Environment and Ecology Research 8(4): 100-104, 2020 http://www.hrpub.org
DOI: 10.13189/eer.2020.080402

Effective Potential of Herbal Preservatives to Reduce Hazardous Impact on Biodiversity by Wood Chemical Preservatives and Fixatives

Bandana Dhiman*, Bhupender Dutt, K. R. Sharma

Department of Forest Products, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, India

Received August 6, 2019; Revised September 11, 2019; Accepted May 13, 2020

Cite This Paper in the following Citation Styles

(a): *[1] Bandana Dhiman, Bhupender Dutt, K. R. Sharma , "Effective Potential of Herbal Preservatives to Reduce Hazardous Impact on Biodiversity by Wood Chemical Preservatives and Fixatives," Environment and Ecology Research, Vol. 8, No. 4, pp. 100 - 104, 2020. DOI: 10.13189/eer.2020.080402.*

(b): *Bandana Dhiman, Bhupender Dutt, K. R. Sharma (2020). Effective Potential of Herbal Preservatives to Reduce Hazardous Impact on Biodiversity by Wood Chemical Preservatives and Fixatives. Environment and Ecology Research, 8(4), 100 - 104. DOI: 10.13189/eer.2020.080402.*

Abstract Wood is being a biological asset for timber purpose, liable to degrade easily than other material products. For its protection and longevity, chemical preservative industries are using chemicals and fixatives for their treatment under pressure. Mostly chemical used in wood preservative industries are heavy metals (Chromium) and have harmful impacts. AS chromate-production workers are exposed to a variety of chromium compounds, including hexavalent (VI) and trivalent (III) compounds. According to US ATSDR 2000 report, about 52% of all chromium compounds used in the U.S. chemical industries was used in the production of wood preservatives; the rest were used about 7-13% in pigments, tanning metals, leather finishing, etc. Environmental exposure from chromium (VI) compounds is difficult to quantify. The chromium (VI) compounds in the environment may be reduced to chromium (III) compounds, but hexavalent forms can persist under some conditions. People who live near industrial facilities that use chromium (VI) compounds have the greatest potential for exposure as it leaches out with prolong use and can become carcinogenic. Not only humans but chemicals from industrial effluents are affecting aquatic biodiversity too. On this serious note, researchers and wood technologists are trying to use herbal extracts in place of chemical preservatives. In this experiment extract of *Acorus calamus* (monocot-marshy plant) has been tried as biopreservative which could fix chromium in wood samples substantially. A difference in chromium (preservative fixative) retention was observed with different concentration of application of *Acorus calamus* extract on the studied wood samples.

Keywords Chromium, Preservative, Fixatives, Herbal Extract, Preservative Industries

1. Introduction

Many chemical preservative industries were set up during the Industrial Revolution. The aim was not in bad intention, as their focus was to substitute durable wood as less quality wood with chemical preservative for the timber purpose. Treating the wood and its products for its life extension is prevalent from the earliest time. Due to advancement of wood preservation industries and chemical fixatives like ‘chromium’ has played an important role in retaining chemical preservatives within the wood. However these chemical preservatives start to leach out from wood on prolonged use. The wood products are treated with chemical preservatives and fixatives under the pressure inside industry. Treated chemicals ooze out after a time from high pressure (inside wood) to low atmospheric pressure. It led contamination to soil, water, flora, as well as fauna, and furthermore interfered with human health. Shaw and Chadwick [1] have discussed the historical review of human impact on Environment in their book *Principles of environmental toxicology* where they point on the Industrial revolution. They called it as sinister date on the calendar of pollution, when the industrial revolution instigates. The pollution emanating from these industries had devastated the environment for miles around. As these preservative chemicals are benefitting society need and their daily works. But chemical relaying habits and prolong relation with them affecting our biodiversity directly or indirectly. Backhaus *et al*., [2], assessed the impact of chemical pollution on biodiversity and ecosystem services and stated that there is a vital need to discuss on the relationship between biodiversity, ecosystem status, and exposure to naturally occurring and man-made chemicals.

Some wood preservative industries relay on standardization methods and amount of use of chemical specified by concerned state and country. With this quality control and systematic maintains of the process should also be acknowledged. These kinds of activities can minimize the chemical industrial effect biodiversity and environment [3].

If we take about wood durability, various species are naturally resistant to bio-deteriorating causal agents. The resistance in these species is mainly due to the existence of extractives act as decay inhibitors [4] and makes heartwood poisonous to wood destroying agents. Haygreen and Bowyer [5] and Milton [6] noted that the chemical composition and amount of extractives in wood are highly variable within and between tree species and can range from 2-15 % of wood weight. The question arises, 'Can these naturally occurring extractives be used to enhance the durability of those wood species in which these extractives are lacking?' Hillis [7] and Laver [8] observed that extractives from bark and wood have the potential to replace synthetic wood preservatives. Investigation revealed that extractives could protect wood effectively at laboratory scale. Majority of vascular plants are potential source of anti-microbial agents [9]. That's why various plant extracts can be used to treat the wood against micro-organism. In the same way, the herbal extract of *Acorus calamus* has been used to treat wood samples. This medicinal plant was reported as bio-preservative against wood fungal decay with expected results [10]. With keeping in mind about biodiversity and preservative chemicals, research was conducted by using herbal extract of medicinal plant replacing chemical preservatives where chromium (10 %) was used as a fixative.

1.1. Chromium

Chromium (Cr) falls in the category of heavy metal which occurs naturally in the environment in the form of metal-ores. Chromium exists predominantly in its chromic (Chromium III-trivalent) form, while the chromate (Chromium VI- hexavalent) state is rarely found in nature and is produced mainly from commercial and industrial processes. Chemicals containing hexavalent Chromium (Cr^{+6}) found to be effective in wood chemical treatment [11] to fix other chemicals in wood. It is known to intensify resistance against fungus [12], control of staining of water-soluble wood extractives through latex paints [11], and improve durability of treated wood [13]. But being heavy metal and with leaching property, Chromium is categories as a toxic chemical. The different types of Chromium exhibit different properties, which is important for assessing the risk of potential harm to human health. The hexavalent Chromium is a human hazardous, highly contaminated Chromium soils pose a health risk to humans [14]. Other than wood preservative industries, Chromium has a great role in variety of industrial processes such as in the tanning of leather, in the manufacture of special alloys, pigments in paints, plastics, ceramics and glass and as decorative plating for taps and door handles, as high-temperature catalysts, and as dietary supplements.

1.2. Chromium Fixation

The purpose of fixation of hexavalent Chromium was to reduce it to the more thermodynamically stable trivalent Chromium, which will precipitate into the wood by keeping preservative intact inside. Hager [15] conducted a leaching test on CCA treated wood sawdust and reported that Chromium (Cr) is essential for fixation of Copper (Cu) and Arsenic (As). Further, copper-based fungicides were combined with Chromium to enable fixation and arsenic to improve performance against copper tolerant fungi and insects [16].

2. Material and Methods

The experiment was conducted to study the Chromium absorption, leaching, fixation activity on *Acorus calamus* L. rhizome extract treated wood samples. Taken wood samples were *Pinus roxburghii* Sargent (Chir pine), *Celtis australis* L. (Khirik), and *Bombax ceiba* L. (Simbal). Samples were procured from local carpenter in the market of size 5cm x 2.5cm x 2.5cm $\pm$ 0.25cm x 0.15cm x 0.15cm (longitudinally x radially x tangentially). Before extract treatment wood samples were rubbed by sand paper to make their surface soft.

2.1. Treatment of Wood Samples with Rhizome Extract of *Acorus Calamus*

Rhizome extract of *Acorus calamus* was prepared with methanol using soxhlet apparatus. For this dried rhizome powder of *Acorus calamus* was taken. Condensed semi-solid greasy extract was obtained and was dissolve in methanol to make it 10% solution as a stock solution. From the prepared 10 percent stock solution of *Acorus calamus* rhizome extract, different concentrations for dip treatment were prepared. The wood samples of *Pinus roxburghii* Sargent, *Celtis australis* L., and *Bombax ceiba* L. were dipped in 0.25%, 0.5%, 1%, 1.5% and 2 % (w/v) *Acorus calamus* L. extract solution for 72 hours. The samples meant for control were dipped in distilled water. After dipping treatment samples were first dried in air and then dried at 105±2°C to constant weight [10].

2.2. Chromium Absorption in Wood Samples

The wood samples which were oven-dried at 105±2 °C to a constant weight were taken for Chromium treatment. The triplicate samples were dip-treated in 5% and 10% Chromium (VI) Trioxide solution (chromic acid). The samples were dip treated for 2 hours for each chromic acid concentration. The treated wood samples were air-dried for four hours and then placed in a pre-heated oven at 135±2 °C for 30 minutes. Chemical absorbed by wood samples were determined from difference in oven-dry weights before and after the Chromium treatment.

Percent Chromium absorption was calculated as:

$$\text{Chromium intake (\%)} = (W_2-W_1)/W_1 \times 100$$

Where,

W_1=Wood weight of oven-dried sample before Chromium treatment

W_2= Wood weight (oven dried) after Chromium treatment

2.3. Chromium Leaching in Wood Samples

Extract cum chromium treated sample were dipped in 150 ml of double distilled water at 25°C for 24 hours. Thus, Chromium leaching was determined by analyzing the leachates from the submerged wood samples in distilled. Percent Chromium leached was calculated as:

$$\text{Chromium leached (\%)} = (W_2-W_1)/W_2 \times 100$$

Where,

W_1=Wood weight of oven-dried sample after Chromium leached

W_2 =Wood weight (oven dried) after Chromium treatment.

2.4. Chromium Retention in Wood Samples

Retention is the measure of the amount of chemical present after the treatment in the portion of wood. The various factors that affect the leaching of the preservative are ; preservative formulation, physical parameters of the preservative treatment like; vacuum pressure cycles, drying temperature and time for drying, preservative retention and concentration preservative solution [17]. Percent Chromium fixed or retained for each sample was determined as:

$$\text{Percent Chromium Retained (\%)} = \text{Chromium intake (\%)} - \text{Chromium leached (\%)}$$

2.5. Data Analysis

The experiment was conducted in Completely Randomized Design (CRD) factorial with three replications *i.e.* R_1, R_2, and R_3. Results shown in the table are the mean value obtained from 5% and 10% Chromium treatments.

3. Results and Discussion

The significant differences have been observed among taken species, treatments and Chromium concentrations for Chromium absorption, leaching out and retention shown below in a single table. The maximum Chromium absorption (27.18%) has been observed in *Pinus roxburghii* Sargent and the minimum (6.95%) in *Bombax ceiba* L. Among taken species *Bombax ceiba* is light in weight means it is low density wood as compare to *Pinus roxburghii*. Aggrawal *et al.* [18] have reported that chromic acid treated *Bombax ceiba* L. wood samples have regained almost the initial weight because chromic acid dries up at a faster rate and does not form any layer over the surface of wood like other water repellants. Among the treatments, the absorption has shown an increase with the increase in concentration of chromic acid in all biopreservative treated wood samples. The highest value has been observed in control (water treated wood sample) and the lowest value at T_1 (0.25% concentration). Because the samples treated for longer duration and with higher concentration, allow more Chromium to penetrate wood samples. Similarly, Chromium leaching and retention found to be increasing with increase in extract treatment and maximum in control. Chemical leaching in wood is influenced by anatomical and structural composition with number, size and distribution of pores. The leached part of Chromium from wood is that could not fix with reactive sites (mainly cellulose and lignin) because of higher concentration of chromic acid or presence of extractives. The probable reason for more retention in higher concentration is that chromic acid gets fixed by the formation of insoluble compounds or complexes and coordination of Cr to the hydroxyls in wood. The same observations have been recorded by a variety of researcher working in different location during different years [19, 20, 21]. They have reported that Chromium pick in wood increases with the increase in concentration and dipping time during treatment. This is because the samples treated for longer duration and with higher concentration which allow more Chromium to penetrate. The extracts might have been providing more sites for Chromium fixation.

Among three species maximum value was noticed in *Pinus roxburghii* Sargent and minimum in *Bombax ceiba* L. Similar findings have been reported by Sharma [21], where small amount of Chromium leaching has been observed in *Bombax ceiba* L. This may be due to the presence of more extractives in the species and moreover *Bombax ceiba* L. wood is more porous. Also, the intake and leaching properties that are influenced by chemical composition through the quantity, nature, and existence of the functional group needed for chemical reactions to take place, which ensure the binding of preservative's agents. The leaching properties are also influenced by structural composition through the pore diffusive inhibition, which is caused by number, size and distribution of pores (wood texture).

Table 1. Percent variation of Chromium concentrations in its absorption, leaching and retention in wood

Treatments	Species					
	(S$_1$) ***Pinus roxburghii*** **Sargent**	**(S$_2$)** ***Celtis australis*** **L.**	**(S$_3$)** ***Bombax ceiba*** **L.**	**Mean (5% & 10%)**		
				Absorption (%)	Leaching (%)	Retention (%)
T$_1$ (0.25%)	16.82	2.10	2.94	**7.29**	**4.72**	**2.56**
T$_2$ (0.50%)	20.41	4.71	5.59	**10.24**	**6.33**	**3.91**
T$_3$ (1.00%)	24.03	6.17	5.76	**11.99**	**7.44**	**4.54**
T$_4$ (1.50%)	26.36	6.73	6.47	**13.19**	**8.32**	**4.87**
T$_5$ (2.00%)	29.20	12.35	8.81	**16.79**	**10.32**	**6.47**
T$_6$ (Control)	46.23	14.32	12.10	**24.22**	**13.07**	**11.15**
Mean	27.18	7.73	6.95			
CD$_{0.05}$						
Species				2.94	0.33	3.84
Treatment				2.08	0.23	2.72
Concentration				1.70	0.19	NS

4. Conclusions

The results of study show an increase in Chromium absorption, leaching, and retention with the increase in the concentration of treated extract of *Acorus calamus* on the wood samples. Eventually, it shows average cumulative effects with the positive response. This will be effective more if concentrated bio-preservative application on larger scale. The more use of herbal extract can fix more Chromium inside the wood. The fixative complex of chromium with applied bio-preservative renders leaching of Chromium (heavy metal) from wood. Ultimately, it will not have any deterring effects on wood preservative workers, user and on soil as well as water which was sink of contaminants. Similarly, there will be no such interference with micro-fauna existing in the soil and water. Moreover, it will prevent the percolation of toxic heavy metal to the ground water and hinder its entry on substantial crop on that soil. Hence herbal plant extracts have a promising ecofriendly potential to preserve wood in substitute to chemical preservatives. All this have an integrative effect on overall biodiversity including terrestrial and aquatic ecosystem which comprises from both flora and fauna.

REFERENCES

[1] I. Shaw, J. Chadwick. Principles of environmental toxicology. CRC Press, 2018.

[2] T. Backhaus, J. Snape, J. Lazorchak. The impact of chemical pollution on biodiversity and ecosystem services: the need for an improved understanding. Integrated environmental assessment and management, Vol.8, No.4, 575-576, 2012.

[3] E. Salminen, R. Valo, M. Korhonen, R. Jernlås. Wood preservation with chemicals: Best Available Techniques (BAT), Nordic Council of Ministers, 2014.

[4] P. W. Kityo, R. A. Plumptre. The Uganda Timbers users Handbook. A guide to better timber use, Common Wealth Secretariat, London, 1997.

[5] J. G. Haygreen, J. L. Bowyer. Forest Products and Wood Science: An introduction, 3rd Ed: 198-199. Lowa State University press, Ames, Lowa, 1996.

[6] F. T. Milton, The Preservation of Wood. A self study manual for wood treaters. Minnesota extension service. University of Minnesota Collage of Natural resources, 1995.

[7] W. E. Hillis. Extractives. Special paper, 8th World forestry congress. Djakarta. WORLD BANK. Forestry sector policy paper, World Bank, Washington, D.C., 1978.

[8] M. L. Laver. Chemicals from Bark. Special paper, 8th World forestry congress. Djakarta. WORLD BANK. Forestry sector policy paper, World Bank, Washington, D.C., 1978.

[9] R. D. Tripathi, D. Srivastava S. N. Dixit, Lawsone, an antifungal antibiotic from leaves of Lawsonia inermis: Its action on pathogen and host plant, Ind. Jour. Mycol Plant Pathol. Vol .81, 89-90, 1978.

[10] B. Dhiman, B. Dutt. Evaluation of Acorus calamus L. rhizome extract as a bio preservative against wood fungal decay Journal of Applied and Natural Science, Vol.10, No.1, 37-40, 2018.

[11] W. C. FiestW. D. Ellis. Fixation of hexavalent Chromium on wood surfaces. Wood Science and Technology, Vol.11, No.2, 76-81, 1978.

[12] J. M. Black, E. A. Mraz. Inorganic surface treatments for weather resistant natural finishes USDA Forest Serve. Res. Pap. FPL 232. Forest Product Laboratory Madision Wis., pp 40, 1974.

[13] A. F. Preston, C. M. Chittenden. Accelerated tests of weather resistant natural finishes for Pinus radiata. Journal of Coatings Technology, Vol.50, No.637, 59-61, 1978.

[14] D. J. Paustenbach, W. E. Rinehart, P. J. Sheehan. The health hazards posed by Chromium-contaminated soils in residential and industrial areas: Conclusions of an expert panel, Regulatory Toxicology and Pharmacology, Vol.13, No.2, 195-222, 1991.

[15] B. Hager, Leaching tests on copper-chrome-arsenic preservatives. For. Prod. J. Vol.19, No.10, 21-26, 1969.

[16] H. W. Richardson. Handbook of copper compounds and applications, M. Dekker, New York, 1997.

[17] A. Wilson. The effects of temperature, solution strength, and timber species on the rate of fixation of a Copper-Chrome-Arsenate wood preservative, Institute of Wood Science, Vol.5, No.6, 36-40, 1971.

[18] P. K. Aggarwal, S. S. Chauhan, N. R. R. Prasad. K. S. Rao. Water repellent treatments for catamaran grade Bombax ceiba L. (Spermatophyta/Dicotyledoneae) wood, Ind. J. Mar. Sci. Vol.32, No.4, 340-343, 2003.

[19] K. Borgin and K. Coarbett. Long term stabilizing effect of water repellents on wood. Timber. Vol.6, No. 6, 5-10, 1969.

[20] S. Khachane. Effect of chromic acid as water repelling wood preservative on some softwoods. M.Sc. Thesis, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni (Solan) 71p, 1992.

[21] R. S. Sharma. Acetylation and Chromium fixation studies on some hardwood species. M.Sc. Thesis, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni (Solan) 65p, 1993.