DECONTAMINATION OF INSECTICIDES FROM VARIOUS SURFACES

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Abstract - We explored decontamination measures which would minimise risk of exposure. Decontamination and cleaning methods were chosen according to the structure of treated surface area and the properties of the active compound. Commercial cleaning agents were used to decontaminate areas treated with insecticides under standard conditions. Insecticides were cyfluthrin, b-cyfluthrin, propoxur, and phoxim, which were used in formulations such as microencapsulated suspension, suspension concentrate, macro emulsion concentrate and emulsifiable concentrates. Successful decontamination was indicated by analytical procedures and biological assay with *Musca domestica.* Greatest reduction was achieved with the micro-encapsulated formulation, then suspension concentrate, macroemulsion concentrate, and emulsifiable concentrates, using high pressure extraction methods. Sealed, waterproof surfaces such as glazed tiles can be more than 99% decontaminated, mainly by the high-pressure extraction; open-pored, water-sensitive surfaces such as carpet with microencapsulated suspension and suspension concentrate formulations can be 90% decontaminated by high-pressure extraction. Decontaminants affect the decontamination result in the high-pressure extraction process by1 - 2 %, the active ingredient is of secondary importance. In manual decontamination of small areas with abrasive pads and scrubbing brushes, the influence of the decontaminant on the decontamination result was increased. Alkaline cleaners containing solvents led to the greatest reduction with manual decontamination. PVC could be decontaminated up to 99% using scouring; 98% of the macro-emulsion formulated cyfluthrin and 99% of other formulations could be removed from uncoated PVC. Decontamination is influenced by the surface, the method and the formulation.
Key words - Pyrethroid, organophosphate, carbamate, formulations, decontaminants

INTRODUCTION

Depending on the formulation, the application of insecticides may lead to undesired contamination of surfaces or objects, regardless of whether their action is short-lived or persistent. Desorbed substances may also escape onto the treated surfaces without being transferred to the air. In the context of the discussion of the effects of insecticides indoors, we explored decontamination measures which would minimise any risk of exposure.

Decontamination methods have already been published, but these methods can only be used in a laboratory (Stout, 1994) or are unsuitable for professional use over large areas, being applied manually with scrubbing brushes (Dechant, 1986). Other methods for decontamination with commercial household cleaners, in which insecticides are washed away from furnishings and carpets, are not satisfactory solutions for decontamination of large areas (Berger-Preiß *et al.*, 1995). Methods based on UV radiation are unconvincing in the area in question (Stolz *et al.*, 1994). Long-established methods for the decontamination of textiles (Laughlin *et al.*, 1991) by washing cannot be transferred to the development of decontamination methods for large areas. Taken as a whole, scientific publications on cleaning methods and decontamination of large areas are very rare. As the surfaces treated are of widely differing structures and as formulations and active ingredients have very different desorption and absorption behaviour, decontaminants and decontamination methods have to be developed experimentally as a function of the surface and the active ingredient.

In this study a selection of commercial detergents was made, insecticides were applied and decontamination was then carried out under practical conditions. In order to have a standard for evaluating large-area decontamination methods, apart from the results of residue analysis, a bioindicator test was performed with *Musca domestica*. In addition the bioindicator test provided information about the bioavailability of the various insecticide formulations on surfaces treated with insecticide prior to decontamination (Hoffmann, 1993).

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MATERIALS AND METHODS

Surfaces

The choice of surfaces was made according to subject-specific criteria, in the kitchen and living area in particular. PVC floor covering, glazed tiles, painted plywood, formica and carpet were chosen as representative surfaces.

Decontaminants and cleaning equipment

Commercial products from the professional cleaning industry were used as decontaminants, according to their suitability for specific surfaces. The equipment and machinery for decontamination were chosen for compatibility with the surfaces, so that no damage was caused to the surfaces after decontamination.

Table 1. Materials used for the decontamination.

Decontaminants	Composition
Multi-purpose cleaner	Ammonia (25 %) 1,2 %, isopropanol 5 %,NTA-Na salt 6 %
Alcohol cleaner	Alkyl sulfonate < 20 %, NTA-Na salt < 20 %, isopropanol 10-15 %
Spray extraction detergent	Non-ionic surfactants < 5%, aliphatic hydrocarbons 5-15 %, care components, water-soluble solvents
Textile shampoo	Anionic surfactants < 5 %, care components
Basic cleaner	Fatty alcohol polyglycol ether < 20 %, butyl glycol < 12,5 %, potassium hydroxide 0,5-1 %, diethylene glycol monobutyl ether < 20 %, NTA-Na salt < 20 %, diethanolamine < 10 %

Table 2. Machines and equipment used for decontamination.

Machine	Type	Equipment
High-pressure spray extraction cleaner	Multi Cleaner MC 600	WDB nozzle
High pressure spray extraction cleaner	MC 600	roller brush spray extraction extension PW 20
Scrubbing vacuum cleaner	BR 400	-
Vacuum cleaner	TBS 35 e	microfilter
Low-pressure spray extraction cleaner	PUZZI S	-
Scrubbing vacuum cleaner	BS 350	-

Insecticides and formulations

In the choice of insecticides and their formulation, care was taken to cover the widest possible range of chemical active ingredient categories. The products used were pyrethroids such as cyfluthrin, beta-cyfluthrin, an organophosphate such as phoxim and a carbamate such as propoxur.

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The formulations selected were EC (emulsifiable concentrate), EW (emulsion, oil-in-water), SC (suspension concentrate) and CS (capsule suspension). All the insecticide formulations were mixed with water according to the manufacturer's instructions before application and then applied to the surfaces.

Table 3. Application rates of insecticides prior to decontamination

Insecticides Trade names	Active Ingredient concentration	A.I. ml/50 ml spray solution	A.I. application rate (mg/m²)
Solfac®CS	60 g Cyfluthrin/l	0.6	36
Solfac®EW	50 g Cyfluthrin/l	0.4	20
Responsar®SC	125 ß-Cyfluthrin/l	0.1	12.5
Blattanex®EC	200 g Propoxur/l	1.25	250
Baythion®EC	500 g Phoxim/l	0.1	50

Decontamination procedure

Various surfaces measuring 2 m x 1 m were sprayed with 100 ml insecticide solution prepared ready for use. Decontamination was carried out on the following day. The temperature in the test rooms was between 18 and 21ºC and the relative air humidity between 35 and 52%.

High-pressure extraction method for water-resistant surfaces such as glazed tiles, Formica and painted wood

The decontaminants multi-purpose cleaner and alcohol cleaner were first diluted to 2.5%. The decontamination solution was then placed in the clean water tank of the MC 600. The machine was fitted with the WDB nozzle. The decontamination solution was sprayed onto the panels at a pressure of 50 bar, and was left for a short time to take effect. At the second stage the spray extraction solution was applied and vacuumed up simultaneously. In the next operation the clean water tank was emptied, rinsed and filled with clean water. To remove residues of detergent from the panels water was applied and then vacuumed up again immediately.

The grouting between the glazed tiles was soaked with water before application of the insecticide in order to prevent the insecticide from migrating into the grouting compound.

Scrubbing vacuum method for PVC

The alkaline basic cleaner (pH = 12.1) was applied with a cloth. After a contact period of 10 minutes it was scrubbed with the scrubbing vacuum cleaner BS 350 with a dark green pad. The floor was gone over twice in overlapping figures of eight, with the suction lips in the raised position. The suction lips were then lowered and the basic cleaner solution was vacuumed up. The operation was repeated once and the pad was then removed and cleaned, the dirty solution tank was emptied and the detergent tank filled with clean water. The operation was repeated twice with water, first scrubbing and then vacuuming.

Low-pressure spray extraction for textile coverings

First the short pile velvet carpet made from polyamide with textile backing was thoroughly vacuumed with the TBS 35e brush vacuum cleaner. A 10% decontamination solution was prepared with the carpet cleaner. The equipment used was the PUZZI S spray extraction cleaner. The decontamination solution was placed in the clean water tank and the carpet was sprayed with it in parallel overlapping strips. The suction tool was not placed on the surface. After a contact time of approx. 5 minutes the floor was

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gone over, with the decontamination solution sprayed on again at 4-5 bar and then vacuumed up simultaneously. The dirty water tank was emptied and the clean water tank rinsed out and filled with clean water. The floor was gone over twice more with simultaneous spraying and vacuuming, in order to remove any remaining spray extraction solution. Further vacuuming was intended to ensure that the carpet retained as little moisture as possible and therefore dried more quickly. After drying, the carpet was vacuumed again with a brush vacuum cleaner.

High pressure spray extraction for textile coverings

The textile covering was first vacuumed thoroughly with a brush vacuum cleaner TBS 35. A 2.5% decontamination solution of the spray extraction detergent was applied with the spray extraction machine. The MC600 was used for spray extraction. The PW 20 spray extraction tool consists of a rotating brush roller, three wide-angle nozzles and a suction nozzle. It was therefore possible to spray, brush and vacuum in one operation. The brush roller helps to work the decontamination solution in deeply and thus to achieve a more intensive action.

The 2.5% decontamination solution was placed in the clean water tank and first sprayed on at 20 bar and worked in with the brush. After approx. 5 minutes' contact time more solution was applied by going over the floor and this was vacuumed up simultaneously. The clean water tank was emptied, rinsed and filled with clean water and the carpet was rinsed twice more with water with rotating brush. It was then vacuumed to allow the floor to dry more quickly. After the carpet had dried it was run over again with a brush vacuum cleaner.

Shampooing and spray extraction of textile coverings

The carpet was first vacuumed thoroughly with the brush vacuum cleaner. The shampoo was worked into the surface with the scrubbing vacuum cleaner BR 400 which was fitted with shampoo brushes. After a contact time of approx. 5 minutes the water was extracted from the carpet with the PUZZI S low-pressure spray extraction machine. For this it was sprayed and vacuumed simultaneously twice. When the carpet was completely dry it was again vacuumed thoroughly with the brush vacuum cleaner.

ANALYTICAL METHODS

Residue analysis tests with the DC/AMD-TLC (Automated Multiple Development) method

After decontamination of the 2 m x 1 m areas, panels measuring 15 cm x 15 cm were sawn out at three different points and after appropriate extraction on HPTLC silica gel plates the active ingredient residue was determined as a percentage of the application solution by the AMD-TLC method (Burger, 1988). The carpet was first prepared by an HPLC separation before the AMD separation was performed.

Bioindication method with *Musca domestica*

To test the residue three baskets each with 20 female flies of the species *Musca domestica* were placed on each 2 m^2 surface. The flies were fed with cotton wool pads soaked in sugar water. A control (surface treated with detergent) and a positive control (surface treated with insecticide without decontamination) were also set up. The survival rates were measured after 1 h and after 24 h following the method described by Hoffmann (1993).

RESULTS

High-pressure extraction – tiles, *Formica*

In the high-pressure extraction process with the multi-purpose cleaner AZ 70 on glazed tiles the decontamination was over 99% reduction for all active ingredients and formulations (Table 4). Depending on the formulation the active ingredient reductions achieved in the high-pressure extraction process with the

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multi-purpose cleaner on Formica were between 85% for Solfac EW and over 99% for Solfac CS with the alcohol cleaner (Table 5). This is documented by the fly test in Table 5, where the lowest values were achieved with Solfac CS with a 0% mortality rate and Responsar SC with a 10% mortality rate after 24 hours.

Table 4. Decontamination of glazed tile. Decontamination was performed with the multi-purpose cleaner by the decontamination procedure MC 600. After treatment 0, resp. 5% of *Musca* are dead after 1, resp. 24 hours. The values for the *Musca* are given in % mortality.

Insecticide	Active ingredient	Reduction in a.i. (%) mean value	% Mortality (before decontamination)		% Mortality (after decontamination)	
			1 hr	24 hr	1 hr	24 hr
Solfac CS	Cyfluthrin	> 99	20	90	0	0
Solfac EW	Cyfluthrin	> 99	100	100	0	10
Responsar SC	ß-Cyfluthrin	> 99	100	100	0	0
Blattanex EC	Propoxur	> 99	45	90	0	0
Baythion EC	Phoxim	> 99	75	100	0	0

The mortality rate for *Musca domestica* was 0% for all insecticides with the exception of Solfac EW 5%. Residue analysis on the grouting compound produced values below 1 mg/kg grouting compound.

Table 5. Decontamination of Formica. Decontamination was performed with the multi-purpose cleaner by the decontamination procedure MC 600. After treatment 0, resp. 5% of *Musca* are dead after 1, resp. 24 hours. The values for the *Musca* are given in % mortality.

Insecticide	Active ingredient	Reduction in a.i. (%) mean value	% Mortality (before decontamination)		% Mortality (after decontamination)	
			1 hr	24 hr	1 hr	24 hr
Solfac CS	Cyfluthrin	98	0	100	0	0
Solfac EW	Cyfluthrin	85	100	100	10	30
Responsar SC	ß-Cyfluthrin	89	5	100	0	10
Blattanex EC	Propoxur	95	30	80	10	38
Baythion EC	Phoxim	94	45	100	30	70

Painted wood

In the decontamination of painted wood in the high-pressure extraction process with an alcohol cleaner, an insecticide reduction of over 99% was achieved except with the active ingredients formulated as EC (Table 6). The bioindication test with *Musca domestica* (Table 6) also showed no increase in mortality rates. Baythion EC had no effect on *Musca domestica* in the positive control.

Table 6. Decontamination of painted wood. Decontamination was performed with an alcohol cleaner by the decontamination procedure MC 600. After treatment with an alcohol cleaner 0, resp. 5% of *Musca* are dead after 1, resp. 24 hours. The values for the *Musca* are given in % mortality.

Insecticide	Active ingredient	Reduction in a.i. (%) mean value	% Mortality (before decontamination)		% Mortality (after decontamination)	
			1 hr	24 hr	1 hr	24 hr
Solfac CS	Cyfluthrin	> 99	10	100	0	5
Solfac EW	Cyfluthrin	99	50	100	0	5
Responsar SC	ß-Cyfluthrin	> 99	10	100	0	10
Blattanex EC	Propoxur	95	5	80	0	15
Baythion EC	Phoxim	94	0	0	0	0

Scrubbing vacuum, PVC

On coated PVC after removal of the protective film a reduction in insecticide of over 99% was achieved in the scrubbing/vacuuming process with a basic cleaner for all active ingredient formulations. The bioindication test also showed no mortality for houseflies. On uncoated PVC the active ingredient reduction was over 99% with the exception of Solfac EW with 98% and Responsar SC with 99% (Table 7). The bioindication test resulted in mortality rates of 5% and under. Only in the case of Blattanex EC was a mortality rate of 20% determined.

Table 7. Decontamination of uncoated PVC. Decontamination was performed with a basic cleaner by the decontamination procedure BS 350. After treatment with a basic cleaner 0% of *Musca* are dead after 1, resp. 24 hours. The values for the *Musca* are given in % mortality.

Insecticide	Active ingredient	Reduction in a.i. (%) mean value	% Mortality (before decontamination)		% Mortality (after decontamination)	
			1 hr	24 hr	1 hr	24 hr
Solfac CS	Cyfluthrin	> 99	10	100	0	0
Solfac EW	Cyfluthrin	98	30	100	0	5
Responsar SC	ß-Cyfluthrin	99	10	100	0	3
Blattanex EC	Propoxur	> 99	0	90	0	20
Baythion EC	Phoxim	> 99	10	10	0	0

Textile coverings, high- and low -pressure extraction

The reduction in active ingredient achieved with the low-pressure spray extraction method was between 53% for Blattanex EC and 86% for Solfac EW (Table 8). The 96% reduction in active ingredient for Baythion EC is exceptional. The fly mortality rates after 24 h were between 13% for Baythion EC and 65% for Solfac EW (Table 8). With the high-pressure spray extraction method using the spray extraction detergent, the reduction in active ingredient achieved was 90% for Solfac CS and 88% for Responsar SC. Resultant mortality rates after 24 hours in the housefly bioindicator test were 5% for Solfac CS and 13% for Responsar SC (Table 9).

Table 8. Decontamination of velvet carpet. Decontamination was performed with a spray extraction detergent by the decontamination procedure Puzzi S. After treatment with a spray extraction detergent 0, resp. 5% of *Musca* are dead after 1, resp. 24 hours. The values for the *Musca* are given in % mortality.

Insecticide	Active ingredient	Reduction in a.i. (%) mean value	% Mortality (before decontamination)		% Mortality (after decontamination)	
			1 hr	24 hr	1 hr	24 hr
Solfac EW	Cyfluthrin	86	100	100	25	65
Solfac CS	Cyfluthrin	84	90	100	12	20
Responsar SC	ß-Cyfluthrin	59	90	100	8	25
Blattanex EC	Propoxur	53	10	60	0	22
Baythion EC	Phoxim	96	0	100	0	13

Shampoo

After shampooing the carpet the reduction in active ingredient was 88% for Solfac CS and 69% for Responsar SC (Table 10); the fly mortality rates for Responsar SC were 17% and for Solfac CS 10% (Table 10).

Table 9. Decontamination of velvet carpet. Decontamination was performed with a spray extraction detergent by the decontamination procedure high pressure extraction. After treatment with a spray extraction detergent 0%, resp. 5 % of *Musca* are dead after 1, resp. 24 hours. The values for the *Musca* are given in % mortality.

Insecticide	Active ingredient	Reduction in a.i. (%) mean value	% Mortality (before decontamination)		% Mortality (after decontamination)	
			1 hr	24 hr	1 hr	24 hr
Solfac CS	Cyfluthrin	90	90	100	2	5
Responsar SC	ß-Cyfluthrin	88	90	100	0	13

Table 10. Decontamination of velvet carpet. Decontamination was performed with textile shampoo by the decontamination method BR 400. After treatment with Shampoo 0% of *Musca* are dead after 1, resp. 24 hours. The values for the *Musca* are given in % mortality.

Insecticide	Active ingredient	Reduction in a.i. (%) mean value	% Mortality (before decontamination)		% Mortality (after decontamination)	
			1 hr	24 hr	1 hr	24 hr
Solfac CS	Cyfluthrin	88	90	100	0	10
Responsar SC	ß-Cyfluthrin	69	90	100	0	17

DISCUSSION

In the decontamination of glazed tiles a reduction in insecticide of over 99% was achieved with all active ingredients and formulations, which can be attributed to the sealed, solvent-proof surface. The

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grouting can be protected against penetration of the formulation components by pre-soaking, resulting in insecticide residues of less than

1 mg/kg grouting compound after decontamination (Table 4). The decontamination results for Baythion EC (94%), Blattanex EC (95%) and Solfac EW (85%) on Formica and the mortality rates for houseflies (Table 5) point to a stronger adhesion by the solvent ingredients in the EC and EW formulations. Solfac CS, Starycide SC and Responsar SC produced mortality rates of 0% or 5% in the case of Responsar SC.

In the application of Baythion EC and Blattanex EC to painted wood the bioavailability of the active ingredients (Table 6) was non-existent or limited, indicating a reaction of the EC formulations with the paint. The residual active ingredient content of 5% for Blattanex EC and 6% for Baythion EC indicates a migration of the solvent-containing components of the EC formulations into the paint. The other insecticides used were 99% decontaminated (Table 6).

The insecticide reduction on a PVC coating with a protective film was over 99% for all the insecticide formulations investigated, while no bioavailability existed for Baythion EC and Blattanex EC; this led to a mortality rate of 0% on surfaces which had not been decontaminated. For Blattanex EC decontamination produced an active ingredient reduction of over 99%, while by contrast the mortality rate of the houseflies was higher at 20%, which may be due to desorption. The low mortality rate of only 10% for Baythion EC on the uncoated PVC which had not been decontaminated (Table 7) also leads to the conclusion that the active ingredient had migrated into the PVC and may also have been desorbed. Further research is needed in order to make more precise statements (Winter, 1998).

As expected, the poorest insecticide reduction during decontamination was achieved with the non-homogeneous textile covering (Table 8); this is evidenced by the higher mortality rates in the houseflies. Only with the improved method, high-pressure spray extraction, could reductions in active ingredient of 90% and 88% for Solfac CS and Responsar SC respectively be achieved (Table 9). In order to achieve an optimum decontamination result, the formulation of the active ingredient chosen for application is decisive. The correct choice of formulation may lead to an improved decontamination result for cyfluthrin, for example, on Formica in the CS formulation (99% reduction in active ingredient) as compared with the EW formulation (85% active ingredient reduction).

The effect of the surface on the decontamination result is quite significant; for instance, Blattanex EC on sealed surfaces can be reduced by over 99%, while on carpet an active ingredient reduction of only 53% is possible. Above all the decontamination result can be influenced by the method used. The use of the high-pressure extraction method (PW 20) on the velvet carpet after application of cyfluthrin SC achieves a better result (88% active ingredient reduction) than the low-pressure spray extraction method (Puzzi S) (59% active ingredient reduction). The results obtained after shampooning were 69% reduction (Table 10).

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