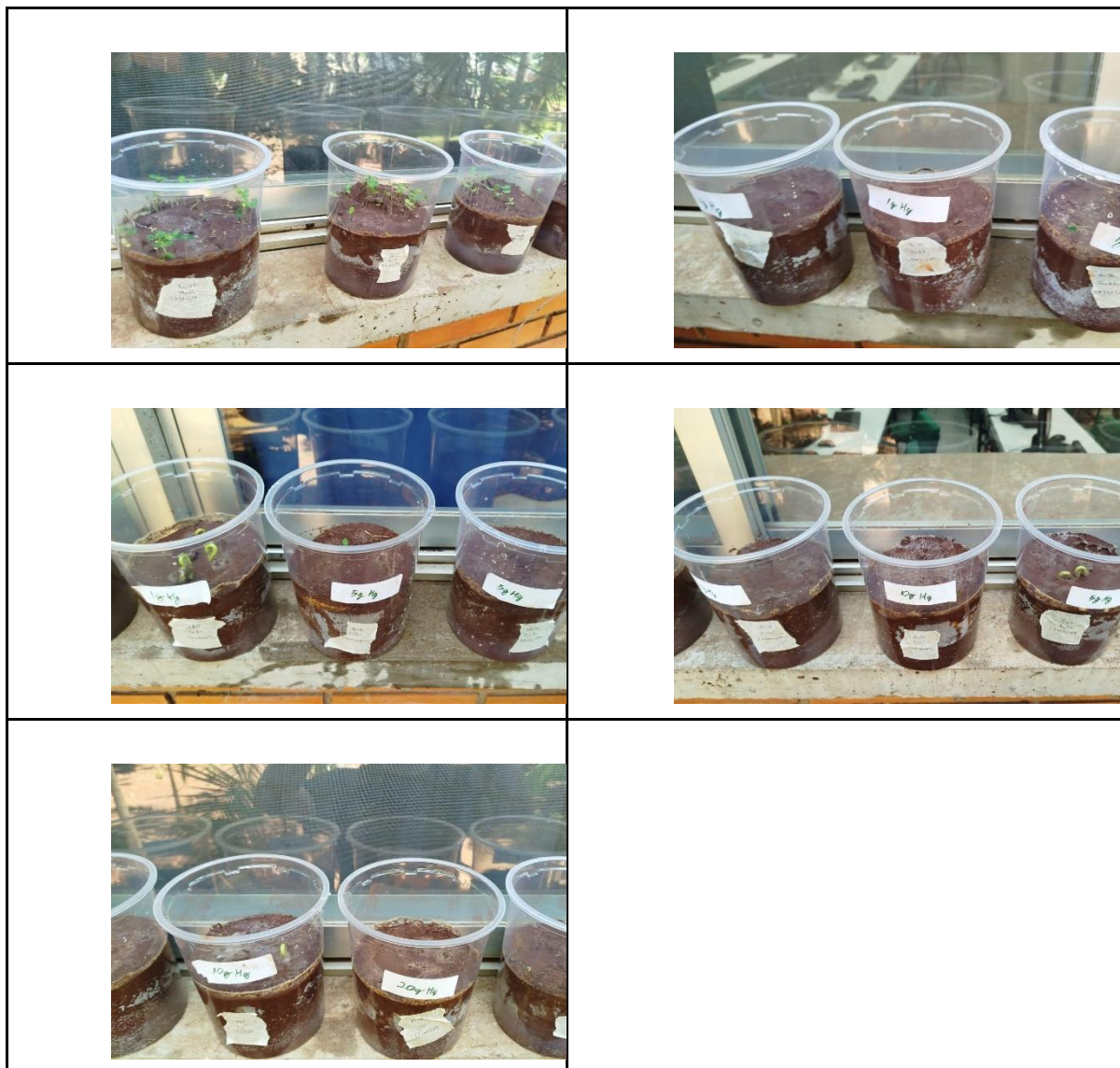


Table 1

Height (cm) of samples.

Date	<i>Mimosa pudica</i> L.					<i>Jatropha curcas</i> L.				
	Control	1 g	5 g	10 g	20 g	Control	1 g	5 g	10 g	20 g
10/17/2024	Day from the plantation of the seeds									
10/24/2024										
10/31/2024	4	2.5	2	2	-	11.38	12.47	12.1	7.04	3.37
7/11/2024	4,73	2,83	3,9	2	1,5	13,26	15,66	15,1	11,33	5,8
14/11/2024	7,23	3,43	4,33	2,5	-	13,86	16	16,16	11,66	6

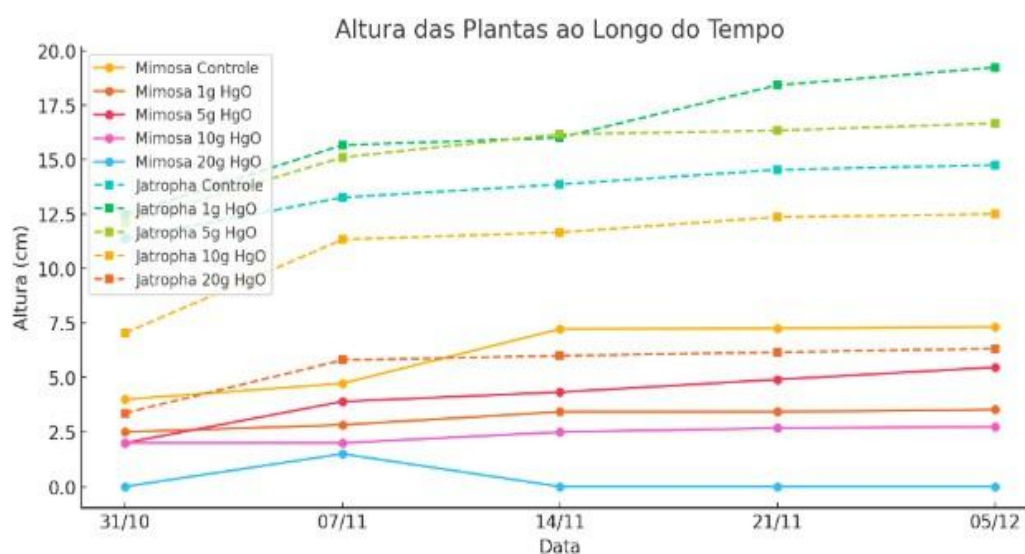


21/11/2024	7,25	3,43	4,91	2,68	-	14,53	18,41	16,33	12,36	6,16
28/11/2024										
5/12/2024	7,33	3,53	5,47	2,74	-	14,75	19,22	16,66	12,5	6,33

The graph (Figure 4) shows the variation in height of the *Mimosa pudica* L. and *Jatropha plants. curcas* L. to far away of five weeks, under different concentrations of HgO node soil. It is observed what the *Mimosa pudica* L presented one growth significantly reduced according to contamination increased. At the end of the experiment, *Mimosa prudish* L of group control reached 7.33 cm, while samples exposed to 1 g, 5 g, 10 g and 20 g of HgO had heights minors, with emphasis on the concentration of 20 g, where there was no growth.

Figure 4

Graphic from the height general of the plants to the far away of study.



Jatropha curcas L. showed a different behavior: at concentrations of 1 g and 5 g of HgO, its growth was even higher than the control group, reaching 19.22 cm and 16.66 cm, respectively. However, at concentrations of 10 g and 5 g of HgO, it grew even more than the control group, reaching 19.22 cm and 16.66 cm, respectively. 20 g, there was one reduction expressive in height, showing that the toxicity of mercury only begins to impact its development at higher levels.

These results indicate that *Mimosa pudica* L. is more sensitive to the Mercury, while the *Jatropha curcas* L. has a higher tolerance, especially at moderate concentrations.

In Table 2, regarding the length of the roots, there was also a reduction associated with the concentration of HgO. For *Mimosa pudica* L. , the root of the control group had an average length of 3.66 cm, while the samples treated with 1 g, 5 g and 10 g of HgO had roots measuring



1.93 cm, 3.37 cm and 2.24 cm, respectively. In *Jatropha curcas* L. , the roots were also smaller with increasing contamination, with emphasis on the control group that reached 7.05 cm, while the groups with 1 g, 5 g and 10 g of HgO presented lengths of 6.33 cm, 7.5 cm and 3 cm, respectively.

Table 2

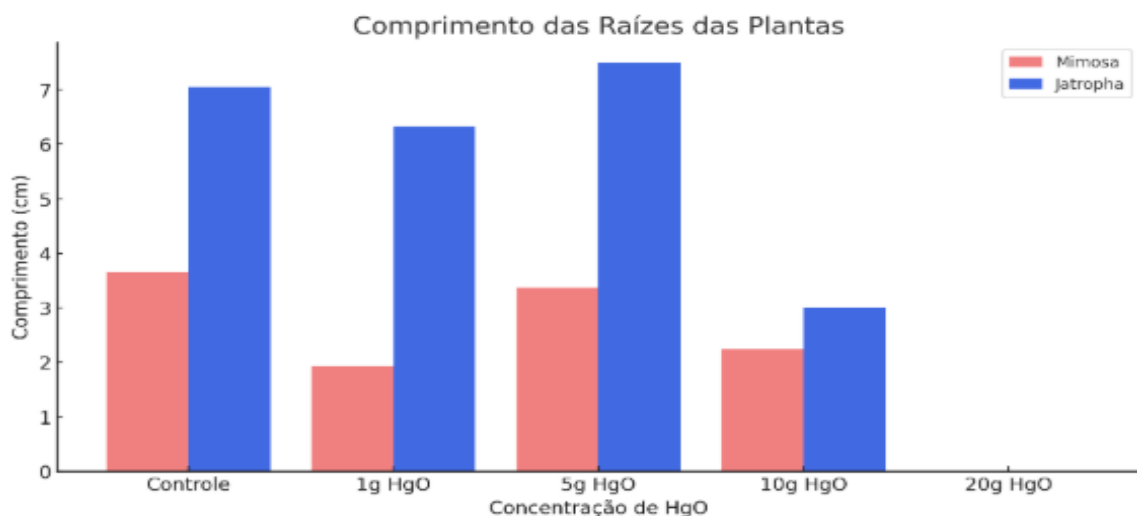
Height (cm) of roots

<i>Mimosa pudica</i> L.					<i>Jatropha curcas</i> L.				
Control	1 g	5 g	10 g	20 g	Control	1 g	5 g	10 g	20 g
3.66 (I made it up)	1.93	3.37	2.24	-	7.05	6.33	7.5	3	-

Analysis of root length (Figure 5) reinforces the trend observed in plant growth.

Figure 5

Graphic of length general of the roots of the plants to the far away of study.



Mimosa pudica L. showed a drastic reduction in root length with increasing HgO concentration, falling from 3.66 cm in the group control to just 1.93 cm at a concentration of 1 g and 2.24 cm in the concentration of 10 g. THE inhibition of growth root suggests that mercury compromises nutrient absorption and directly affects plant development.

Jatropha curcas L. , on the other hand, demonstrated greater resistance to HgO, with one length root relatively stable in the concentrations of 1 g and 5 g (6.33 cm and 7.5 cm, respectively). However, at a concentration of 10 g, the root showed a significant shortening (3 cm), suggesting that mercury toxicity affects its roots only at higher levels. These results



indicate that *Jatropha curcas* L. may be a more efficient species in the phytoremediation of contaminated soils, as its roots can grow even under moderate contamination.

Finally, in Table 3, referring to the mass of the plants, observed again one negative effect of HgO on growth. For *Mimosa pudica* L., the mass of group control was of 0.33 g, while in the groups treated with 1 g, 5 g and 10 g of HgO, the masses were 0.114 g, 0.62 g and 0.315 g, respectively. For *Jatropha curcas* L., although contamination affected its development at higher concentrations, the species demonstrated some resistance to the Mercury, especially in groups of 1 g and 5 g, where the masses (27.41 g) and 30.66 g, respectively) were even higher than that of the control group (17.46 g). Only at the highest concentrations (10 g and 20 g) was there a significant drop in mass, reaching 8.83 g and 1.86 g, respectively.

Table 3

Mass (g) of samples.

<i>Mimosa pudica</i> L.					<i>Jatropha curcas</i> L.				
Control	1 g	5 g	10 g	20 g	Control	1 g	5 g	10 g	20 g
0.33	0.114	0.62	0.315	-	17.46	27.41	30.66	8.83	1.86

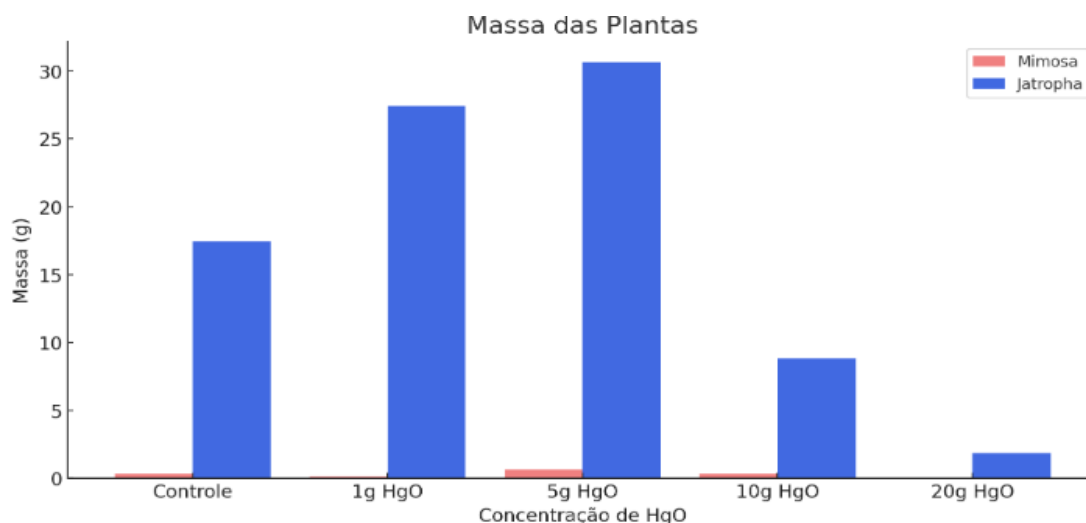
Generally speaking, your results indicate what the Mercury it has one effect inhibitory on the growth of *Mimosa pudica* L. and *Jatropha curcas* L., this effect being more pronounced at higher concentrations. However, *Jatropha curcas* L. demonstrated an ability of growth relatively good in concentrations moderate of HgO (1 g and 5 g), which suggests a greater tolerance to this heavy metal when compared to *Mimosa pudica* L.. The reduction in height, root length and root mass plants reinforces what HgO contamination directly impacts the development of these species, but *Jatropha curcas* L. may present a greater resistance potential under certain conditions.

The plant mass graph (Figure 6) shows the impact of HgO contamination on the total weight of individuals at the end of the experiment.



Figure 6

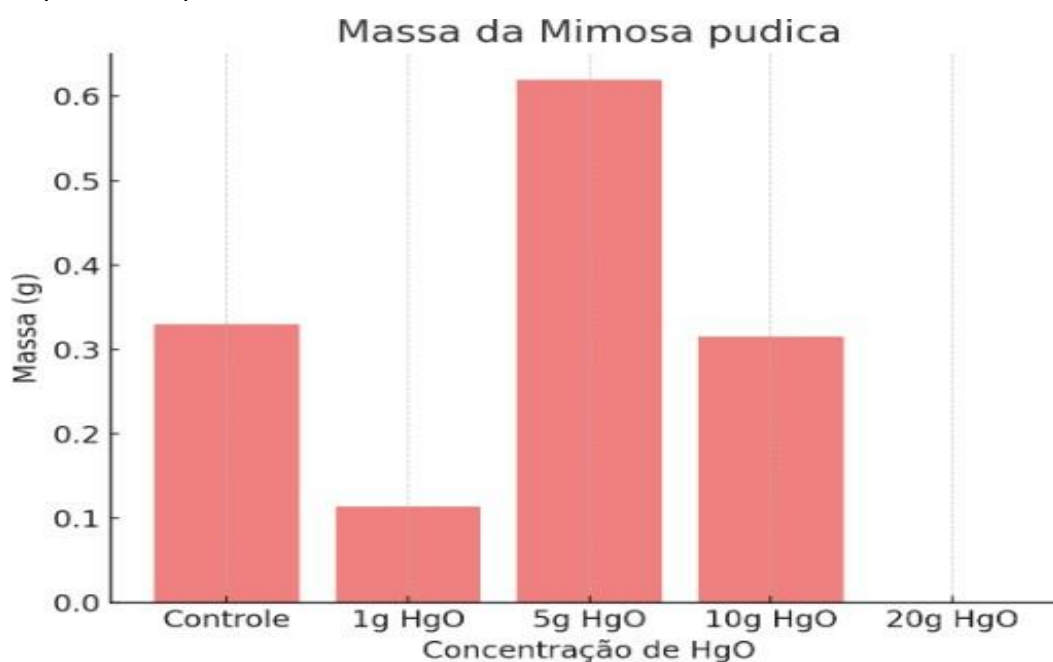
General graph of plant masses



For *Mimosa pudica* L. (Figure 7), the mass decreased significantly as the mercury concentration increased. In the control group, the average mass was 0.33 g, but decreased to 0.114 g in the concentration of 1 g and 0.315 g in the of 10 g. That reinforces the vulnerability from species to contamination.

Figure 7

Graphic from mass from *Mimosa modest* L



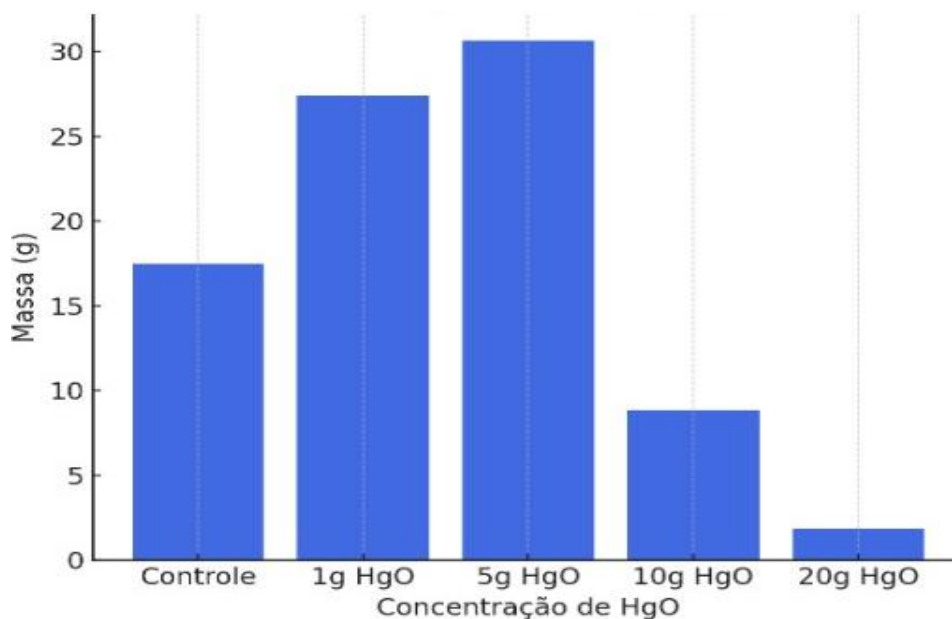
Jatropha curcas L. (Figure 8), in turn, showed interesting behavior. At low and



moderate concentrations (1 g and 5 g), its mass was even greater than that of the group control (27.41 g and 30.66 g against 17.46 g). That result he can indicate one effect growth stimulation at low concentrations of HgO. However, at higher concentrations (10 g and 20 g), the mass it fell drastically, reaching 8.83 g and 1.86 g, respectively.

Figure 8

Graphic from the mass from the *Jatropha curcas* L.



These data suggest that *Jatropha curcas* L. has a greater capacity to adaptation to HgO in moderate concentrations, but also suffers negative impacts when contamination exceeds a certain limit.

The results obtained indicate that mercuric oxide (HgO) has a specific negative impact on the growth and development of the proven plants, *Mimosa pudica* L. and *Jatropha curcas* L., especially at higher concentrations. These results are in agreement with previous studies, such as the of Sharma *and al.* (2018), what report that mercury directly interferes with plant physiology, reducing the absorption of essential nutrients and causing oxidative stress.

Mimosa pudica L. showed greater sensitivity to mercury, with significant drops in both root mass and length at all concentrations tested. In the control group, the root of *Mimosa pudica* L. had an average length of 3.66 cm, while in the concentrations of 1 g, 5 and 10 g of HgO, you values they were reduced to 1.93 cm, 3.37 cm and 2.24 cm, respectively. These data suggest that the root system of *Mimosa pudica* L. is more susceptible to damage caused by the presence of heavy metals in the soil, corroborating studies such as that of Qiu *et al.*



(2011), which highlight the low adaptive capacity of some species to environmental stress caused by metals.

On the other hand, *Jatropha curcas* L. demonstrated greater resistance to moisture at moderate concentrations (1 to 5 g). The average masses of 27.41 g and 30.66 g for these conditions were higher to the of group control (17.46 g). That response he can be associated with the physiological tolerance capacity of *Jatropha curcas* L. to contaminated environments, as reported by Srivastava *et al.* (2016), who demonstrated the potential of this species for phytoremediation in soils contaminated by heavy metals. However, at higher concentrations (10 g and 20 g), there was a significant reduction in root mass and length, establishing a limit on the plant's adaptive capacity.

In addition to its impact on growth, mercury is also absorbed and accumulated in plant tissues, especially in the roots. Studies such as that of Patra and Sharma (2000) highlight that mercury tends to accumulate in systems root due the your interaction with cell walls and bonds with sulfhydryl groups of proteins, the what he can explain the reduction in root growth observed in this study. This accumulation process, although detrimental to the plant, also demonstrates the potential of the proven species, especially *Jatropha curcas* L. , to extract and retain mercury from contaminated soil, an essential characteristic for plants used in phytoremediation.

In general, the reduction in root mass and length reinforces that mercury contamination directly impacts plant development. *Jatropha 's greater tolerance curcas* L. in relation to *Mimosa prudish* L. suggests what there is bigger potential for use in first programs of phytoremediation, especially in environments with moderate levels of mercury.

5 CONCLUSION

The results indicate that *Jatropha curcas* L. shows promising potential for the phytoremediation of mercury-contaminated soils, demonstrating greater tolerance to heavy metal, with growth relatively robust, especially in the concentrations from 1 g to 5 g. The species maintained good development compared to *Mimosa pudica* L. , suggesting a greater capacity for adaptation to contaminated environments.

On the other hand, *Mimosa pudica* L. was more sensitive to the presence of HgO, presenting significant reductions in height, root length and mass, especially at higher concentrations. This response suggests that the species he can be less efficient for phytoremediation in highly contaminated soils, but can still be useful for indicating the



toxicity of mercury in the environment.

Given these findings, we recommend additional studies to evaluate the absorption and accumulation of mercury in different plant tissues, as well as long-term research. deadline to analyze its continued development under contamination.

REFERENCES

- Coutinho, H. L. C.; Barbosa, F.A. (2007). Fitorremediação de solos contaminados. *Revista Brasileira de Ciência do Solo*, v. 1, 9-16.
- Diniz, F.A., *et al.* (2013). A contaminação por mercúrio em ecossistemas terrestres e aquáticos no Brasil. *Revista Ambiente & Água*, v. 2, 64-74.
- Liu, H., *et al.* (2018). Fitorremediação de metais pesados: mecanismos e aplicações. *International Journal of Environmental Research and Public Health*, v. 15, n. 6, 1-23.
- Lone, M. I., *et al.* (2008). Fitorremediação de solos e águas poluídos por metais pesados: progresso e perspectivas. *Environmental Science and Technology*, v. 12, n. 1, 159-170.
- Patra, M., Sharma, A. (2000). Toxicidade de mercúrio em plantas. *Revista Botânica*, v. 66, 379-422.
- Qiu, R., Zhao, X., Tang, Y., Xiong, Y., Xia, Y., Huang, X. (2011). Potencial de plantas ornamentais para fitorremediação de metais pesados em solo contaminado. *Water, Air, & Soil Pollution*, v. 214, n. 1, 111-119.
- Shah, M. I., Daverey, A. (2020). Toxicidade de mercúrio em ecossistemas de solo: efeitos em plantas e técnicas de remediação. *Environmental Science and Pollution Research*, v. 27, n. 1, 1-18.
- Sharma, P., Dubey, R. S. (2018). Toxicidade do chumbo em plantas: efeitos e mecanismos. *Environmental Chemistry Letters*, v. 16, n. 1, 373-398.
- Srivastava, M., Singh, A., Sharma, N. (2016). Fitorremediação de solo contaminado por metais pesados por meio de plantações de *Jatropha curcas* L.. *Environmental Science and Pollution Research*, v. 23, n. 19, 19570-19580.
- Susarla, S., Medina, V. F., Mccutcheon, S.C. (2002). Fitorremediação: uma solução ecológica para contaminação química orgânica. *Ecological Engineering*, v. 18, n. 5, 647-658.