Edição especial – VI Workshop de Inovações Tecnológicas na Agricultura - WINOTEC

ISSN 2359-6562 (ONLINE) 2359-6562 (CD-ROM)

FITOTOXICIDADE AGUDA DE EFLUENTE TÊXTIL IN NATURA EMPREGANDO SEMENTES COMO BIOINDICADORES

LAÍS MONTENEGRO TEIXEIRA[1]; HELLEN LOYSE SOUSA AGUIAR[2]; ALBANISE BARBOSA MARINHO[3]; AMANDA GONDIM CABRAL QUIRINO[4] E ELISÂNGELA MARIA RODRIGUES ROCHA[5]

[1]Depto. de Engenharia civil e ambiental, Universidade Federal da Paraíba (UFPB), Cidade Universitária S/N- Campus 1, Castelo Branco, CEP: 58051-900, João Pessoa – PB, Brasil. ORCID:0000-0001-8146-5982, laismontenegrot@gmail.com
[2]Depto. de Engenharia civil e ambiental, UFPB, Cidade Universitária S/N- Campus 1, Castelo Branco, CEP: 58051-900, João Pessoa – PB, Brasil. ORCID: 0009-0008-9332-4683, hellenloyse5@gmail.com
[3]Depto. de Engenharia civil e ambiental, UFPB, Cidade Universitária S/N- Campus 1, Castelo Branco, CEP: 58051-900, João Pessoa – PB, Brasil. ORCID:0000-0002-8006-2011, albanise.marinho@academico.ufpb.br
[4]Depto. de Engenharia civil e ambiental, UFPB, Cidade Universitária S/N- Campus 1, Castelo Branco, CEP: 58051-900, João Pessoa – PB, Brasil. ORCID:0000-0002-0188-275X, amandagcq@hotmail.com
[5]Profa. Depto. de Engenharia civil e ambiental, UFPB, Cidade Universitária S/N- Campus 1, Castelo Branco, CEP: 58051-900, João Pessoa – PB, Brasil. ORCID: 0000-0001-7024-6979, elis@ct.ufpb.br

RESUMO: Os efluentes têxteis contêm uma ampla gama de poluentes orgânicos e substâncias tóxicas como, corantes e metais pesados, que são necessários para produção de pigmentos do tecido. Esses efluentes quando lançados nos corpos hídricos causam o desequilíbrio ambiental, uma vez que, podem ser bioacumulados ao longo da cadeia alimentar, além de provocarem alterações no aspecto visual dos mananciais. Este estudo consistiu, portanto, em avaliar a fitotoxicidade aguda de um efluente têxtil in natura, realizando testes de germinação para analisar as respostas de organismos vegetais ao efluente. Então, os testes de fitotoxicidade aguda foram realizados com sementes de Pepino (*Cucumis sativus*), Rabanete (*Raphanus sativus*), Tomate (*Solanum Lycopersicum*), Rúcula (*Eruca sativa*) e Algoão (*Gossypium hirsutum*), utilizados como bioindicadores. Os resultados revelaram uma sensibilidade das sementes de pepino ao efluente *in* natura. No entanto, em relação as outras sementes, os resultados obtiveram o aumento da taxa de germinação das sementes e contribuíram para potencializar essa germinação.

Palavras-chaves: Germinação, ecotoxicidade, sensibilidade

ACUTE PHYTOTOXICITY OF IN NATURA TEXTILE EFFLUENT USING SEEDS AS BIO INDICATORS

ABSTRACT: Textile effluents contain a wide range of organic pollutants and toxic substances, such as dyes and heavy metals, which are necessary for the production of fabric pigments. These effluents, when released into water bodies, cause environmental imbalance, as they can be bioaccumulated throughout the food chain, in addition to causing changes in the visual appearance of the water sources. This study therefore consisted of evaluating the acute phytotoxicity of an in natura textile effluent and performing germination tests to analyze the responses of plant organisms to the effluent. Then, acute phytotoxicity tests were carried out with seeds of cucumber (Cucumis sativus), radish (Raphanus sativus), tomato (*Solanum lycopersicum*), Arugula (Eruca sativa) and cotton (*Gossypium hirsutum*), which were used as bioindicators. The results revealed the sensitivity of cucumber seeds to raw effluent. However, in relation to other seeds, the results revealed an increase in the seed germination rate, which contributed to enhancing germination.

Keywords: Germination, ecotoxicity, sensitivity

Recebido em 03/12/2024 e aprovado para publicação em 12/12/2024
DOI: http://dx.doi.org/10.17224/EnergAgric.2024v39p74-80

1 INTRODUCTION

In Brazil, the textile industry is a fundamental pillar of the socioeconomic scenario, with a significant turnover of R$194 billion in 2021, according to data from the Brazilian Textile and Clothing Industry Association (Abit, 2022). However, this importance is accompanied by considerable environmental challenges, such as high water consumption and the disposal of contaminants in ecosystems, especially aquatic environments (Kishor *et al*., 2021).

The release of industrial effluents into the ecosystem is largely unregulated and untreated and is on the rise to satisfy the demand of the population for commercial products. The ecotoxicological effects are more pronounced, affecting the flora and fauna of the biosphere and, ultimately, putting public health safety at risk. The discharge of effluents into the environment begins mainly in aquatic systems, making them entry points into ecosystems (Saravanakumar *et al*., 2022; Tounsadi *et al*., 2020).

The disposal of textile effluents can result in the depletion of dissolved oxygen in water bodies, can cause chronic diseases, and can have mutagenic effects, since the polluting compounds in the composition of dyes can bioaccumulate along the food chain, in addition to causing changes in the visual aspects of water sources, thus triggering an imbalance in ecosystems (Altohamy). *et al*., 2022; Dutta; Bhattacharjee, 2022). The low biodegradability of textile effluents is generally attributed to the existence of recalcitrant organic products, including dyes, which are widely used in various industrial sectors (Oyeniran; Sogbanmu; Adesalu, 2021; Wu *et al*., 2021).

Phytotoxicity tests can be used to evaluate the response of test organisms to toxic components present in the effluent. The application of these tests requires the selection of sensitive organisms with wide availability and significant ecological representation (Lei *et al*., 2018; Santana *et al*., *2018).* Phytotoxicity tests provide a static assessment of acute toxicity, allowing the analysis of adverse effects on the seed germination process and initial seedling development. In addition, they have low implementation costs and present rapid results (Oliveira; Baldan, 2022; Dhaouefi *et al*., 2019).

Therefore, the present study aims to evaluate the acute phytotoxicity of natural textile effluent using cucumber seeds (*Cucumin sativus*), radish (*Raphanus sativus*), tomato (*Solanum lycopersicum*), Arugula (*Eruca sativa*) and cotton (*Gossypium hirsutum*) as bioindicators. The results obtained will be crucial not only for understanding the potential effects of this effluent on the environment but also for providing information for the textile industry and environmental regulatory agencies.

2 MATERIALS AND METHODS

Germination tests were performed with cucumber seeds (*Crocumin sativus*), radish seeds (*Raphanus sativus*), tomato seeds (*Solanum lycopersicum*), Arugula seeds (*Eruca sativa*) and cotton seeds (*Gossypium hirsutum*), adapting methodologies used by Sobrero and Ronco (2004). For this purpose, Petri dishes (90 mm) lined with qualitative filter paper soaked with 6 mL of the liquid sample were used. Ten seeds were randomly placed on each plate and subsequently sealed and incubated in the dark at 22 ± 2 °C in a BOD incubator for 120 days. After this period, the plants were removed from the incubator, and the roots and stem length of the seedlings were measured.

The *in natura* textile effluent used was diluted to percentages of 5%, 10%, 15%, 25% and 50%, and all tests were performed at the Environmental Sanitation Laboratory of the Federal University of Paraíba (UFPB) in triplicate. For each test, 3 plates were used as negative controls with distilled water.

With the collected data, statistical analysis of the average length of each seedling was performed via Dunnett's test (for comparison with the control group) and coefficient of variation, and the germination index (GI) was obtained according to Soares *et al*. (2013), explicit in Equation (1).

$$IG\ (\%) = \left(\frac{\underline{NS}_{GA} * CPa}{\underline{NS}_{GB} * CPb}\right) \times 100 \qquad (1)$$

where CPb is the average length of the seedlings (hypocotyl + radicle) in the negative control; CPa is the average length of the seedlings in the effluent dilution samples; NSGA is the number of germinated seeds in the dilution samples; and NSGB is the number of germinated seeds in the negative control.

After the data were obtained, due to the application of the values obtained in the phytotoxicity tests, the qualitative phytotoxicity classification scale was proposed by Soares *et al*. (2013) was considered, as shown in Table 1.

Table 1. Germination index classification

IG (%)	Classification of the material under analysis
> 100	The material enhances germination and root growth of plants
80-100	Nonphytotoxic; matured compost
60-80	Moderately phytotoxic
30-60	Phytotoxic
< 30	Very Phytotoxic

GI- Germination index
Source: Adaptation of Soares *et al*. (2013)

3 RESULTS AND DISCUSSION

The results obtained with the test using the effluent *in* natura, shown in Table 2, were carried out to determine how much the effluent affected the germination of the seeds and how sensitive these seeds were.

The control group (CN) presented values above 90% germination for cucumber and arugula, 77% germination for radish, and 83% germination for tomato and cotton. The coefficient of variation (C_V) remained below 30%, except for tomato and cotton, confirming the heterogeneous distribution of the data resulting from the diluted samples of textile effluent and its deleterious effects on seed germination.

The results of the phytotoxicity test revealed that the *in* natura effluent diluted in distilled water to 50% was moderately phytotoxic and phytotoxic for the germination of only the cucumber seeds, as shown in Figure 1. For the other seeds analyzed, there was an increase in their germination, indicating that they are resistant to the textile effluent analyzed.

Table 2. Results and statistics of the phytotoxicity test of the *in natura* textile effluent with seeds of cucumber, radish, Arugula, tomato and cotton

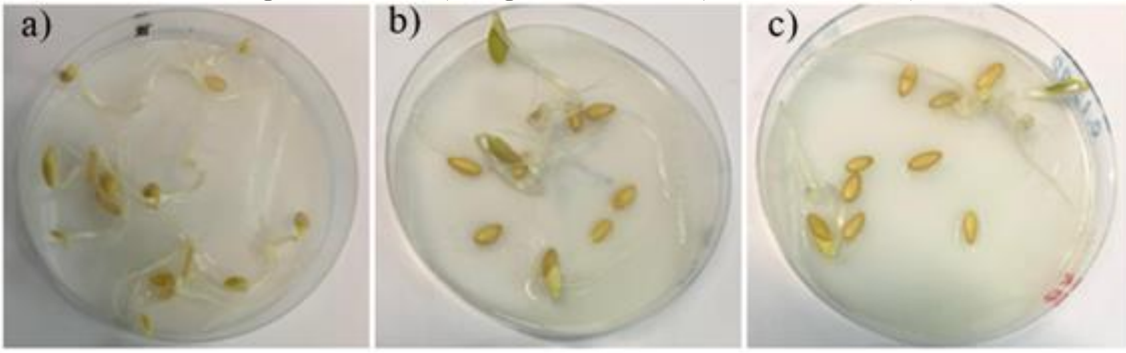
Indexes	Seed	CN	Dilution percentage				
			5%	10%	15%	25%	50%
CM (cm)	Cucumber	7.6	11.05	10.93	9.00	11.44	13.80
	Radish	12.73	12.49	13.23	15.67	15.68	16.83
	Arugula	5.01	5.80	6.47	6.76	6.42	8.16

	Tomato	4.12	3.86	4.93	5.78	4.19	5.83
	Cotton	1.88	2.74	1.67	2.35	2.09	3.25
CV (%)	Cucumber	18	17.00	8.00	8.00	7.00	11:00
	Radish	28	31.00	30.00	35.00	41.00	40.00
	Arugula	29	25.00	35.00	27.00	43.00	32.00
	Tomato	41	47.00	47.00	30.00	48.00	39.00
	Cotton	55	54.00	103.00	63.00	84.00	35.00
IG (%)	Cucumber	97	85.21	39.68	32.47	37.87	57.10
	Radish	77	106.66	108.44	123.09	128.56	132.22
	Arugula	100	100.20	103.26	121.34	106.78	130.25
	Tomato	83	82.54	124.25	129.10	97.67	124.44
	Cotton	83	122.77	78.34	110.43	102.28	131.70

CM- average seedling length; Cv- coefficient of variation; IG- germination index; CN- negative control.
Source: Authorship (2024)

As presented, Engelhardt *et al.* (2020) reported the resistance of radish to effluent toxicity compared with that of other seeds. In addition, the study by Hoss *et al*. (2019) demonstrated the good sensitivity of cucumber seeds in phytotoxicity tests with crude leachate, with a germination rate of 49.61%.

Figure 1. Cucumber seed germination: a) Negative control b) 10% dilution c) 50% dilution

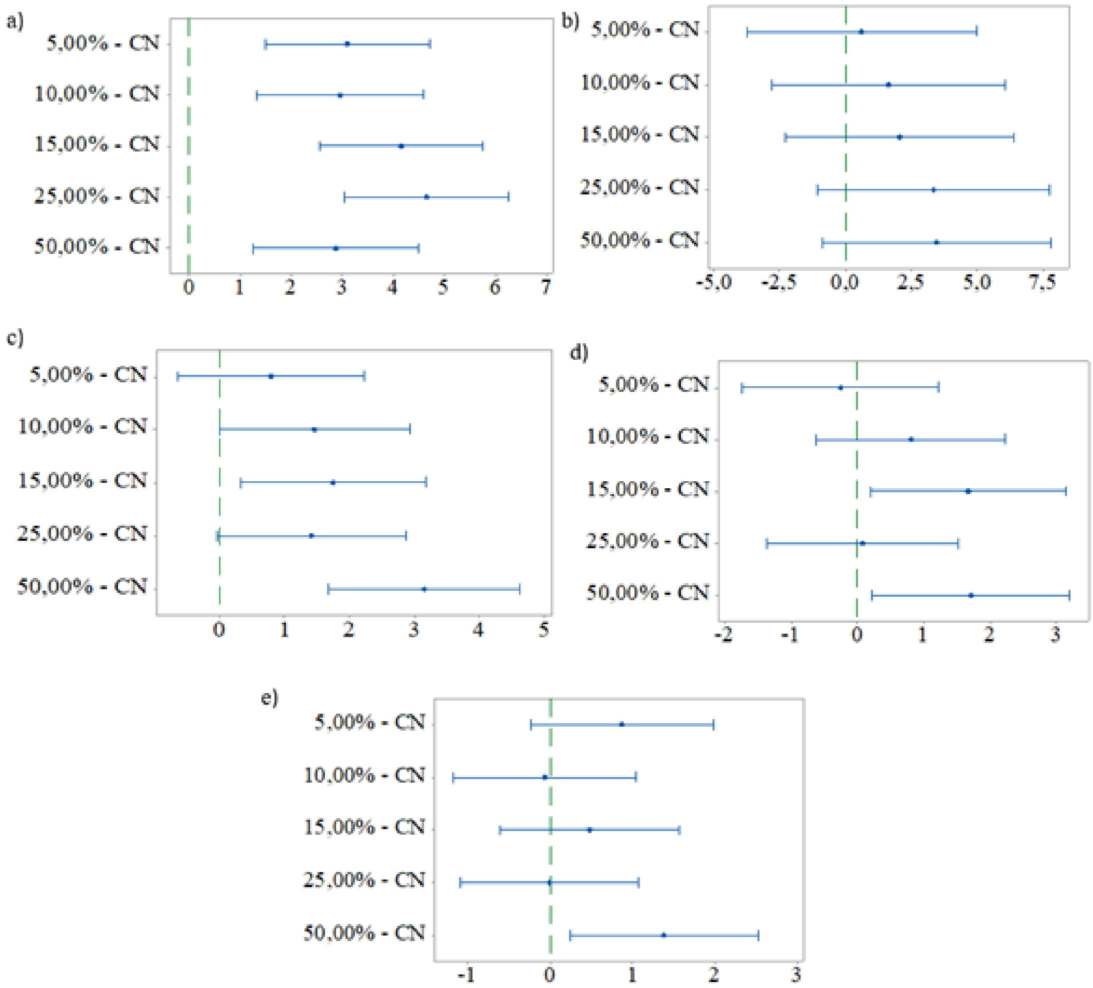


Source: Authorship (2024)

Figure 2 shows the statistical analysis of the data for cucumber, radish, arugula, tomato and cotton according to the *Dunnett test for the in natura* effluent.

When the seedling growth data were compared with the control data, the average length of the seedlings at all dilutions of the fresh cucumber seed effluent *differed* significantly in relation to that of the control group, according to *Dunnett's test* (α=0.05), because if an interval does not contain the zero (0) shown in the graph, the corresponding average will be significantly different from the control average.

Figure 2. Dunnett's test with *in* natura effluent and bioassays with the seeds: a) cucumber b) radish c) Arugula d) tomato e) cotton.



Source: Authorship (2024)

However, the statistical results of most dilutions of the other seeds, according to *Dunnett's test*, of the seedling lengths are similar to those of the negative control, becoming completely similar for radish.

4 CONCLUSIONS

The results of acute phytotoxicity tests using *raw* textile effluent revealed that it is necessary to carry out prior treatment before its final disposal, since it can be harmful to the environment and inhibit seed germination, as is the case with cucumber. It is also suggested that chronic phytotoxicity tests be carried out to confirm the germination potential of radish, arugula, tomato and cotton seeds, taking into account the longer life cycle of the plant, to verify the greater influence on seed germination.

5 REFERENCES

ABIT. **Perfil do setor**. São Paulo: Abit, 2022. Disponível em: https://www.abit.org.br/cont/perfil-do-setor. Acesso em: 13 nov 2023.

AL-TOHAMY, R.; ALI, S. S.; LI, F.; OKASHA, K. M.; MAHMOUD, Y. A. G.; ELSAMAHY, T.; SUN, J. A critical review on the treatment of dye-containing wastewater: Ecotoxicological and health concerns of textile dyes and possible remediation approaches for environmental safety. **Ecotoxicology and Environmental Safety**, Lagos. v. 231, article 113160, p. 1-17, 2022.

DHAOUEFI, Z.; TOLEDO-CERVANTES, A.; GHEDIRA, K.; CHEKIR-GHEDIRA, L.; MUÑOZ, R. Decolorization and phytotoxicity reduction in an innovative anaerobic/aerobic photobioreactor treating textile wastewater. **Chemosphere**, Amsterdã, v. 234, p. 356-364, 2019.

DUTTA, S.; BHATTACHARJEE, J. A comparative study between physicochemical and biological methods for effective removal of textile dye from wastewater. **Development in Wastewater Treatment Research and Processe**, Haldia, p. 1-21, 2022.

ENGELHARDT, M.M.; LIMA, F.R.D.; MARTINS, G.C.; VASQUES, ICF; SILVA, AO; OLIVEIRA, JR; REIS, R.H.C.L.; WILLIAM, LRG; MARQUES, JGS Phytotoxicity of copper in agricultural crops grown in tropical soils. **Semina** : Agricultural Sciences, Londrina, v. 41, n. 6, supplement 2, p. 2883-2393, 2020.

HOSS, L.; LOEBENS, L.; SANTOS, NR; SCHOELER, G.P.; SILVEIRA, M. Effect of ozonation on the phytotoxicity of landfill leachate. *In* : South American Congress on Solid Waste and Sustainability, 2nd, 2019, Foz do Iguaçu . **Proceedings** […]. Bauru, SP: IBEAS, 2019. p. 1-6.

KISHOR, R.; PURCHASE, D.; SARATALE, GD; SARATALE, RG; FERREIRA, LFR; BILAL, M.; CHANDRA, R.; BHARAGAVA, RN Ecotoxicological and health concerns of persistent coloring pollutants of textile industry wastewater and treatment approaches for environmental safety. **Journal of Environmental Chemical Engineering** , Lucknow , vol. 9, n. 2, article 105012, p. 1-18, 2021.

LAW, C.; SUN, Y.; TSANG, DCW; LIN, D. Environmental transformations and ecological effects of iron-based nanoparticles. **Environmental Pollution** , Amsterdam, v. 232, p. 10-30, 2018.

OLIVEIRA, FG; BALDAN, LT **Fundamentals of Ecotoxicology** : principles and applications. Palotina: UFPR, 2022.

OYENIRAN, DO; SOGBANMU, TO; ADESALU, TA Antibiotics, algal evaluations and subacute effects of abattoir wastewater on liver function enzymes, genetic and hematological biomarkers in the freshwater fish, Clarias gariepinus . **Ecotoxicology and Environmental Safety** , Lagos, v. 212, article 111982, p. 1-8, 2021.

SANTANA, R.M.R.; BIRTH, GE; SILVA, P.K.A.; LUCENA, ALA; PROCOPIUS, TF; NAPOLEON, TH; DUARTE, M.M.B.; NAPOELÃO, DC Kinetic and ecotoxicological evaluation of the direct degradation of orange 26 dye by Fenton and solar photoFenton processes . **Electronic Journal of Management, Education and Environmental Technology** , São Luís, v. 22, n. 5, p. 1-20, 2018.

SARAVANAKUMAR, K.; SILVA, S.; SANTOSH, S. S.; SATHIYASEELAN, A.; GANESHALINGAM, A.; JAMLA, M.; WANG, M. H. Impact of industrial effluents on the environment and human health and their remediation using MOFs-based hybrid membrane filtration techniques. **Chemosphere**, Amsterdã, v. 307, parte 1, article 135593, p. 1-8, 2022.

SOARES, M. R.; MATSINHE, C.; BELO, S.; QUINA, M. J.; QUINTA-FERREIRA, R. Phytotoxicity evolution of biowastes undergoing aerobic decomposition. **Journal of Waste Management**, Amsterdã, v. 2013, n. 1, article 479126, p. 1-8, 2013.

SOBRERO, M. C.; RONCO, A. Acute toxicity test with lettuce seeds (Lactuca sativa L. **)** . *In* : MORALES, GC **Toxicological tests and water quality assessment methods :** standardization , intercalibration , results and applications . Jiutepec : IMTA. 2004. p. 71-79.

TOUNSADI, H.; METARFI, Y.; TALEB, M.; EL RHAZI, K.; RAIS, Z. Impact of chemical substances used in textile industry on the employee’s health: epidemiological study. **Ecotoxicology and Environmental Safety,** Lagos, v. 197, article 110594, p. 1-8, 2020.

WU, L.; XU, Y.; LV, X.; CHANG, X.; MA, X.; TIAN, X.; SHI, X.; LI. X.; KONG, X.

Impacts of an azo food dye tartrazine uptake on intestinal barrier, oxidative stress, inflammatory response and intestinal microbiome in crucian carp (Carassius auratus). **Ecotoxicology and Environmental Safety**, Lagos. v. 223, article 112551, p. 1-8, 2021.