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Environment

Effluent disposal on soil as an sustainable alternative: a integrative review on its agricultural effects

Disposição de efluentes em solo como uma alternativa sustentável: uma revisão integrativa nos efeitos da agricultura

Larissa Barcelos Campos[I], Guilherme Sgobbi Zagui[I], Marília Vasconcellos Agnesini[I]

[I] Universidade de Ribeirão Preto, Ribeirão Preto, SP, Brasil

ABSTRACT

The objective of this article was to evaluate the effect of wastewater disposal on soil based on scientific evidence. For this purpose, an integrative review was conducted in two databases using the cross-referenced terms “irrigation,” “wastewater,” “effluent,” “soil,” and “disposal.” To meet the eligibility criteria established in this study, the papers, in addition to having been published in the last three years, had to address the effects of effluent irrigation on agricultural crops and present original results. The vast majority of the texts evaluated showed an increase in various metals on soil after irrigation with effluents (some with previous treatment and others untreated). Nevertheless, when considering the availability of organic nutrients in the soil, it was possible to identify benefits for both fertility and agricultural productivity, including an increase in the yield of secondary agricultural products. The variation in the results of the studies evaluated is justified by the different effluent matrices and their characteristics, as well as by the agricultural culture in which they will be applied. In this way, the data obtained show that the reason for wastewater reuse is becoming increasingly relevant, and to prevent this from resulting in environmental damage or even risks to public health, it is necessary to consider the changes and effects pointed out in the physical environment.

Keywords: Agriculture; Wastewater irrigation; Environmental impacts

RESUMO

O presente artigo teve como objetivo avaliar o efeito da disposição de águas residuárias em solo mediante evidências científicas. Com esse intuito, foi realizada uma revisão integrativa em duas bases de dados utilizando o cruzamento de termos “irrigação”; “águas residuárias”; “efluente”; “solo”; e “disposição”. Para atingir os critérios de elegibilidade estabelecidos neste trabalho, os estudos, além de terem sido publicados nos últimos três anos, deveriam abordar os efeitos da irrigação de efluentes em culturas agrícolas e apresentar resultados originais. A grande maioria dos textos avaliados evidenciou o aumento de diversos metais no solo após a irrigação com efluentes (alguns com tratamento prévio e outros não). Ainda assim, ao se considerar a disponibilização de nutrientes orgânicos no solo, foi possível identificar benefícios tanto para a fertilidade quanto para a produtividade agrícola, inclusive no aumento do rendimento de produtos secundários da agricultura. A variação nos resultados dos trabalhos avaliados se justifica pelas diferentes matrizes de efluentes e suas características bem como pela cultura agrária em que eles serão aplicados. Dessa forma, os dados obtidos mostram que a razão para o reúso de águas residuais se torna cada vez mais relevante, e para evitar que isso resulte em danos ambientais ou mesmo em riscos para a saúde pública, é necessário considerar as alterações e efeitos apontados no meio físico.

Palavras-chave: Agricultura; Irrigação de água residuária; Impactos ambientais

1 INTRODUCTION

Almost 70% of the world's freshwater is used for agricultural activities, mainly for crop irrigation, justified by the need to produce commodities and food, which are necessary for the development of society (FAO, 2020). Climate change, pollution of rivers and groundwater, population growth, and globalization have led to water supply shortages and degraded water quality, affecting the proper use of these resources. The agricultural system contributes to pollution, as pesticides have been found in various Brazilian compartments, such as water, soil and food (Oliveira et al., 2023), because Brazil is the largest consumer and importer of pesticides (Figueirêdo et al., 2020; Souza et al., 2020). In addition to these challenges, another issue stands out: water scarcity, which has become a major problem for productivity (Kama et al., 2023).

In this context, irrigation using wastewater has become a common agricultural practice worldwide to mitigate the effects of water scarcity (Castor et al., 2023). The reuse of effluents, whether treated or not, is considered an alternative to alleviate water deficit in the irrigation of crops, owing to its large volume of release, as well as the supply of nutrients to the soil–plant system (Giudici, Marco & Olivera, 2023). Although this may seem beneficial at first, fertigation of effluents can also be a source of soil and groundwater contamination, depending on the characteristics of the application matrix, which in turn are influenced by its source and the efficiency of removal during effluent treatment, when applicable (Khan et al., 2023; Gonçalo-Filho et al., 2023).

Therefore, it is necessary to carry out studies to assess the effects of effluent disposal on crops, soil, and other natural resources. Moreover, in a cyclical system such as the environment, the connectivity between the use of groundwater/surface water (direct or indirect) and agricultural products can spread adverse effects, which may impact human health; For that reason, this study also assessed such impacts. Several studies from Chinese, Indian, and European academics indicate water management in all cycles of use; yet, studies in nations like Brazil are still limited in significant projections of water scarcity (Rodrigues et al., 2020).

Issues like food production and the demand for irrigation water are topics of discussion addressed by the United Nations (UN) in the *Sustainable Development Goals (SDGs)*, regarding Goal 6 (Ensure availability and sustainable management of water and sanitation for all), and Goal 2 (End hunger, achieve food security and improved nutrition, and promote sustainable agriculture) (UN, 2015). Thus, it is important to seek practices that ensure the protection of the environment and the basic needs of the world population. Considering this, the main objective of this research was to conduct an integrative literature review on the effects of the disposal of both treated and untreated effluents on soil under crop cultivation.

2 MATERIALS AND METHODS

Several studies focused on the treatment and disposal of urban and industrial effluent, and its use in crops; however, it is important to use a scientific method to consolidate and analyze these results critically, corroborating current legislation and consolidating this hypothesis that is not very widespread. In this context, the integrative review directly assists the outcome of this article, which involves numerous studies. Its rigorous method underpins scientific research, and the systematic presentation of results provides a synthesis of knowledge to both practical and market applications (Mendes, Silveira & Galvão, 2019).

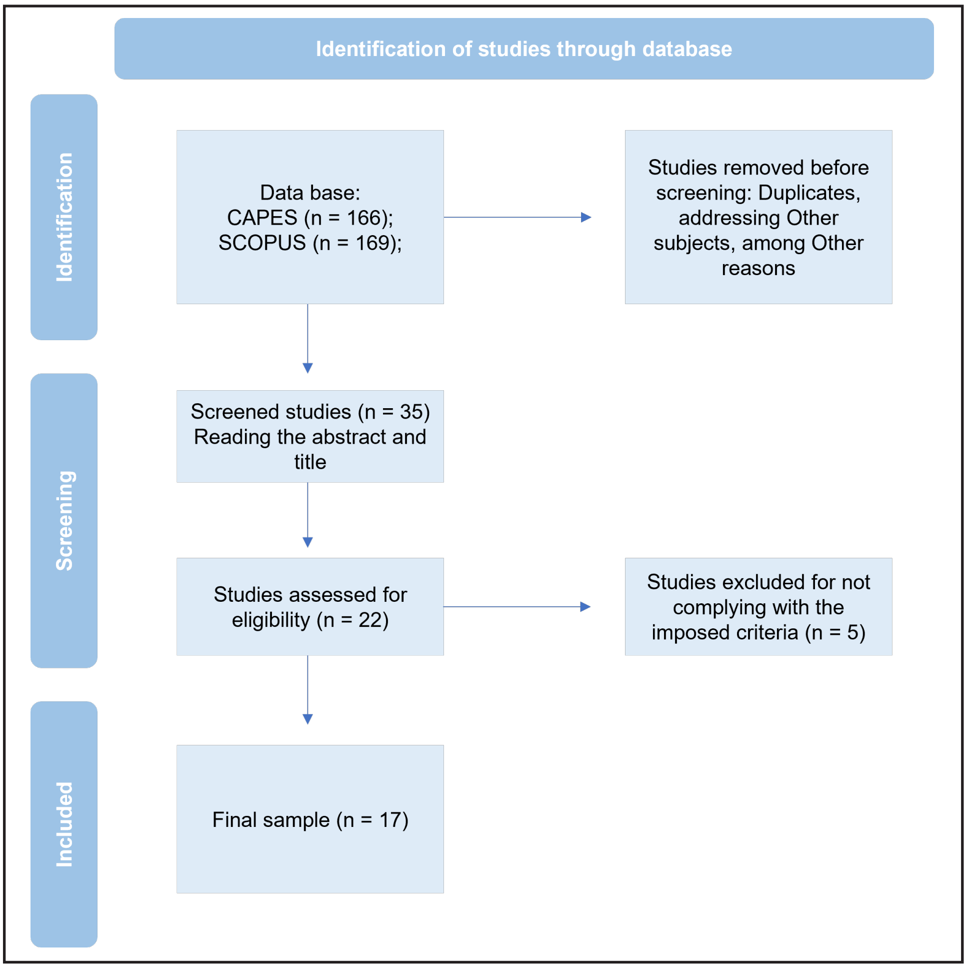
This work employed an integrative review methodology, focusing on studies that analyzed the effects of disposing of treated and raw effluents on agricultural crops and plants. To this end, five stages were followed: 1) identifying the problem and formulating a hypothesis; 2) selecting the samples to be reviewed, 3) defining the characteristics of the studies; 4) analyzing the results; and 5) presenting the results and the review.

The study was carried out in June 2023 using the CAPES (*Brazilian Federal Agency for Support and Evaluation of Graduate Education*) data platform and the international Scopus database. Three elements of the PICO strategy were applied to form the guiding hypothesis: P (problem) related to the disposal of effluents on agricultural land, I (intervention) associated with the treatment of effluents, and O (outcome) related to the environmental impact of this disposal. This resulted in the following guiding question: What is the extent of treated and raw effluent disposal on agricultural soils and its potential environmental impact?

Both databases used descriptors/keywords combined with the Boolean operator AND, namely “Irrigation”, “Wastewater”, “Effluent”, “Soil”, and “Disposal”. The searches were done in English to maximize the reach. The search strategy is shown in Table 1.

As inclusion criteria, the following guidelines were used to select the studies: studies had to be in English or Portuguese, original, freely available, published within the last three years (2020 - 2023), and entirely related to the topic of interest cited. The articles selected had to present a chemical, physical, or biological assessment on the effects of effluents disposal on soil, with the presence of waste such as sewage sludge (a compound frequently found in research) as an exclusion criterion. Books, legislation, operating guides and manuals, duplicate documents, review articles or any other material that did not meet the guiding question were excluded. Files that met the inclusion criteria were exported and analyzed. The most relevant articles were selected considering the results found and the coherence of the content (soil parameters), so that the evaluation of the integrative review could be as comparative as possible. As a result, 35 publications were initially identified and, after the final selection, 17 publications were selected. Figure 1 shows the stages involved in screening the papers.

Figure 1 – Flowchart for identifying and selecting scientific articles



Source: Authors, 2023

Table 1 – Search strategy on data platforms

Database	Descriptors used	Results
CAPES Platform	Irrigation AND industrial wastewater | 2023	166
SCOPUS	Disposal AND industrial AND effluent AND soil | 2020-2023	107
	irrigation AND industrial AND wastewater | 2023	62
Total		335

Source: Authors, 2023

Finally, it was possible to catalog the data from each scientific article regarding the results obtained on the effects of adding effluents to crops, the origin of the effluent, and the purpose of the disposal. Additionally, the countries in which the studies were carried out were considered to understand the complexity and worldwide demand for the subject.

3 RESULTS

In all the 17 selected articles, changes in the soil after irrigation with wastewater or after a period of non-application of wastewater were reported: 53% of the articles showed negative changes in the soil, 12% found both negative and positive changes for the soil or plants, and 35% reported positive changes. One article evaluated the ability of the soil to recover after irrigation was stopped.

Most of the articles (76%) were published in 2023, demonstrating the importance of solving the problem of water scarcity in irrigation in line with environmental pollution control. Among the selected articles, 13 directly associated the reuse of effluent for irrigation with water shortages and semi-arid climates.

The studies were carried out in 12 countries from different economic strata (1 developed (Germany), 3 emerging (Brazil, China, and India), and 8 underdeveloped (Argentina, West Bank, Egypt, Iran, Mexico, Pakistan, Tunisia, and Turkey), which highlights the relevance and scope of wastewater reuse. Research in this area is directly linked to the main water economies of these countries, which are based on agricultural production, and as mentioned above, require around 70% of the world's fresh water. Table 2 shows the results from the selected articles.

Table 2 – Synthesis of the evidence on the effects of effluent irrigation in agricultural areas (Continued)

Author(s) and year	Soil disposal methodology	Origin of the effluent	Observed effects
Ahmed et al., 2023	Irrigation	Dye industry	Presence of heavy metals above the recommended values by WHO, and bioaccumulation factor in plants.
Dolu & Nas, 2023	Irrigation	Urban effluent treatment plant	Presence of anti-inflammatory precursors and metabolites in the soil and in the plants grown in the soils evaluated.
Giudici, Marcos & Oliveira, 2023	Irrigation	Fishing industry	Increased microbial life, the presence of salts, and other microbial communities from similar soils began to inhabit this soil.
Carlos et al., 2022	Irrigation	Leather industry effluent treatment plant	Availability of nitrogen, BOD, potassium, calcium, magnesium, and increased sodium in the soil.
Mosa et al., 2023	Irrigation	Paper industry	High concentration of metals in eucalyptus soil and lower concentration of these metals in soil where eucalyptus had been harvested.
Karthika et al., 2021	Irrigation	Dye industry	The cohesion of the soil was damaged.
Haddad, Nassar & Shtaya, 2023	Irrigation	Untreated urban effluent	Values higher than permitted for heavy metals in the barley roots and values within the permitted range in the soil.
Khan et al., 2023	Irrigation	Untreated urban and industrial effluent	Nickel values within standard limits.
Oueslati et al., 2023	Irrigation	Poultry meat industry	General improvement in the quality of the soil and an increase in heavy metals in both the fruit and the soil.
Ahmed et al., 2023	Irrigation	Industrial effluent	Concentrations of toxic metals in tomato plants, bioaccumulation in the roots, increased nutrients in the soil, and increased productivity.
Soltani-Gerdefaramarzi et al., 2023	Surface and subsurface irrigation	Urban effluent treatment plant	Increase in nutrients in the soil by the subsurface irrigation method using permeable tubes and greater water absorption in lavender crop.
Castor et al., 2023	Irrigation	Urban effluent treatment plant	Increased levels of organic carbon in the soil.

Table 2 – Synthesis of the evidence on the effects of effluent irrigation in agricultural areas (Conclusion)

Author(s) and year	Soil disposal methodology	Origin of the effluent	Observed effects
Kama et al., 2023	Irrigation	Livestock industry effluent treatment plant	Increased availability of nutrients in the soil, higher corn yields, and partial absorption of heavy metals present in the soil in corn crops.
Nawaz et al., 2021	Irrigation	Urban-industrial wastewater treatment plant	Heavy metal contamination in the soil, reduced wheat growth and increased nitrate levels in the plant.
Gonçalo-Filho et al., 2023	Irrigation	Diluted untreated urban effluent	Improved cotton fiber quality, increased plant growth and productivity.
Haoyu et al., 2023	Irrigation	Rural mixed pond	Reduction in dissolved organic carbon and phosphorus in the soil in all its layers, increase in microbial diversity in the surface layers, changes in microbial activities, and reduction of microorganisms along the depth of the soil profile.
Asadzadeh, Ghavam & Mirzaei, 2023	Irrigation	Untreated urban effluent	Increased mint productivity and higher yields of essential oil.

Source: Authors, 2023

4 DISCUSSION

Wastewater reuse for agricultural purposes, which uses surface irrigation as the main form of application in agriculture, is in high demand. Of the studies evaluated, 94% reported that irrigation was applied superficially, with only one article evaluating and comparing superficial and subsurface irrigation.

Soltani-Gerdefaramarzi et al. (2023) demonstrated that the subsurface irrigation method using permeable tubes is more efficient at availing nutrients in the soil and ensuring greater water absorption in lavender crops from treated domestic effluent. However, using large-scale volumes with this method may be unfeasible in practice, as is commonly the case in industrial operations and urban effluent treatment plants in large cities.

The selected papers show a homogeneous interest in the use of industrial effluents (eight cases) and urban effluents (six cases). The other three studies deal with mixed wastewater in their composition: urban, industrial, and even hospital effluent. Industries from various sectors utilize their effluent for agricultural reuse, given the volume of water collected and, consequently, the generation of effluent, which meets, to an extent, the need for water and some nutrients in the field; however, it also impacts the local ecosystem. The effects of this use are directly associated with the origin of the effluent and its chemical, physical, and biological characteristics.

Of the studies evaluated, eight found heavy metals in the soil or plants. In a research carried out in Egypt by Ahmed et al. (2023) on the disposal of effluent from the dye industry in agricultural areas, lead, zinc, chromium, cadmium, nickel, and arsenic concentrations higher than those recommended by the World Health Organization (WHO) were found in the wastewater. The soil followed the same trend, with a high contamination factor for lead and chromium. The authors showed that the pollution also affected plants, demonstrating a critical bioaccumulation factor for metals. Oueslati et al. (2023) analyzed the concentration of various chemical elements from the family of metals and minerals in olive tree crops—both in the fruit and oil—irrigated by effluent from the poultry meat industry. The results indicated an accumulation of chromium, aluminum, vanadium, strontium, barium, titanium, and nickel in the olives, and the same metals were detected in the olive oil above the recommended standards for the product. Other metals such as cadmium, nickel, iron, chromium, and lead were found in barley roots when sanitary effluents were disposed on agricultural soil (Haddad, Nassar & Shtaya, 2023). Nawaz et al. (2021) also found chromium, nickel, and cadmium in grain crops using irrigation from treated urban and industrial wastewater.

Given the above, there is evidence of mobility of metals in the soil from effluent disposal in agriculture on different crops. Concentrations above the recommended standards were reported, indicating risks to the environment. Some studies have reported metals in leaf mass, roots, fruit, and even derived products, some of which are intended for animal or human consumption, posing health risks.

Despite the warning that these studies provide, there is also the perception of the phytoremediation capacity that plants have, some more than others. This presents possibilities for decontamination studies in degraded areas. In Mosa et al. (2023), lower concentrations of nickel and cadmium were detected in soils where eucalyptus trees had been planted, while in exposed soils (the area had already been cleared) the concentrations were higher, showing that part of these elements had been absorbed by the planted trees.

Regarding assessments of the physical structure of the soil in areas where effluent from the dye industry was used, Karthika et al. (2021) identified changes in soil cohesion after shear tests, whereas in control areas, which were not irrigated with the effluent, the soil structure was firmer and with less potential for disintegration.

In contrast to the studies that found negative aspects in soil and plants, (mainly metals), there are also benefits in productivity and soil fertility. For vegetative growth, there are essential macro and micronutrients, which are not always supplied by the soil in the quantities required for the plants. Fertilizers are commonly used to supplement these compounds. Effluent, whether treated or not, has many of these necessary nutrients, making it a form of reuse that favors not only an alternative way of disposing of wastewater, but also a supply of water and nutrients for the soil–plant system. Asadzadeh, Ghavam and Mirzaei (2023) showed not only an increased mint plantation productivity, but also a higher yield and quality of the essential oil extracted from fields cultivated with raw urban effluent fertigation.

In the same way, Gonçalo-Filho et al. (2023) observed better quality in cotton fibers from areas irrigated with untreated and diluted urban effluent, which was associated with increased productivity and plant growth. In a control area irrigated with water from a well, there was a discrepancy in the results, with better performance in fertigation with effluent. The addition of nitrogen, potassium, and phosphorus to the soil from sewage favored photosynthesis, in addition to the accumulation and translocation of carbohydrates to the fruit in the cotton plant, resulting in good fiber yields, among other benefits highlighted by the author.

Carlos et al. (2022) confirmed the gains from fertigation using treated effluent from the leather industry, pointing to greater availability of nitrogen, organic matter, potassium, and magnesium in the soil of corn crop, where the sandy soil was degraded. They observed benefits not only for plant growth, but also for the restoration of degraded areas. Analyzing the impact of reusing wastewater on the biological environment of soil, Dolu and Nas (2023), Giudici, Marco and Oliveira (2023), and Haoyu et al. (2023) studied changes in the existing microbiota and the introduction of new microorganisms from effluent. Essentially, more changes were found in the existing environment than new pathogens.

Giudici, Marcos, and Oliveira (2023), observed the emergence of new microbial communities owing to changes in the characteristics of the soil, such as the one caused by dumping of fishing effluent on the soil, which results in salinization of the environment. Despite a period without irrigation, the environment did not show a clear recovery to its original state in biological terms, but a new type of soil appeared to be forming.

Having considered the chemical, physical, and biological biases reported by the studies, changes in the natural environment caused by the disposal of effluent can be observed, especially heavy metals that bioaccumulate in vegetative crops and their respective products, which are the characteristics most evident in the studies. Disposing of effluent on soil should be considered a good practice in terms of reuse and the circular economy; however, other factors must be assessed to avoid undesirable consequences for the environment and human health. Among these factors, the origin and characteristics of the effluent are important in the initial diagnosis of the agronomic potential and environmental contamination. In addition, the characteristics of the site to be irrigated and the crop must be studied and considered in terms of compatibility with the wastewater to be disposed on the soil.

5 CONCLUSION

Both benefits and harm to the soil–plant system from irrigation with effluent have been reported, highlighting the dangers that this practice poses to the environment and public health when consuming agricultural products. However, one must consider the premises that bring this subject: the water crisis, for example. Some factors need to be considered, such as the origin and characteristics of the effluent, the presence or absence of prior treatment, the regional water supply, and the characteristics of the crop and/or soil in which the effluent is to be disposed. Even so, studies on this subject are extremely important in advancing the feasibility of reusing wastewater in agriculture.

REFERENCES

Ahmed, D. A. E., Slima, D. F., Al-Yasi, H. M., Hassan, L. M., & Galal, T. M. (2023). Risk assessment of trace metals in *Solanum lycopersicum* L. (tomato) grown under wastewater irrigation conditions. *Environmental Science and Pollution Research, 30*, 42255–42266. https://doi.org/10.1007/s11356-023-25157-8

Ahmed, R. S., Abuarab, M. E., Ibrahim, M. M., Baioumy, M., & Mokhtar, A. (2023). Assessment of environmental and toxicity impacts and potential health hazards of heavy metals pollution of agricultural drainage adjacent to industrial zones in Egypt. *Chemosphere, 318*, 137872. https://doi.org/10.1016/j.chemosphere.2023.137872

Asadzadeh, M., Ghavam, M., & Mirzaei, R. (2023). The effect of irrigation with treated and untreated wastewater on the yield and chemical composition of essential oil of *Mentha spicata* L. and *Rosmarinus officinalis* L. *Environmental Science and Pollution Research, 30*, 46175–46184. https://doi.org/10.1007/s11356-023-25398-7

Carlos, F. S., Schaffer, N., Tedesco, M. J., Weinert, C., Reginato, J. L., de Sousa, R. O., Boechat, C. L., Andreazza, R., & Camargo, F. A. O. (2022). Chemical attributes of percolate from degraded sand soil irrigated with treated industrial wastewater. *Environmental Quality Management, 31*, 19–29. https://doi.org/10.1002/tqem.21749

Castor, C. P., Gastélum-Strozzi, A., Sammartino, S., Michel, E., Vicente, J., & Prado, B. (2023). Long-term (>90 years) wastewater irrigation effect on the pore characteristics and stability of soil aggregates. *Geoderma, 434*, 116469. https://doi.org/10.1016/j.geoderma.2023.116469

Dolu, T., & Nas, B. (2023). Dissemination of nonsteroidal anti-inflammatory drugs (NSAIDs) and metabolites from wastewater treatment plant to soils and agricultural crops via real-scale different agronomic practices. *Environmental Research, 227*, 115731. https://doi.org/10.1016/j.envres.2023.115731

Figueirêdo, L. P., Athayde, D. B., Daam, M. A., van Gestel, C. A. M., Guerra, G. S., Duarte-Neto, P. J., & Espíndola, E. L. G. (2020). Impact of temperature on the toxicity of Kraft 36 EC® (a.s. abamectin) and Score 250 EC® (a.s. difenoconazole) to soil organisms under realistic environmental exposure scenarios. *Ecotoxicology and Environmental Safety, 194*, 110446. https://doi.org/10.1016/j.ecoenv.2020.110446

Food and Agriculture Organization of the United Nations. (2020). *The state of food and agriculture 2020: Overcoming water challenges in agriculture*. FAO. https://doi.org/10.4060/cb1447en

Giudici, P., Marco, M., & Olivera, N. L. (2023). Effects of the cessation of fish-processing effluent discharges on the soil microbiome associated with saltbush patches. *Applied Soil Ecology, 187*, 104832. https://doi.org/10.1016/j.apsoil.2023.104832

Gonçalo-Filho, F., Ferreira-Neto, M., Fernandes, C. S., Dias, N. S., Holanda, J. S., Barros-Júnior, A. P., Medeiros, J. F., & Sá, F. V. S. (2023). Domestic sewage effluent increases plant growth, yield, and fiber quality of cotton cv. BRS 335. *Journal of Natural Fibers, 20*(1), 2146914–2146926. https://doi.org/10.1080/15440478.2022.2146914

Haddad, M., Nassar, D., & Shtaya, M. (2023). Heavy metals accumulation in soil and uptake by barley (*Hordeum vulgare*) irrigated with contaminated water. *Scientific Reports, 13*, 4121. https://doi.org/10.1038/s41598-022-18014-0

Haoyu, C., Bo, Y., Tao, Z., Bo, L., Chunxue, Z., & Xiaocheng, W. (2023). Rural mixed pond water irrigation affected microbial community and eco-enzymatic stoichiometry of soil profiles. *Applied Soil Ecology, 188*, 104863. https://doi.org/10.1016/j.apsoil.2023.104863

Kama, R., Liu, Y., Song, J., Hamani, A. K. M., Zhao, S., Li, S., Diatta, S., Yang, F., & Li, Z. (2023). Treated livestock wastewater irrigation is safe for maize (*Zea mays*) and soybean (*Glycine max*) intercropping system considering heavy metals migration in soil–plant system. *International Journal of Environmental Research and Public Health, 20*, 3345. https://doi.org/10.3390/ijerph20043345

Karthika, T., Shalini, S., Kothai, P. S., & Arumugam, K. (2021). Impact of dyeing industry effluents on geotechnical properties of soil. *Journal of Physics: Conference Series, 2070*(1), 012233. https://doi.org/10.1088/1742-6596/2070/1/012233

Khan, Z. I., Ahmad, K., Ahmad, T., Zafar, A., Alrefaei, A. F., Ashfaq, A., Akhtar, S., Mahpara, S., Mehmood, N., & Ugulu, I. (2023). Evaluation of nickel toxicity and potential health implications of agriculturally diversely irrigated wheat crop varieties. *Arabian Journal of Chemistry, 16*, 104934. https://doi.org/10.1016/j.arabjc.2023.104934

Mendes, K. D. S., Silveira, R. C. C. P., & Galvão, C. M. (2019). Use of the bibliographic reference manager in the selection of primary studies in integrative reviews. *Text & Context Nursing, 28*. https://doi.org/10.1590/1980-265X-TCE-2017-0204

Mosa, A., Hawamdeh, O. A., Rady, M., & Taha, A. A. (2023). Ecotoxicological monitoring of potentially toxic elements contamination in *Eucalyptus* forest plantation subjected to long-term irrigation with recycled wastewater. *Environmental Pollution, 329*, 121739. https://doi.org/10.1016/j.envpol.2023.121739

Nawaz, H., Anwar-ul-Haq, M., Akhtar, J., & Arfan, M. (2021). Cadmium, chromium, nickel and nitrate accumulation in wheat (*Triticum aestivum* L.) using wastewater irrigation and health risks assessment. *Ecotoxicology and Environmental Safety, 208*, 111685. https://doi.org/10.1016/j.ecoenv.2020.111685

Oliveira, M. P. de, Silva, A. B. S., Rigueto, C. V. T., Loss, R. A., Guedes, S. F., & Geraldi, C. A. (2023). Pesticides in different environmental compartments in Brazil: A review. *Ciência e Natura, 45*, e2. https://doi.org/10.5902/2179460X70715

United Nations. (2015). *Agenda 2030 for sustainable development*. https://brasil.un.org/pt-br/91863-agenda-2030-para-o-desenvolvimento-sustent%C3%A1vel

Oueslati, A., Dabbou, S., Methneni, N., Montevecchi, G., Nava, V., Rando, R., Bartolomeo, G., Antonelli, A., Di Bella, G., & Ben Mansour, H. (2023). Pomological and olive oil quality characteristics evaluation under short time irrigation of olive trees cv. Chemlali with untreated industrial poultry wastewater. *Sustainability, 15*(5), 4198. https://doi.org/10.3390/su15054198

Rodrigues, T. V., Vasconcelos, A. M., Ferreira, D. D. M., Araujo, A. R. M., & van Bellen, H. M. (2020). Water use, reuse and treatment in the food industry: A theoretical study. *Ciência e Natura, 42*, e79. https://doi.org/10.5902/2179460X42099

Soltani-Gerdefaramarzi, S., Alemzadeh, A., Yarami, N., & Dehestani-Ardakani, M. (2023). The effects of irrigation methods and water quality on soil chemical properties and leaf nutrient uptake of *Lavandula angustifolia* L. in an arid region. *Journal of Plant Growth Regulation, 42*, 1256–1265. https://doi.org/10.1007/s00344-022-10627-z

Souza, M. F., Langaro, A. C., Passos, A. B. R. J., Lins, H. A., Silva, T. S., Mendonça, V., Silva, A. A., & Silva, D. V. (2020). Adsorption mechanisms of atrazine isolated and mixed with glyphosate formulations in soil. *PLOS ONE, 15*(11), e0242350. https://doi.org/10.1371/journal.pone.0242350

Authorship contributions

1 – Larissa Barcelos Campos

Graduated in Environmental Engineering from the São Paulo State University Júlio de Mesquita Filho
https://orcid.org/0009-0007-7418-5553 • larissa.campos@sou.unaerp.edu.br
Contribution: Conceptualization, Methodology, Software, Validation, Data curation, Formal analysis, Investigation, Visualization, Resources, Project administration, Writing - original draft, Writing – review & editing

2 – Guilherme Sgobbi Zagui

PhD in Public Health Nursing from the University of São Paulo
https://orcid.org/0000-0002-6104-4360 • gszagui@unaerp.br
Contribution: Methodology, Writing – review & editing

3 – Marília Vasconcellos Agnesini

PhD in Environmental Technology from the University of Ribeirão Preto
https://orcid.org/0000-0002-2388-6735 • magnesini@unaerp.br
Contribution: Supervision, Writing - review & editing

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