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Hazardous Effect of Chemical Wood Preservatives on Environmental Conditions, Ecological Biodiversity and Human Being and its Alternatives through Different Botanicals: A Review

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ABSTRACT

Preservation of wood is essential for the increase the life service of wood during the utilization. At the present time different type of chemical wood preservatives are used viz. copper sulfate, zinc chloride, mercuric chloride and oil born preservative (creosote) are used for the protect the wood from the different wood degrading agencies, but chemicals leach out from the wood and may negatively affect the environment, soil health, ecology and biodiversity. Due to the hazardous effect of chemical wood preservatives, it is essential need to replace with alternative eco-friendly wood preservative. Now chemical wood preservatives are replaced with the natural preservatives. Natural wood preservatives are consisting by resin, tannin and dye which are extract from the different parts of plants. Researchers conduct the research on the testing the efficiency of the natural preservatives against to the wood degrading agencies and find out the significant results. This review paper aims to compare the efficiency of bio preservatives with traditional available preservatives and promote the natural preservatives for the wood preservation.

Keyword Wood preservation, Chemical wood preservatives, Chromate copper arsenate (CCA), Hazardous effect, Bio-preservatives.

INTRODUCTION

Wood preservation is essential for the protection of wood from the different wood degrading agencies, i.e., fungus, incest, pests, termites and woodborers insects. Numbers of chemical wood preservatives are available in market for the protection of wood. Main object of wood preservation is increase the total life of wood. Treated woods are nearly resistance to wood destroying agencies, allow to use for outdoor use. The wood preserving industry, as defined in Standard Industrial Classification (SIC) 2491. These artificial organic and inorganic wood preservatives like chromated copper arsenate, arsenic and chromium

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are create environmental and health risks to workers exposure with hazardous chemicals and all synthetic wood preservatives are not cost effective (Barnes 1992, Venmalar and Nagaveni 2005). However, Due to hazardous effects on water ecology, forest ecological and human health at the present time water-soluble preservatives replaced with oil borne preservatives like creosote. Chemical wood preservatives are ban in many developed countries (Moutaouafiq *et al*. 2019 and Lu *et al*. 2016). From 18^{th} Century creosote used mainly for the railway sleepers. The copper-based preservatives are also poor checker of mould (Arango *et al*. 2005). Therefore, traditional wood preservatives are replaced with bio-based synthetic wood preservatives. Primarily, regularly natural chemical extract from the plants are used for wood preservatives such as Sardine oil, Neem oil, and Cashew nut oil.

Wood preservatives

The wood decay eliminated by proper treatment with some chemicals preservatives. The treatment usually helps in increasing the service life of the wood. A good preservatives should be highly toxic to the fungi, have low volatility, high resistance to leaching and more ability to penetrate deep into the wood.

Types of preservatives

A. Preservative oils

Creosote is the very commonly used oil for preservation of wood used in railways and marine industry.

B. Chemicals soluble in water

The chemicals like copper sulfate, zinc chloride and mercuric chloride are used for preservation of woods. 'ASCU', the mixture of Copper-chrome-arsenic is efficiently use for wood preservation.

C. Chemicals soluble in organic solvents

The chemicals like pentachlorophenol, zinc, and copper napthenates come under this group.

Methods of application of preservatives

A. Surface application

Surface application used for short-term preservation of wood. Wood preservatives are applied on wood surface.

B. Wood impregnation

Wood impregnation is useful for long term preservation of the wood, in which the chemical is impregnated into the wood either by open tank treatment under atmospheric pressure or by employing pressure to fill the cells of wood with the chemical.

C. Boucherie method

In this method, the wood sap is replaced with the wood preservative.

Life cycle of wood preservatives

Development of active compounds: During manufacture stage, chemical material is manufactured, through chemical reactions through biotechnological processes, isolated, purified and drummed or bagged.

Development of wood preservative: In the development stage materials are pooled in a process of transformation and mixing to produce to a product. By product are used for further doling out either as such or watered down or organic solvents.

Application of wood preservatives for wood treatment: During this stage, wood preservatives are applied on wood for the prevention of wood decayed and other degrading agencies and preservatives are applied before first use of wood.

Service life of treated wood: Services of treated wood are consider as wood used for the various uses. Wood is used for the various purpose and durability of wood is increase by preventively or curatively treatment. Wood preservatives are release in environment throughout the use of wood. Service of treated wood might be considerable up to 50 years.

Waste treatment: In the waste treatment stage, non-utilized treated wood is leave as waste. Final dispose of treated wood may consist of burning and landfill dumping. Releases chemical during waste treatment stage through leaching models and discharge of non-decompose chemical during fire, mainly heavy metal oxides.

Recovery: **Out-of-service use***:* On this stage, cover alternate uses of out-of-service wood, e.g., railway sleepers in landscaping.

Contaminated sites: Contaminated sites can comprise functioning and non-functioning treating plants and preservative plants for treated wood and wood products. Even if infected sites have a well-marked separate periphery they may discharge toxic chemical to the atmosphere.

Chemical wood preservatives are very harmful for the environment, soil microbes, aquatic biodiversity and human health. However, researcher are work for the alternative of the chemicals used in the wood preservation, in this contest many researches worked on wood species naturally resistant to bio-deterioration agents due to the build up of natural chemical extracts in the inner (heartwood) wood which are formed during the metabolic activity of plants, some of which are wood rotting fungi resistance (Kityo and Plumptre 1997). However, number of benefits when natural plant extractives are use as wood preservatives to increase the durability during the service of wood products. Percentage of plant extractives differ with species-to-species, sometime plant extractive varies within the same trees of the same species and within a single tree Hinterstoisser *et al*. (2000). Natural wood extractives have been found to be comparatively eco-friendly with environmental and human being health than synthetic chemical wood preservatives, but still useful against natural organic based wood preservatives developed by nature and might be easier to detoxify and decomposed without affecting environment (Barnes 1992, Arango *et al.* 2005).

Effect of wood preservatives on environmental conditions

Chemical wood preservatives are used for the wood treated but at the same time, these wood preservatives are sensitive to ecosystems. where contamination by major roles of wood preservative components could bad influence the environment, wood structure constructed with CCA-treated wood have caused unpleasant environmental effects due to leaching of Cr, Cu and As into nearby soils (Abdelhafez *et al.* 2009), due to hazardous effect on environment, use of chemical wood preservatives has been banned in developed countries. In Sweden, for instance, wood material treated with chromium and arsenic has been banned in most above ground conditions (Kemi 1990, Coles *et al.* 2014). In recent years effects of wood preservatives on environmental have been risen, the possible impact of wood preservatives to the environment may happen at different levels of the product utilization cycle, i.e. manufacturing, allocation, construction, service life and end-of-life. During the utilization period and end-of-use stages, both of which are usually spread over many decades, the release of chemicals due to contact with water is the main source for the move from one place to another place, as a result of the leachin. Hereafter, the main preservatives used for wood treatment are alive together with their toxic compounds. The possible environmental impact due to releasing the chemical components during the utilization of the wood and wood products, discarding of the wood products has high levels of wood preservative present inside the wood. In Germany and France, around 2.1-2.4 million tons of wood throw away measured hazardous (according to the European Council directive 91/689/EEC on hazardous waste). Only in France, out of 25 million CCA-treated poles 50,000 tons of wood become to west wood in single year and must be discarded (Helsen and Van den Bulck,1998). Once wood preservatives released from the wood, it may go through cycling processes in the environment, based on its oxidation state, chemical structure, concentrations, and presence of organic matter, competing ions, and other environmental factors (e.g., pH, redox).

Now arsenic concentration in the environment has turn into a major worldwide problem due to its toxicity and harmful impact on human health; even if arsenic present in low concentration it is harmful for the environment and human health. It is very poisonous and responsible as a carcinogen (0.002 mg/l) (Liu *et al.* 2009). Arsenic affects internal organs of human such as the lung, kidney, urinary bladder and liver. Arsenic also responsible for non-carcinogenic disease such as keratosis, hypopigmentation, peripheral vascular, hyperpigmentation, and cardiovascular disease, diabetes mellitus, peripheral nervous and central nervous disorders (Rosen and Liu 2009, Rahman *et* *al.* 2009, IARC 2004 and WHO 2015). There are two major potential exposure ways for arsenic to human body ingestion and inhalation. Ingestion through water, food, soil (hand to mouth) and inhalation of dust containing arsenic has been commonly reported. Another important way of concern by drinking water (Rahman *et al.* 2009).

Oil-borne wood preservatives like pentachlorophenol and creosote also used for the wood preservation it will provide the long durability against to the wood destroying agencies (Kitechens and Amburgey 2015). Oil borne wood preservatives have high heat and chemical stability. It is not easily leach out from the wood and they are not soluble in water. However, treated wood with oil-borne wood preservatives are in blackish color and create a pungent smell (Kang *et al.* 2005). Oil born wood preservatives are also injurious to people, ecology, natural biodiversity and environmental conditions (Chen *et al.* 2006). Creosote (oil borne wood preservative) are used only for poles, railways sleepers and other outdoor utilization. Where less human activity or human not get in touch with and less impact on the environmental conditions (Roman 2015). (Rawant *et al.* 2015), reported that the metallic wood preservatives leach out with rain water. It is also dangerous for environment because they are made-up with heavy metals (Mercer and Frostick 2012, 2014).

Number of research are conducted on acute and chronic health disorders pertaining to arsenic contamination (Mandal and Suzuki 2002, Bhattacharya *et al.* 2007, Srivastava *et al*. 2011 and Liu *et al*. 2009).

Effect of aquatic environment

Chromate copper arsenate (CCA) is the most common wood preservative for wood exposed with in aquatic environments. CCA is an inorganic type, waterborne preservative i.e., Ammoniacal Copper Zinc Arsenate, Ammoniacal Copper Arsenate, Chromated Copper Boron, Acid Copper Chromate, and Ammoniacal Copper Quaternary. Inorganic wood preservatives are recently replaced with substitute organic preservatives i.e. pentachlorophenol and creosote, coal tars for aquatic use, due to the ecological and human health issue with these types of preservatives, higher prices and shortage of availability.

The toxic effects of copper (Cu), chromium (Cr) and arsenic (As) all three chemicals to marine ecology is well recorded (Bodek *et al.* 1988 a, b, Fleming and Trevors, 1989, Wong and Chang 1991, Havens 1994, Nriagu 1994 a,b, Walley *et al.* 1996 a, b) and all chemicals are noted as highly pollutants by the United States Environmental Protection Agency (Weis *et al.*1992, Weis and Weis 1995). Leaching CCA form the wood mainly depends on the species metal and reactions of wood preservatives with wood metals and the sub- sequent toxicity of these leachates. The toxicity of Cu, Cr are highly dependent on the specific presentable form.

Studies conducted on effects of CCA on marine ecology and environment and adverse effect noted against a range of aquatic organisms (Weis *et al.*1991, 1992). Criticism of this work focused on the unrealistically great ratio between wood and water volume, which certified the metal level to build up to toxic levels (Albu- querque and Cragg 1995 a, Breslin and Adler- Ivanbrook 1998). Further work has recommended a reduced in biodiversity close to CCA-treated marine structures, and examined the levels of metal elements in benthic organisms (Weis and Weis 1994 a, b, 1995, 1996, Albuquerque and Cragg 1995a, Wendt *et al*. 1996, Cragg and Eaton, 1997, Weis *et al.* 1998). Although Cu concentrations noticed that significantly elevated in algae growing on CCA-treated wood panels, increase in associated of fish species was found with the same panels (Weis and Weis 1999). This suggests that trophic transfer to consumers did not occur, although it was possible that the duration of the studies was insufficient to allow accumulation in higher consumers.

Effect of wood preservatives on soil properties and bioremediation

Soil properties are affected by the wood preservatives, wood preservatives are leach out during the utilization wood and contaminated the soil by chemicals used in wood preservation and its affect the soil micro organism activity. Wood preservatives elements viz As, Cu, Cr, and Zn can be observed in higher in affected soils at wood treatment plants, mainly when Cu sulphates and chromate copper arsenate are used as preservative to protect the wood from termites, borer, insects, pests and fungi, which may result in soil phyto-toxicity (Kumpiene *et al.* 2008). Phytoremediation was tested as a successive treatment for the creosote affected surface soil at the McCormick and Baxter (M and B) superfund site in Portland, Oregon. Soil at the M and B site was infected with pentachlorophenol (PCP) and polyaromatic hydrocarbons (PAHs). The soil amendments, mineral nutrients and dolomite, are used to raise the soil pH (Ferro *et al.*1999). CCA treated waste wood materials has been examined by two leaching experiment, first based upon batch leaching tests and second based upon a series of lysimeter tests, reported that the degraded waste wood mulch can source for major pollution in soil water with possible impacts on environment and human health (Mercer and Frostick 2012). Cao and Ma (2004) studies the discharge of arsenic (As) in soil from Chromate Copper Arsenate treated wood. Thus, an environment concern arises regarding accumulation as in vegetables and in these soils. Results showed the vegetables growing near the soil CCA treated wood may risk of as exposure for human and soil health and environmental conditions.

An alternative of eco-friendly wood preservatives

Environmentally friendly wood preservatives are develop from the different part of trees, shrubs and herbs, that is different kinds of tannins, wood extracts, plant extracts. Several avoidances found that wood extracts and tannin reported inhibit the wood routing fungi (Anttila *et al.* 2013, Da Silveira *et al.* 2017, Tomak, Gonultas 2018, Morard *et al.* 2007, Oramahi *et al*. 2014, Gonzalez-Laredo *et al.* 2015 and Salem *et al.* 2016). Nakayama *et al.* (2001) reported that the resistance property of resin materials extracted from guayule plant (*Parthenium argentatum*) against to the insect and microbial. Another study conducted by Kartal *et al.* (2004) found the antifungal and termiticidal properties of Sugi (*Cryptomeria Japonica*) and black wattle (*Acacia mangium*) wood. The authors stated that phenolic compounds in filtrates could provide protection from fungi. Soil and other microbes easily decompose these natural wood preservatives. Therefore, it is preferable used when it comes to their disposal. Wood extractives from three hard wood species of *Milicia excelsa, Albizia coriaria* and *Markhamia lutea* are found to be very resistant against termite attack and fungal decay. Acetone, hexane and distilled water are used for the extraction of these compounds from the outer heartwood of the selected durable species. Extracts from selected species are used to treat wood of *Pinus caribaea* and *Antiaris toxicaria* species, which are known to be vulnerable to termites and fungal attack. Treated wood blocks are expose with *Macrotermes bellicosus* termites in the field conditions. It was noticed that improve the resistance capacity of treated wood against to the termite attack by 50% compared to the controls. It was also noticed that resistance capacity of durable wood decrease after removal of extractives from the durable wood. It can be evident that wood extractives are giving the protection of less durable wood species against termite attack (Syofuna *et al*. 2012). Lopez *et al.* (2021) studied compression between the bio chemicals and traditional wood preservatives for their eco-toxicity and reported that the bio-based chemicals with potential use in wood preservation have clearly less eco-toxicity than traditional available wood preservatives.

CONCLUSION

Wood preservation industry is one of the most important industry in India and throughout the world. Wood is in hygroscopic nature. It is susceptible for the wood degrading agencies. Therefore, wood preservation is very important. Wood preservatives help to increase the durability of wood. Wood preservation is very essential to reduce the pressure from the primary wood producing species like teak, shisam, deodar, mahogany. Wood preservatives are help in the improvement of the durability and wood properties of lees voluble wood species. However, chemical wood preservatives are very harmful for the environmental conditions, ecological biodiversity and human being. Now it is very essential to find the alternative of chemical wood preservatives. In this regarding, researchers are conduct number of studies to testing the natural plant extracts which is obtained from the different part of plants and find the positive response against to the wood degrading agencies.

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