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Articles

Soil contamination by the use of fence posts treated with chromated copper arsenate

Contaminação do solo pelo uso de moirões tratados com arseniato de cobre cromatado

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ABSTRACT

The chemical components used to treat fence posts with chromated copper arsenate (CCA) leach from the wood and have the potential to contaminate soil, surface water and groundwater, be absorbed by plants and, consequently, pose risks to animals and human health, which makes its use questionable. The present work aimed to evaluate soil contamination through the use of fence posts chemically treated with chromated copper arsenate type C. To this end, five fence posts of *Eucalyptus* spp., previously treated industrially with chromated copper arsenate, were planted in the field. To evaluate soil contamination, a cross section was removed from each fence post and the soil was collected, before the experiment was set up and after the end of the field evaluations. Throughout the experiment, six soil collection evaluations were carried out (1, 94, 226, 318, 460 and 880 days) at two depths (0 to 20 cm and 20 to 40 cm). The wood preservative chemical constituents leached from the fence posts into the soil. The arsenic concentration of the fence posts showed a reduction of 55.0%. The concentration of arsenic in the soil increased by 129.2%, being 32.3% higher than the maximum value for investigation in the agricultural sector, according to CONAMA resolution 420/2009, demonstrating potential risks of contamination, direct or indirect, to human health.

Keywords: Wood preservation; Wood treatment; Chemical leaching; CCA-C

RESUMO

Os componentes químicos utilizados para tratar moirões com arseniato de cobre cromatado (CCA) lixiviam da madeira e apresentam potencial de contaminação do solo, águas superficiais e subterrâneas, uma vez que podem ser absorvidos pelas plantas e, consequentemente, representar riscos para animais e a saúde humana, tornando seu uso questionável. O presente trabalho teve como objetivo avaliar a contaminação do solo pela utilização de moirões tratados quimicamente com CCA tipo C. Para isso, foram implantados à campo cinco moirões de *Eucalyptus* spp., os quais foram previamente tratados sob vácuo-pressão com CCA em autoclave industrial. Para avaliar a contaminação do solo foram realizadas seis amostragens (1º dia, 94, 226, 318, 460 e 880 dias) em duas profundidades (0 a 20 cm e 20 a 40 cm), além da retirada uma secção transversal de cada moirão no momento da instalação e no término do experimento. Os constituintes químicos preservativos da madeira lixiviaram para o solo, uma vez que a concentração de arsênio dos moirões apresentou uma redução de 55,0% e a do solo aumentou 129,2%, valor 32,3% maior que o máximo de investigação no setor agrícola, de acordo com a resolução do CONAMA 420/2009, demostrando riscos potenciais de contaminação, diretos ou indiretos, à saúde humana.

Palavras-chave: Preservação da madeira; Tratamento químico; Lixiviação; CCA-C

1 INTRODUCTION

Planted forest wood treated with preservative products is an excellent alternative for use in urban and rural construction systems, as well as for sleepers on railway lines and power transmission structures. This is justified not only because it is a renewable and sustainable material, but because the treatment extends its useful life and allows any type of traditional finish.

In order for the natural durability of wood to be increased, it is essential to preserve it through chemical treatments, especially when exposed to attack by xylophagous organisms or physical, chemical and/or mechanical agents. For this, there are different wood treatment processes used commercially, with those using vacuum and pressure with a water-soluble chemical solution of chromated copper arsenate (CCA) being the most used and effective (Santos; Ferrarini; Pires; Azevedo; Coudert; Blais, 2020), as they can extend the useful life of wood by more than 50 years for the most varied purposes (Mohajerani; Vajna; Ellcock, 2018).

Currently, there is little information regarding the amount of wood that is destined for preservative treatment in Brazil. According to the Brazilian Tree Industry

(IBÁ, 2019), it is estimated that the production of treated wood in the country was 1.4 million m³ in 2018 and continues to grow every year. The multiple use of this preserved material can be exemplified in the rural (posts, stakes and rural installations), electrical (posts and crosspieces), railway (sleepers), civil construction (round and sawn parts, tiles, structures) sectors and for other purposes, such as automotive flooring and exports (Vidal; Evangelista; Silva; Jankowsky, 2015), with the vast majority coming from the *Eucalyptus* genus. The preference for using species of this genus is linked to some advantages, such as rapid growth and annual increase, adequate mechanical properties and sapwood with good permeability, which allows for satisfactory preservation (Schneid; Gatto; Cadermartori, 2013).

Therefore, the use of CCA can be considered a viable option to increase the durability of wood, but is still questionable in relation to the harm that chemical components can cause to the environment and human health (Vidal; Evangelista; Silva; Jankowsky, 2015) if leached over time in service. Several countries have already adopted restrictions on the use of CCA, mainly due to its formulation, as the components arsenic (As) and chromium (Cr) have high toxicity and possible risk of contamination when leached or volatilized at high concentrations (Santos; Ferrarini; Pires; Azevedo; Coudert; Blais, 2020). In Brazil, there are no restrictions on the use of CCA (Vidal et al., 2015).

In general, products used to preserve wood can leach intermittently due to the action of rainfall, especially when recently treated, resulting in contamination of the soil, surface water and/or underground water. The chemical elements copper (Cu) and As when leached can be toxic to soil microorganisms and pose risks to human health at residual levels, causing skin cancer, among others (Tao; Shi; Kroll, 2013). High concentrations of Cu are also a concern, as they limit plant growth (Marco; Da Silva; Scheid; Da Ros; Da Silva, 2017), in addition to inhibiting the development of microorganisms in the soil (Andreazza; Camargo; Antoniolli; Quadro; Barcelos, 2013; Rahman; Khalid; Kayani; Tang, 2020).

Therefore, considering the environmental risks related to chemically preserved wood, it is considered important to carry out experiments in this area, as there are few studies in the literature on soil contamination due to the use of posts treated with CCA. Therefore, this study aimed to evaluate soil contamination through the use of fence posts chemically treated with CCA-C.

2 MATERIALS AND METHODS

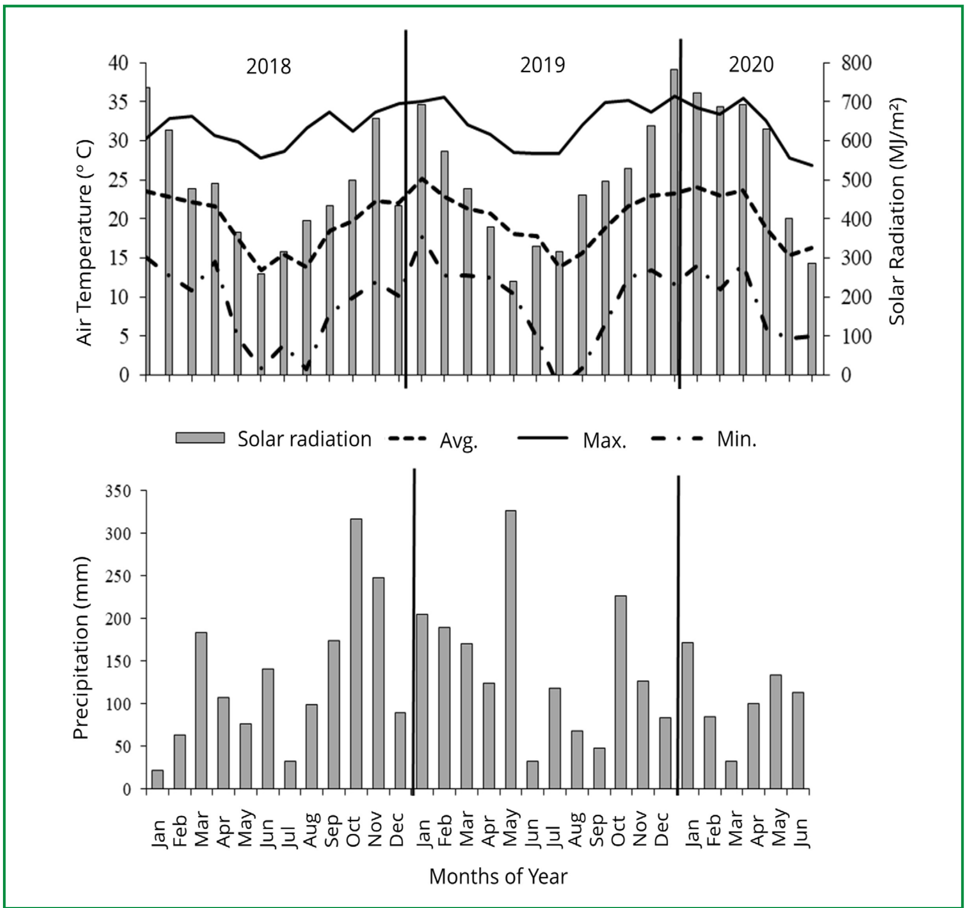
2.1 Study area and experimental design

The experiment was set up in an area belonging to the Federal University of Santa Maria (UFSM), Campus Frederico Westphalen, under geographic coordinates of 27°23’40” S, 53°25’39” W, 480 m above sea level, in the municipality of Frederico Westphalen, RS, Brazil. According to Köppen’s (1931) climate classification, the region’s climate is characterized as subtemperate subhumid, with an average annual temperature of 18.8ºC in the warmest month and an average temperature of 13.3ºC in the coldest month (Alvares; Stape; Sentelhas; Gonçalves; Sparovek, 2013).

During the experimental period, January 2018 to June 2020, data on minimum, maximum and average temperature, accumulated incident solar radiation and accumulated precipitation (Figure 1) were collected through the automatic meteorological station linked to the National Institute of Meteorology (INMET), located 300 meters from the experiment. The predominant soil in the experimental area is of the typical dystrophic Red Latosol, clayey texture, deep and well-drained, belonging to the Passo Fundo mapping unit (Eloy; Da Silva; Caron, 2022).

The experiment was set up in a completely randomized design, using a 6 × 2 bifactorial experimental arrangement, that is, six periods: 1, 94, 226, 318, 460 and 880 days after experiment setup and two soil collection depths: 0 to 20 cm and 20 to 40 cm, with 5 repetitions.

Figure 1 – Average monthly values of minimum, maximum and average temperature, accumulated incident solar radiation and accumulated precipitation during the experimental period from 01/28/2018 to 06/12/2020



Source: Authors (2023)

In wehere: Avg. = average temperature, Max. = maximum temperature and Min. = minimum temperature.

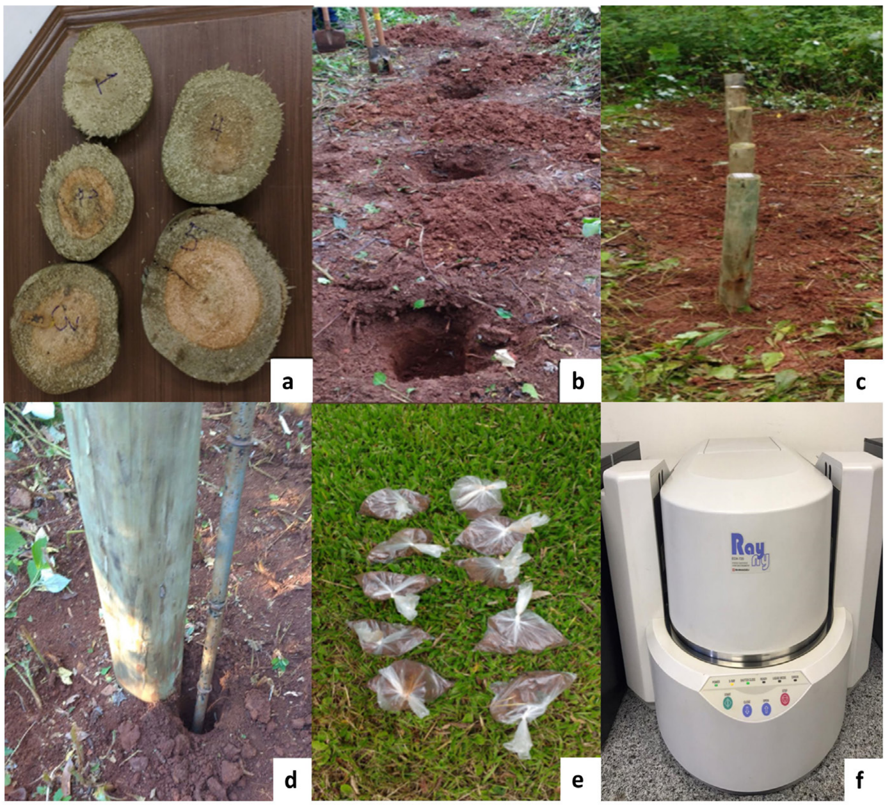
Five fence posts of *Eucalyptus spp*. were planted in the field, under natural climatic conditions, 1.5 m long and approximately 20 cm in diameter, with one of its ends buried in the ground at a depth of 40 cm. It is worth noting that the posts were obtained from a company that carries out the preservative treatment of reforestation wood commercially, using the vacuum-pressure method in an industrial autoclave, using CCA-C with a concentration of 6.5 kg m^{-1} as a preservative.

2.2 Sampling and evaluations

To evaluate the eventual leaching of wood preservative chemical constituents, before experiment setup and after the end of the field evaluations, a cross section was removed from each fence post (Figure 2A), and the soil was collected at the bottom of the pit (Figure 2B), thus obtaining initial and final wood and soil samples.

The fence posts were placed in the experimental area two meters apart (Figure 2C). Subsequently, soil samples were collected with a Dutch auger on the day the experiment was set up (1st day) and on 94, 226, 318, 460 and 880 days after the experiment was set up, at a distance of 5 cm from each fence post, at two depths, 0 to 20 cm and 20 to 40 cm from ground level (Figure 2D).

Figure 2 – The fence posts in the experimental area



Source: Authors (2024)

In where: Cross section of each fence post (A); initial and final collection of soil at the bottom of the pit (B); installation of fence posts two meters apart (C); soil collections with a Dutch auger at depths of 0 to 20 cm and 20 to 40 cm (D); packaging of soil samples in plastic bags (E); X-ray Fluorescence Spectrometer (F).

The collected samples were placed in plastic bags (Figure 2E) and transported to the Forest Products Technology Laboratory at UFSM/FW, where they were left to dry in the open air. Subsequently, homogeneous fractions of the samples were placed in porcelain crucibles and taken to the drying oven at approximately 50 °C. After drying, the wood samples were ground in a knife mill and sieved through 40/60 mesh, aiming at obtaining a thinner and more uniform material. The soil samples were crushed with maceration in crucibles to reduce their particle size and homogenize the material.

The wood and soil samples were analyzed according to the spectrophotometry method, following the NBR 16137 standard (ABNT, 2016), using the X-ray Fluorescence Spectrometer, EDX-720 Shimadzu, to determine Cu, Cr and As (Figure 2F).

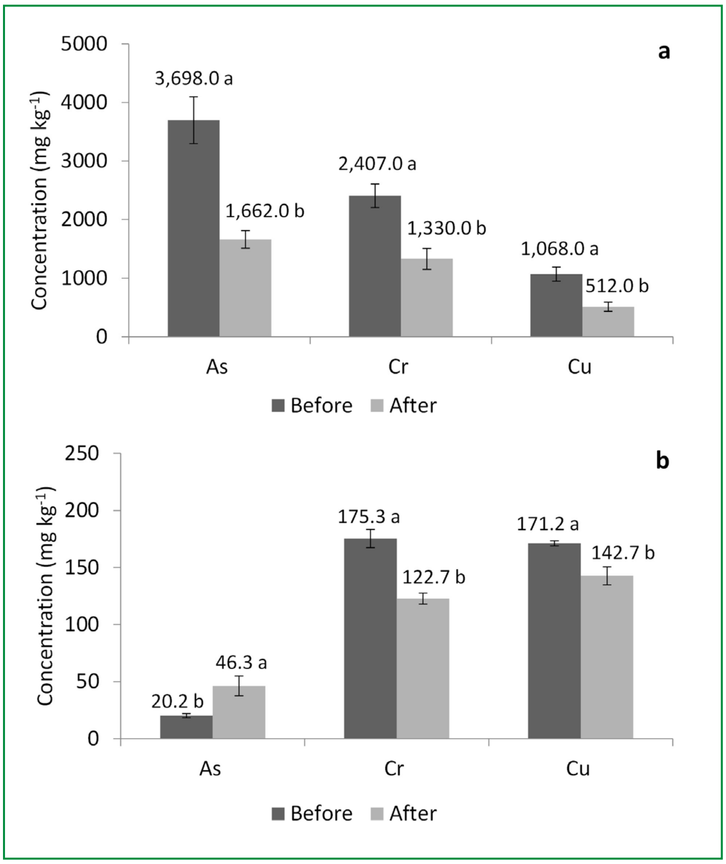
2.3 Data Analysis

The data obtained were subjected to statistical analysis using the Statistical Analysis System Software (SAS, 2003). Analysis of variance tests (F-test) and Shapiro-Wilk tests were applied to check normality, Bartlet test was used to assess homoscedasticity of variances, which showed normal behavior of the data, and Tukey mean test was performed at 5% probability error.

3 RESULTS

From the analysis of variance, it was observed that there was a difference between the evaluation periods before the installation of fence posts in the experimental area (1st day) and after 880 days, when it was completed, both for the wood and for the soil located in the lower position of the fence posts, in the three metals present in the preservative solution (copper, chromium and arsenic). For wood, the amount of As varied from 3,698 to 1,662 mg kg^{-1}, corresponding to a decrease of 55.0%. For Cr, this reduction was from 2,407 to 1,330 mg kg^{-1}, that is, 44.7% and for Cu, a variation from 1,068 to 512 mg kg^{-1} was observed, which represents a reduction of 52.0% of this chemical constituent (Figure 3A).

Figure 3 – Concentrations of the chemical constituents of the preservative solution in the wood material (A) and in the soil (B), before installing the posts and after 880 days



Source: Authors (2024)

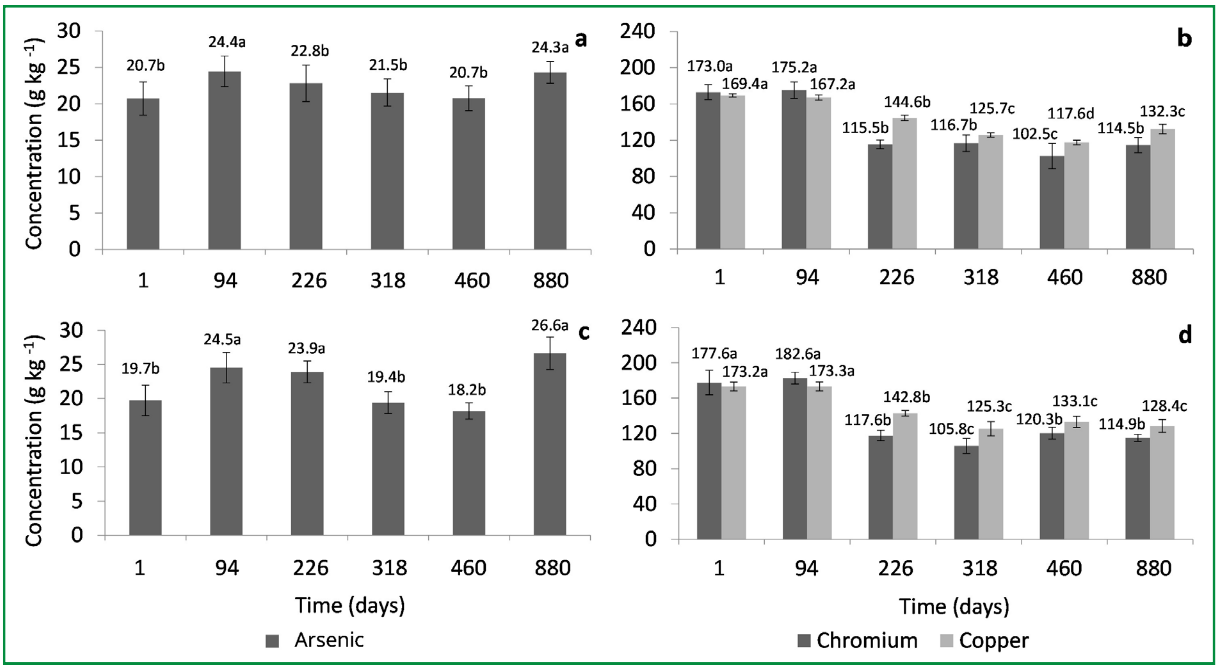
In where: Means followed by different lowercase letters compare the two periods for each chemical constituent and indicate differences between them, according to the Tukey test at a 5% probability of error.

The reduction in the amount of chemical constituents of the preservative solution was also observed for the soil component, with Cr varying from 175.3 to 122.7 mg kg^{-1} and Cu from 171.2 to 142.7 mg kg^{-1}, resulting in reductions of 30% and 17%, respectively. On the other hand, As was the only element that increased its concentration in the soil, with a variation from 20.2 to 46.3 mg kg^{-1}, representing an increase of 129.2% between the initial value before the installation of posts and after 880 days, when the posts were removed from the experimental area (Figure 3B).

From the analysis of variance that tested the concentration of the chemical constituents of the preservative solution in the soil around the fence post, a difference was observed between the six evaluation periods. On the other hand, this difference was not observed between the two depths. When analyzing the interaction between different periods and depths, a difference was observed for the constituents As, Cr and Cu.

The test analysis of means of the chemical constituents of the preservative solution in the soil around the post, over the six periods evaluated, at two different depths, showed an increase in the concentration of the chemical component As between the first period (1st day) and the second period (94 days), at depths of 0 to 20 cm (Figure 4A) and 20 to 40 cm (Figure 4C), followed by a reduction from 94 days to 460 days, with a subsequent increase in values until the sixth and last evaluation (880 days) (Figures 4A and 4C). For the Cr and Cu components, the highest concentrations in the soil were observed in the first two evaluation periods (1 and 94 days), and they did not differ from each other. Subsequently, there was a reduction until 318 and 460 days at depths of 20 to 40 and 0 to 20 cm, respectively, and from these periods onwards there was an increase until 880 days (Figures 4B and 4D).

Figure 4 – Concentrations of the chemical constituents of the preservative solution in the soil at depths of 0 to 20 cm (A and B) and 20 to 40 cm (C and D), in the different periods analyzed



Source: Authors (2024)

In where: Means followed by different lowercase letters compare the six periods for each chemical constituent and indicate differences between them, according to the Tukey test at a 5% probability of error.

4 DISCUSSIONS

The analysis of the chemical constituents of the preservative solution, before and after setting up the experiment, showed a reduction in the concentrations of the elements As, Cr and Cu in the wood and an increase in As in the soil (Figure 3). These results corroborate those observed by Jankowsky and Takeshita (2011), who analyzed a 30-year-old rotting field and highlighted that the preservative chemical solution leaches from the wood migrating into the soil.

The levels of As, Cr and Cu present in the soil in the vicinity of the stakes evaluated by Jankowsky and Takeshita (2011) showed a concentration below the reference value adopted by Resolution 420/2009 of the National Environmental Council (CONAMA, 2009), and the concentrations of chemical constituents were similar to that observed for the control treatment. The authors found that the concentration of the element As was below 4.0 mg kg^{-1} at all points analyzed, with the exception of just one, equal to 22.0 mg kg^{-1}, but still below the reference value established by CONAMA (2009), 35.0 mg kg^{-1}.

As for the soil samples in the lower part of the fence posts, it can be observed that only the element As showed an increase in concentration after 880 days, unlike Cr and Cu, whose values decreased. This characteristic proves that there is a high level of As leaching from the wood preservative solution in the longitudinal direction of the posts and that the chemical constituents leach from this material through the capillary process. Likewise, Magalhães, Mattos and Missio (2012) reported that Cr and Cu concentrations decrease with soil depth, and just below the fence post these constituents reach the lowest concentrations in the soil. The highest concentrations of leachate from these components were found on the soil surface closest to the post.

This result contradicts the common sense that leaching of all components would be greater at the end of the post due to the longitudinal vascular structure of the wood. Both Cr and Cu concentrations decrease with soil depth, and these results suggest that leaching caused by rainwater running down the exposed part of the fence posts is more important than water leaching below the soil surface, despite the high moisture content in it. Although metal ion leachates reach the soil, they end up being retained at higher concentrations on the surface as they have mobility difficulties in clayey soils (Stilwell; Musante, 2004).

The greatest soil contamination occurs close to utility poles treated with CCA, which contain a high concentration of potentially harmful metals in all fractions studied (Kallen; Gosselin; Zagury, 2020). For these authors, metal concentrations increased with the reduction of soil particles. The increase in As concentration in the soil observed after 880 days is directly related to the decrease in its concentration in wood, with a loss of 2036 mg kg^{-1}, corresponding to 55%. These results corroborate those observed by Mercer and Frostick (2014), who evaluated soil contamination by CCA wood preservative under natural climatic conditions with pine chips through the use of lysimeters. The authors identified a significant increase in metals and a decrease in chemical constituents in wood for As (15.13%), Cr (17.76%) and Cu (13.40%) and concluded that, as the elements are leached, they accumulate in the underlying layer of the soil and can contaminate it and be absorbed by plants, affecting the microorganisms that inhabit it.

When analyzing the variation in the concentrations of contaminating elements in the soil over the six periods evaluated, at two depths, 0 to 20 cm (Figure 4B) and 20 to 40 cm (Figure 4D), it can be observed that in the first measurement the As values were lower than at 880 days, a divergent behavior from that of Cr and Cu concentrations, which were higher in the initial period and gradually decreased over time. For Usman, Lle, Awad, Lim and Yang (2012), this characteristic is justified by the fact that the concentrations of As present in soil contaminated with CCA are lower than those of other elements, since most of the original As is fixed in the wood and is released gradually and, due to the high mobility of this element, it can migrate vertically and horizontally to neighboring soils, as its mobility is greater than that of Cr and Cu. For the same author, As is generally more mobile in the soil profile, while Cr and Cu are more effectively bound to the soil.

It is noteworthy that the soil analyzed over time was collected from the side of the fence posts, at a distance of 5 cm, and in the lower position of the posts, as leaching occurs in both the transverse and longitudinal directions. However, it is known that in the axial direction there is greater leaching of elements into the soil due to the sap flow being more constant (Macchioni; Pizzo; Capretti, 2016). This was confirmed in the experiment and it was observed that the soil just below the fence had an As concentration 190.5% higher than on the sides at the first depth. Likewise, Usman, Lle, Awad, Lim and Yang (2012) report in their studies that the concentrations of Cr, Cu and As were respectively 8.1%, 50.7% and 195.8% higher in soil adjacent to fence posts than in soil samples collected 75 cm away from them.

To verify whether the values found in the soil 880 days after experiment setup caused any risk to human health, CONAMA Resolution 420/2009 (CONAMA, 2009), a national reference that delimits the investigation value, that is, the concentration of a certain substance in the soil or groundwater above which there are potential direct or indirect risks to human health, was used as reference (Table 1).

Table 1 – Comparison between the investigation values presented in CONAMA Resolution 420/2009 and the soil concentration values found in this work at 880 days

Investigation values		**As**	**Cu**	**Cr**
			mg kg^{-1}	
CONAMA Resolution 420/2009	Agriculture	35	200	150
	Residential	55	400	300
	Industrial	150	600	400
	Prevention	15	60	75
At 880 Days		46.3	147.0	122.7

Source: Authors (2024)

The concentrations of As, Cu and Cr, evaluated after 880 days, are below those defined by the CONAMA resolution for the residential and industrial sectors (Table 1). For the agricultural sector, the concentrations were closer, that is, for Cr the concentration found in this work was 18.2% lower than that recommended in the aforementioned resolution, as well as for Cu, with a value 28.6% lower. However, for As, the values were 32.3% higher than those defined by the resolution for the agricultural sector, hence posing potential direct or indirect risks to human health.

The leaching of heavy metals from CCA-treated wood and the movement through soil and leachate is complex and controlled by a combination of meteorological factors, physicochemical factors, as well as factors related to wood and soil, as these are not readily biodegradable and can accumulate in flora and fauna (Mercer; Frostickb, 2014). The toxicity and effects on organisms are broad and include damage to DNA, organs and tissues (Matos; Vieira; Morais; Pereira; Pedrosa, 2010), growth retardation, behavioral changes and mortality of individuals, reducing richness and diversity of species at community level. Likewise, organisms living in CCA-contaminated soils are likely to be affected, as are plants growing in these locations (Cao; Ma, 2004).

Research on the effective detection of CCA chemical components in treated posts, which leach from the wood into the soil and which have the potential to be absorbed by cultivated plants and weeds, should be encouraged, widely publicized and debated. The accumulation of these contaminants at different levels of depth below the fence posts, as well as at more distant points on the sides of the fences and in groundwater for a longer period of time, must be further explored, providing theoretical support to avoid inappropriate use and contamination of animals and humans.

5 CONCLUSIONS

After analyzing soil contamination by the wood preservative chromated copper arsenate during the experimental period, it can be concluded that:

Wood preservative chemical constituents leach from the fence posts into the soil at different depths over time.

Arsenic concentration showed a reduction of 55.0%, leaching from fence post wood into the soil. The soil had an increase of 129.2%, with the concentration of preservative chemical constituents in the soil being higher in the lower part of the fence post when compared to the soil on the sides.

Considering the CONAMA resolution 420/2009, up to 880 days after setting up the experiment, the Arsenic concentration was 32.3% higher than the maximum investigation value in the agricultural sector, showing potential risks of contamination, direct or indirect, to human health.

REFERENCES

ALVARES, C. A; STAPE, J. L; SENTELHAS, P. C; DE MORAES GONÇALVES, J. L; SPAROVEK, G. Köppen's climate classification map for Brazil. **Meteorologische Zeitschrift**, Stuttgart, v. 22, p. 711-728, jan. 2013.

ANDREAZZA, R; CAMARGO, F. A. DE O; ANTONIOLLI, Z. I; QUADRO, M. S; BARCELOS, A. A. Biorremediação de áreas contaminadas com cobre. **Ciências Agrárias**, Portugal, v. 2, n. 36, p. 127-136, jan. 2013.

ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 16137**: Ensaios não destrutivos - Identificação de materiais por teste por pontos, espectrometria por fluorescência de raios X e espectrometria por emissão óptica. 2 ed. Rio de Janeiro. 2016. 5 p.

BRASIL. Ministério do Meio Ambiente. **Resolução CONAMA nº 420, de 28 de dezembro de 2009.** Dispõe sobre critérios e valores orientadores de qualidade do solo quanto à presença de substâncias químicas e estabelece diretrizes para o gerenciamento ambiental de áreas contaminadas por essas substâncias em decorrência de atividades antrópicas. 2009.

CAO, X; MA, L. Q. Effects of compost and phosphate on plant arsenic accumulation from soils near pressure-treated wood. **Environmental Pollution**, v. 132. p. 435–442, 2004.

ELOY, E; DA SILVA, D. A; CARON, B. O. Produção e qualidade da biomassa de florestas energéticas no norte do Rio Grande do Sul, Brasil. **Floresta**, Curitiba, v. 52, n.3, p. 457 - 465, jul/set. 2022.

FERRARINI, S. F; SANTOS, H. S. D; MIRANDA, L. G; AZEVEDO, C; PIRES, M. J; MAIA, S. M. Classificação de resíduos de madeira tratada com preservativos à base de arseniato de cobre cromatado e de boro/flúor. **Química Nova**, São Paulo, v. 35, n. 9, 2012.

INDÚSTRIA BRASILEIRA DE ÁRVORES - IBÁ. Relatório 2019: ano base 2018. Brasília, p. 73, 2019.

JANKOWSKY, I. P; TAKESHITA, S. Comportamento de madeira de *Pinus* tratada com preservativos CCA e CCB após 30 anos de ensaio de campo. **Revista Referência**, São Paulo, p. 82-88, 2011.

KALLEN, C. C. V. D; GOSSELIN, M; ZAGURY, G. J. Oral and bioaccessibility of metal (loid)s in chromated copper arsenate (CCA) –contaminated soils: Assessment of particle size influence. **Science of the Total Environment**, Canadá, v. 734, p. 10 2020.

MACCHIONI, N; PIZZO, B; CAPRETTI, C. An investigation into preservation of wood from Venice foundations. **Construction And Building Materials**, v. 111, p. 652-661, mai. 2016.

MAGALHÃES, W. L. E; MATTOS, B. D; MISSIO, A. L. Field testing of CCA-treated Brazilian spotted gum. **International Biodeterioration & Biodegradation**, v. 74, p. 124-128, out. 2012.

MARCO, R; DA SILVA, R. F; SCHEID, D. L; DA ROS, C. O; DA SILVA, V. R. Amenizante Orgânico e *Eucalyptus grandis* para Fitoestabilização de Solo Contaminado com Cobre. **Floresta e Ambiente**, Seropédica, v. 24, e00029315, 2017.

MATOS, R. C; VIEIRA, C; MORAIS, S; PEREIRA, M. L; PEDROSA, J. Toxicity of chromated copper arsenate: a study in mice. **Environmental Research**, v. 110. p. 424–427, 2010.

MERCER, T. G; FROSTICK, L. E. Evaluating the potential for environmental pollution from chromated copper arsenate (CCA) treated wood waste: a new mass balance approach**. Journal Of Hazardous Materials**, Amsterdã, v. 276, p. 10-18, jul. 2014.

MOHAJERANI, A; VAJNA, J; ELLCOCK, R. Chromated copper arsenate timber: a review of products, leachate studies and recycling. **Journal Of Cleaner Production**, [S.L.], v. 179, p. 292-307, abr. 2018.

RAHMAN, S; KHALID, M; KAYANI, S. TANG, K. The ameliorative effects of exogenous inoculation of *Piriformospora indica* on molecular, biochemical and physiological parameters of *Artemisia annua* L. under arsenic stress condition. **Ecotoxicology and Environmental Safety**, v. 206, e111202, set. 2020.

SANTOS, H. S; FERRARINI, S. F; PIRES, M. J. R; AZEVEDO, C. M. N; COUDERT, L; BLAIS, J. F. Descontaminação em processo de contra-corrente de madeira tratada com CCA e tratamento do efluente gerado por eletrorrecuperação e precipitação. **Scientia Forestalis**, Piracicaba, v. 48, n. 127, e3234, 2020.

SAS LEARNING EDITION. **Getting started with the SAS Learning Edition. Cary**. p. 200, 2003.

SCHNEID, E; GATTO, D. A; CADEMARTORI, P. H. G. Avaliação do tratamento sob pressão de postes de *Eucalyptus saligna* e *Eucalyptus cloeziana* com CCA-C. **Scientia Forestalis**, Piracicaba, v. 41, n. 100, p. 541-547, dez. 2013.

STILWELL, D. E; MUSANTE, C. L. Effect of coatings on CCA leaching from wood in a soil environment. In: Pre-conference Proceedings, Environmental Impacts of Preservative-treated Wood. Florida Center for Solid and Hazardous Waste Management, Gainesville, Florida, pp. 113-123, 2004.

TAO, W; SHI, S; KROLL, C. N. Influences of wood preservation, lumber size, and weather on field leaching of red pine lumber. **Journal Of Hazardous Materials**, v. 260, p. 296-304, set. 2013.

USMAN, A. R. A; LLE, C. S; AWAD, Y. M; LIM, K. J; YANG, J. E. Soil pollution assessment and identification of hyperaccumulating plants in chromated copper arsenate (CCA) contaminated sites, Korea. **Chemosphere**, v. 87, n. 8, p. 872-878, mai. 2012.

VIDAL, J. M; EVANGELISTA, W. V; SILVA, J. DE C; JANKOWSKY, I. P. Preservação de madeiras no Brasil: histórico, cenário atual e tendências. **Ciência Florestal**, Santa Maria, v. 25, n. 1, p. 257-271, jan/mar. 2015.

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