The Environmental Advantages of Using Diffusible Preservatives

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Abstract

The environmental advantages of using diffusible preservatives, based upon boric acid or its sodium salts, are considerable. These compounds have unique characteristics of solubility, toxicity, volatility, durability, and an ubiquitous presence in soil, water, and plants. Most borates occur in nature as several closely related compounds, which differ mainly in their water of hydration and are difficult to tell apart. Most are in the form of boric acid or boron salts. Boron is a micronutrient in soil and borate salts occur naturally in low concentrations in most unpolluted waterways. Risks to birds, fish, and wildlife species are minimal, although some common-sense precautions should be followed.

Introduction

The use of diffusible borate materials has been under consideration or in practice since the late 1930s. Most of the early work with diffusible borates was done in New Zealand and Australia. Very little was done in the United States until the early 1960s (2).

Environmental concerns for the use of pesticides were voiced in the 1960s with the publication of Rachel Carson's *Silent Spring*. Rachel Carson's book created quite a stir when it was published, as it still does today. Many of her expressed concerns about pesticides and their use are becoming the reality of today (1). After Earth Day in 1970, the Environmental Protection Agency (EPA) was organized into existence in December 1970, and environmental concerns became a matter of law. In 1972 Congress amended the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), making the terms "unreasonable adverse effects on the environment," "restricted use pesticides," and "certified applicator" enforceable aspects of the law (6). These terms had not been used before relative to pesticide law, but now we all recognize and use them. In the 24 years since (and several amendments to FIFRA later), materials and methods for wood preservation have changed considerably. Many of the older, more toxic wood preservative pesticides are no longer available. Boric acid was first registered as a pesticide in the United States in 1948. There are about 190 or more pesticide products currently registered that contain boric acid, or one of its sodium salts, as an active ingredient to control crawling insects, fleas, flies, weeds, and other pests in addition to protecting wood products. Now it is common knowledge that the diffusible borates are the most effective means to preventing damage to wood by termites, carpenter ants, wood-boring beetles, and the staining or wood-rot fungi.

When discussing the environmental advantages of diffusible preservatives, "the environment" is described as that area of the earth around us, the land, the water, the air, and the plants and animals that occupy those areas; and the living and working environments inside our buildings. The materials used to manage those pests that attack, damage, and destroy our commodities, structures, and peace of mind often may have adverse effects on our health.

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One definition of integrated pest management (IPM) is risk reduction. IPM reduces risks associated with the presence of a pest, and reduces the risk from the measures used to manage the pest. The diffusible borates indeed provide low-risk protection of wood products used in our environment.

Dietary exposure may occur when treated raw agricultural commodities are eaten. Boron tolerances for residues were established at 30 parts per million (ppm) in or on cotton seed and at 8 ppm in or on citrus fruits. These tolerances covered pre- and post-harvest applications of boric acid, borax, and other borates, plus the naturally occurring boron in agricultural commodities. These tolerances indicate there is a low risk of human injury from dietary exposure to the borates. Boron occurs naturally in fruits, vegetable, and forage crops and is an essential nutrient for plants. In pears and strawberries, the natural levels may reach 160 ppm, and in red cabbage occasionally go as high as 200 to 300 ppm. The increment of added boron residues resulting from the use of boric acid or its salts is insignificant compared to levels that naturally occur.

In 1993, the EPA established an exemption from the requirement for a tolerance for residues of boric acid and its sodium salts on all raw agricultural commodities (including cotton seed and citrus) (5). Although there are no direct food application uses, the environmental presence of boron is much greater than what could occur from its use as a diffusible wood preservative.

The EPA has also determined that boric acid and its sodium salts do not show any evidence of carcinogenicity for humans and no evidence of mutagenicity. However, boric acid and the borate salts are lethal human poisons by ingestion at levels of 5 to 20 g. Exposure through the skin, eyes, or inhalation is minimal, so minimal protective measures are necessary. Expensive specialized protective gear is not needed.

Since 1934, borates have been known to provide a good measure of fire retardancy to wood and paper. This can provide an added environmental advantage by reducing fire risks within structures from heat sources or even open flame for a short time. To achieve good fire retardancy, higher levels of borate impregnation are needed than levels that preserve wood from insect and fungi attack. Borate bombers using borate solutions are still being used extensively to combat brush and forest fires (3).

Borates have a distinctive advantage in that they are invisible when properly applied to wood or wood products. This becomes especially important when preserving historic fabric found in old homes, furniture, tools, or other artifacts. Historic buildings, now under the care of the National Park Service or other historic preservation societies, find that wood can be preserved indefinitely with borate solutions without showing that a preservative has been used.

The borates are essentially nonvolatile. This means that they do not evaporate from the site where applied. This characteristic prevents environmental degradation from chemical trespass from borate vapors. Additionally, indoor air quality is not adversely affected by borate-preserved wood. This is also true for borates (boric acid or disodium octaborate tetrahydrate (DOT)) used for management of cockroaches, fleas, ants, silverfish, bed bugs, or other household insect pests. Most of the other products available to the householder or professional cannot truthfully make this claim.

With diffusible borate preservatives, nonvolatile characteristics convey an additional bonus in being odorless. Odorless borate-preserved wood used in home and furniture construction can make a home more livable. Those with environmental illness or multiple chemical sensitivity may not experience reactions to clean raw wood preserved with a DOT solution.

Borates are durable. They do not break down into ineffective byproducts. They do not evaporate. Although they are water soluble, they do not move far in the environment, especially in soil. If placed in solution, the borates recrystallize and keep working when the water evaporates. When properly applied for insect control in homes or other structures, their insecticidal efficacy lasts for years and years. The same property of durability applies to diffusible borates used for wood preservatives.

The borates have a relatively low toxicity—LD-50 of about 3,500 mg per kg of body weight of test animals. There are many other pesticide chemicals that have lower toxicity LD-50 ratings. However, low toxicity does not necessarily equal low risk. Most pesticides are volatile, which increases nontarget risk. Methods of application that aerosolize pesticides increase risk. Placement of materials can increase risk. Frequency of application can increase risk. If all wood used in structures or furniture was treated with diffusible borates, risks to people occupying those structures would be greatly reduced.

Boron exists in four major forms in soil:

- in rocks and minerals;
- absorbed on surfaces of clays and hydrous iron and aluminum oxides;
- combined with organic matter; and

- as free non-ionized boric acid (H_3BO_3) and $B(OH)_4$ in the soil.

The total concentration of boron in soil varies between 2 and 200 ppm, most frequently ranging between 7 to 80 ppm. Boron is the only nonmetal among the micronutrient elements. The boron complex in soil is bound to clay or organic matter to varying degrees. However, this retards the movement of boron through the soil, reducing its environmental impacts. In the soil, the boric acid is available to plants that utilize its nutrient qualities. However, large amounts of boron can inhibit growth and become toxic to plants.

The average concentration for boron in surface waters is reported to range from 0.001 mg/l to 0.1 mg/l. Seawater boron concentrations average 4.5 mg/l. The low toxicity and ubiquitous natural occurrence reduce the potential risk to nontarget organisms. Boric acid and the borates are "practically nontoxic" to most bird species. There are no records of field mortalities associated with the use of boric acid. Although aquatic invertebrates are more sensitive than fish, boric acid is considered "practically nontoxic" to fish and aquatic invertebrates. The presence of boric acid and borates in the environment provides an additional advantage to their use as wood preservative. The borates have a reduced risk to nontarget organisms.

From the standpoint of reducing environmental risk, every stick of lumber should be treated with DOT by a dip-diffusion process before it leaves the lumber mill. This will eliminate the need for the use of termiticides in home construction and reduce the use of volatile pesticides inside structures.

Another diffusion method for controlling pests in wood and wood products is fumigation with methyl bromide or sulfuryl fluoride. These two highly toxic fumigants can provide total control of wood-infesting insects, and methyl bromide can control wood-infesting fungi. Once the toxic gas in fumigants has been removed, there is no residual protection of the wood from insect or fungus attack. However, methyl bromide will be phased out of use and manufacture in the United States by 2001.

A new developing technology is the use of heat to manage wood-infesting insects and fungi. This technology is available today for use in insect control including termites, carpenter ants, powderpost beetles, and other wood-boring insects that may be infesting new or used wood pallets, wood crating materials, wood packing materials and excelsior, wood chips, timber and finished lumber, debarked logs, plywood, and finished furniture and cabinets.

The benefits of heat are many, but the most important are:

- heat kills all life stages of insects;
- heat requires no toxic chemicals or pesticides;
- because of its low risk, guards do not have to be posted;
- heat has greatly reduced liability;
- heat poses no threat to workers; and
- little or no labor is required during treatment with a mostly automated system.

Superheating wood in the range of 150° to 165°F along with humidity control that retains wood moisture levels provides total insect control.

Key factors that are important for disinfesting wood and wood products are:

- temperature must be elevated slowly and incrementally;
- ambient humidity must be maintained so that the heat-treated wood does not lose moisture; and
- heat treatment time would vary between 6 and 24 hours depending upon the variety of the wood being treated and its moisture content.

As with the fumigants, once the heat is removed, the wood again becomes susceptible to infestation by insects or fungi. Therefore, to achieve a long-lasting, effective preservation of heat-treated wood, treatment by the diffusible borates is in order. This technology is available today as an almost turn-key operation.

Conclusion

The environmental advantages of using diffusible borates for wood protection are many. They can be summarized as follows:

- very effective in protecting wood against termites, carpenter ants, wood-boring beetles, and staining and wood-rot fungi;
- invisible when properly applied, most useful for protecting historic wood artifacts;
- not volatile, so do not evaporate or pollute indoor air space;
- odorless;
- durable, providing wood protection from insect and fungus attack for years, eliminating repeated treatments;
- reduce susceptibility to fire; and
- have low risk to humans and other nontarget organisms.

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