

high photostability. As a result, rooms that have been subject to pyrethroid exposure may have to be decontaminated [32].

- Phosphoric esters

Another class of insecticides frequently found are phosphoric esters, also known as organophosphates. The main types found indoors are dichlorvos, chlorpyrifos and diazinon. They appear in various products, including many insecticides found in the home, most of which are sprayed or applied in powder form. Dichlorvos is commonly found in insect strips because its relatively high vapour pressure means that it is distributed evenly throughout the room. As a result of recent findings concerning the properties of this substance, it has been removed from the list of active ingredients permitted in plant protection products. All phosphoric esters have a high acute toxicity for warm-blooded animals. As with the pyrethroids, they attack the nervous system but their method of attack is to inhibit important enzymes that are involved in muscle control processes. They also inhibit the breakdown of a pyrethroid-cleaving enzyme, thus reinforcing the effect when phosphoric esters are used in combination with pyrethroids.

- Carbamates

Carbamates are not very widespread in insecticide products, apart from those used in agriculture. They work in much the same way as organophosphates though their effect is not quite as strong. The main type is propoxur, which is mostly used in combination with active ingredients from the other two categories mentioned.

All insecticides can be emitted into the indoor air even quite some time after they are applied. This is due to a variety of processes such as vaporisation, desorption or attachment to dust. In practice, they can pollute the air for anything from a few days (as in the case of pyrethrum) to several weeks (dichlorvos) and months or longer (deltamethrin, permethrin).

Since many insecticides accumulate in dust, analysing dust deposits can deliver important information about the substances that have been applied indoors and the doses used. For instance, samples are taken from the air, airborne dust, house dust and surfaces (swipe samples) in order to analyse indoor pyrethroid levels.

Special polyurethane foam filter heads are suitable for air sampling. The airborne dust is separated off onto a fibreglass filter. Household dust is collected using conventional vacuum cleaners; selected sieve fractions with an upper grain size of 2 mm or 63 µm are then examined. Swipe sampling involves a defined surface being wiped with a swipe material (usually cotton) containing a solvent.

12.4.9 Pentachlorophenol (PCP) and lindane wood preservatives

With their biocidal agents, chemical wood preservatives prevent damage to wood. A distinction is made between fungicides, which prevent wood being destroyed or discoloured by fungi, and insecticides for preventing wood damage caused by insects.

In terms of indoor air quality, the wood preservatives pentachlorophenol (PCP) and lindane play a particularly significant role especially due to their widespread use, toxic effects and emission patterns.

Pentachlorophenol (PCP)

Due to its wide spectrum of activity, PCP was used to combat bacteria, fungi, dry rot, algae, snails and insects. It was primarily used as a fungicide in wood preservatives but it was also used in the textile and leather industry, e.g. for marquees and tents. It was approved for large-scale indoor coating between the end of the 1960s and 1978. The substance used was almost always technical-grade PCP, contaminated with dioxins and furans. The contamination levels reached up to 0.3%.

Following a ban on indoor PCP use in 1986, production of PCPs was banned in former West Germany in 1989 [33].

Lindane

PCP's significance as a fungicide was matched by lindane's as an insecticide wood preservative. Since 1983, at least 99% of the content of lindane has been γ -hexachlorocyclohexane – an effective insecticide. Lindane used to be the most commonly used insecticide in chemical wood protection, but substitutes such as pyrethroids (see Section 12.4.8) have largely taken its place.

Lindane was usually combined with PCP (see above) or dichlorodiphenyltrichloroethane (DDT). In the German Democratic Republic, the lindane/DDT mixture was used under the name "hylotox 59" up until 1988, especially in attics and sometimes in indoor rooms. Remaining supplies of hylotox products were allowed to be used until the end of June 1991. Since September 2006, there has been an EU-wide ban on the use of lindane indoors [35].

The active ingredients in the wood preservatives are emitted from the treated materials over a period of several years. Consequently, like many of the insecticides described in Section 12.4.8, they can be detected in many indoor rooms. An effective approach is to examine the treated materials and the house dust as well as taking air samples.

Investigation

To determine the level of pollution from wood preservatives, it is first necessary to establish when and how the wood preservative in question was used and in what quantity. Based on the PCP Directive [35], the following steps are then taken:

- If the investigation reveals that no PCP wood preservatives have been used, no further action is necessary.
- If there are grounds to suspect that PCP wood preservatives have been used, the first step, notwithstanding the PCP Directive, is to calculate the quotient of the treated wood surface and the room volume. Further action is only required if the quotient is $> 0.2 \text{ m}^2/\text{m}^3$.

- If the quotient is exceeded, an analysis of “fresh dust” or “old dust” is required. The fresh dust, which is approximately one week old, is collected using vacuum cleaners. Old dust, i.e. dust deposits that have accumulated over a long period, as can be found behind panelling, for example, is merely collected passively, e.g. with the aid of a brush and spatula.
- If the concentrations are higher than 1 mg PCP/kg of fresh dust or more than 5 mg PCP/kg of old dust, the next step is to take samples from a depth of 0 to 2 mm in the wood concerned. Past wood preservation practice meant that PCPs were mainly only found at the edges of the wood.
- If the resulting value is higher than 50 mg PCP/kg of wood, the annual mean indoor air pollution level must be determined. The PCP Directive stipulates that remediation is necessary if the annual mean concentration is above 1 µg PCP/m³ of air.

The individual steps are shown in Figure 28. The same procedure can be used for lindane.

There are special cases in which people regularly spend more than eight hours a day over a prolonged period in indoor rooms whose purpose is such that exposure to dust, foodstuffs, etc. is likely (e.g. in nurseries or care homes). Where this is the case, the anticipated annual mean air pollution must be checked to determine whether it is higher than the target refurbishment value of 0.1 µg PCP/m³ of air [36]. If it is not, it is unlikely that there is any hazard to health. If the indoor air pollution levels are between 0.1 and 1.0 µg PCP/m³ of air, blood and urine tests must be conducted before making a decision [36]. The remaining procedure is described in the PCP Directive [35].

Figure 28: Flowchart for investigation of PCP pollution from wood preservatives in indoor rooms (based on the PCP Directive [35])

