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CONTENT OF TRANSFLUTHRIN IN INDOOR AIR DURING THE USE OF ELECTRO-VAPORIZERS

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Abstract: The quality of indoor air evokes increasing interest; however, no standards have been developed which determine the content of pesticides in the air of living space. At present, insecticides are increasingly more frequently applied to control household pests, flies, mosquitoes, termites and other harmful insects. In this study, the content of transfluthrin was measured indoors after the application of two consumer products containing this active substance, using commercially available electro-vaporizers. It was found that during the application of insecticides in the form of gel and liquid the mean concentration of transfluthrin in the air was 1.295–2.422 μg/m^3 and 3.817–5.227 μg/m^3, respectively. The concentration of an active agent in the air did not depend on the day of application. The concentration of transfluthrin was higher when used in the form of a liquid than a gel preparation. 18–24 hours after the discontinuation of the use of the preparation no active agent was found in the air. As long as the standards are developed regulating the content of insecticides in the air of living spaces and utility rooms, the most important method of preventing their potential hazardous effect is informing the users of these preparations about the occurrence of active substances in indoor air, and eventual risk of exposure to the effect of pesticides during their application at home.

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INTRODUCTION

Recently, the quality of indoor air has evoked increasing interest, and organizations are being created which undertake actions on behalf of the establishment of standards concerning the purity of indoor air. However, to-date, no standards have been developed which would determine content of pesticides in the air of living spaces.

The Scientific Committee on Health and Environmental Risks attracted attention to the importance of the following components: formaldehyde, carbon monoxide, nitrogen dioxide, benzene, naphthalene, environmental tobacco smoke, radon, lead and organophosphate pesticides [13]. From among insecticides, only organophosphorus compounds are mentioned as potential toxins, which should be taken into consideration while developing standards.

Nevertheless, at present, pyrethroids are increasingly more frequently applied to control household pests, such as flies, mosquitoes, termites, and other harmful insects. Pyrethroids are considered as substances of low toxicity. However, due to the long time which humans spend in indoor spaces, the duration of exposure is long, which may bring about health effects. The health effects of a long-term exposure to low concentrations of pesticides have been very poorly recognized. Moreover, the occurrence of interaction between various factors originating from the air and from other sources may also be of great importance. Hazardous neurotoxic interactions have been described while searching for the explanation of Gulf War Syndrome [1, 2, 3, 4]. Therefore, searching for and characterizing the sources of exposure to pesticides outside workplaces in agriculture is very important.

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The objective of the study was determination of the content of an active substance in a room in which a biocidal product was applied. Transfluthrin, a component of many consumer products for indoor use, was selected as a model substance. At the first stage of the study, a properly sensitive and precise method was developed for the determination of transfluthrin in the air. Subsequently, the content of transflutrin was measured indoors after the application of two consumer products containing this active substance.

MATERIALS AND METHODS

Air samples were collected during the operation of an electro-vaporizer with a product containing transfluthrin: Baygon Master electro-vaporizer for insect control with S.C. Johnson refill inserts (in the form of gel) (37.5% transfluthrin) and Baygon Geniusz T electro-vaporizer for insect control with S.C. Johnson liquid for electro-vaporizer (37.5% transfluthrin).

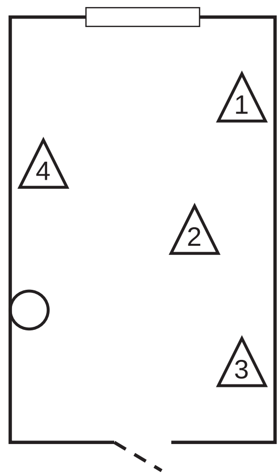

Figure 1. Diagram showing location of electro-vaporizer and four air samplers in the room. Circle – electro-vaporizer; triangles with numbers – air samplers, numbers correspond to respective data presented in Table 1 and 2; rectangle – window; dashed line – door.

Air sampling. Air samples were collected at 4 sites in an enclosed space of the surface of 15.31 m^2 and cubature of 46.70 m^3, with a widow. A gravity ventilation system was in operation in the room. The study was conducted during the period from May–June at the ambient temperature of 20 ± 2ºC. The samples were collected in parallel at 4 sites at the height of 1 meter from the floor surface (Fig. 1), during the operation of the electro-vaporizer for a period of 6 hours; after the taking of air samples the electro-vaporizer was switched off. The air samples were collected with the use of samplers filled with silica gel with chemically bonded octadecyl phase ODS-C18 (0.8 g); 180 l of the air was sampled with the velocity of 0.5 l/min for the period of 6 hours.

Analytical procedure. The sampler with the air sample collected was placed in a vertical position with the air inlet downwards, and diethyl ether was passed through with the flow velocity of approximately 0.5 ml/min. 20 ml of extract was collected into the vacuum evaporator probe; subsequently, the extract was evaporated at room temperature to dry residue. The dry residue was diluted in 1 ml of cyclohexane and analyzed by the gas chromatography method.

Gas chromatography. The content of the compound in the extracts was determined by the gas chromatography method with an electrone capture detector (ECD). A Hewlett Packard gas chromatograph was applied – type 5890 series II with ECD detector and electronic integrator equipped with HP-5 capillary column of the length of 10 m, internal diameter 0.53 mm, with a phenoxysilicon resin network (5%) of the film thickness of 2.65 µm. Chromatographic analysis of the extract (at least 2–3 measurements) was performed in selected conditions for the determination: column temperature of 185ºC, dispenser temperature of 200ºC, detector temperature of 300ºC, nitrogen flow rate through the column of 8 ml/min. In the selected conditions the transfluthrin retention time was 5.12 min.

The mean tranfluthrin recovery obtained in the model analyses after sorption of the liquid phase and extraction with diethyl ether for the mass of 0.05–0.50 µg/sampler was 97.88% (accuracy of the method ± 2.23%).

Durability of the samples at storage temperature of +4ºC was not less than 2 weeks.

Respiratory exposure. Respiratory exposure was calculated by means of the following formula:

$$\text{respiratory exposure} = a \times b \times c$$

a – pulmonary ventilation volume [dm^3/min],
b – duration of exposure to the inhalation of pesticides [min] – 360 min,
c – concentration of active substance in respiratory zone [mg/dm^3].

Statistical analysis. The results were presented as the mean values ± SEM. Statistical analysis was performed with the use of Student's t-test or ANOVA followed by *post hoc* Tukey test. The p value <0.05 was considered statistically significant.

RESULTS

During the application of insecticides in the form of a gel the mean concentration of transfluthrin in the air of the room varied from 1.295–2.422 µg/m^3, on different days. The differences were not significant (ANOVA test, $p>0.05$) (Tab. 1).

During the application of insecticides in the form of a gel the mean concentration of transfluthrin in the air recorded at 4 various sites varied from 1.428–2.199 µg/m^3. The differences were not significant (ANOVA test, $p>0.05$) (Tab. 1).

Table 1. Content of transfluthrin in indoor air [μg/m^3] collected at 4 sites during the operation of the electro-vaporizer for insect control with refill insert in the form of gel.

Day	Sampler				Mean	SEM
	1	2	3	4		
1	1.406	1.340	1.045	1.388	1.295	0.084
2	2.003	1.831	1.459	2.287	1.895	0.173
3	2.482	2.908	1.644	1.240	2.069	0.381
4	3.021	3.118	1.186	1.758	2.271	0.476
5	2.110	2.106	2.170	3.302	2.422	0.294
6	1.566	1.616	1.169	2.418	1.692	0.262
7	1.262	1.238	1.346	2.659	1.626	0.345
8	1.332	1.056	1.407	2.539	1.583	0.327
Mean	1.898	1.902	1.428	2.199	–	–
SEM	0.221	0.270	0.125	0.245	–	–

Table 2. Content of transfluthrin in indoor air [μg/m^3] collected at 4 sites during the operation of the electro-vaporizer for insect control with liquid.

Day	Sampler				Mean	SEM
	1	2	3	4		
1	4.047	3.491	3.773	5.338	4.162	0.408
2	3.351	3.861	3.890	4.165	3.817	0.170
3	4.063	5.147	4.198	7.500	5.227	0.795
Mean	3.821	4.166	3.954	5.668	–	–
SEM	0.235	0.502	0.127	0.977	–	–

During the application of insecticides in the form of a liquid the mean concentration of transfluthrin in the air of the room varied from 3.817–5.227 μg/m^3, on different days. The differences were not significant (ANOVA test, $p>0.05$) (Tab. 2).

During the application of insecticides in the form of a liquid the mean concentration of transfluthrin in the air recorded at 4 various sites varied from 3.821–5.668 μg/m^3. The differences were not significant (ANOVA test, $p>0.05$) (Tab. 2).

The mean concentration of transfluthrin in the air was higher when used in the form of a liquid than a gel preparation as compared on day 1, 2 and 3, respectively (Student's t-test, $p<0.05$).

The active agent was not detected in the air 18–24 hours after the discontinuation of the use of each preparation (data not shown).

Mean respiratory exposure to transfluthrin assessed by means of the formula described in the section Materials and Methods was 0.0134 mg/day for the gel preparation and 0.0317 mg/day for the liquid preparation, respectively.

DISCUSSION

Two commercially available preparations were investigated in the study, Baygon Master refill inserts in the form of a gel, and Baygon Genius T in the form of a liquid. The preparations were applied in accordance with the user's guide. The measurements were performed in a standard room with a window, in which a gravity ventilation system was in operation during the summer season from May-June. The air samples had been collected for 3 or 8 days at 4 various sites at a height of 1 meter above the floor surface. It was found that during the application of insecticides in the forms of a gel and liquid in a living space, the mean concentration of transfluthrin in the air was from 1.295–2.422 μg/m^3 and 3.817–5.227 μg/m^3, respectively. The concentration of transfluthrin in the air was higher when used in the form of a liquid than a gel preparation. The concentration of an active agent in the air did not depend on the day of application. The study showed no presence of the active agent in the air 18–24 hours after the discontinuation of the use of the preparation.

In the literature available, no results were found concerning the measurement of the content of transfluthrin in the air in a living space after application of the electro-vaporizers. The maximum content of transfluthrin was only described in indoor air after the application of mosquito repellent in a spray, which was 0.0134 ppm [12]. However, the content of other pyrethroids was determined in the air of living areas following the use of electro-vaporizers. The concentration of metofluthrine was 0.15 μg/m^3, while allethrin concentration was 150 μg/m^3 [16]. In another report, the concentration of allethrin in the air was 5–12 μg/m^3, and of pyrethrin 0.5–2 μg/m^3 [5]. The concentration of allethrin was earlier described on the level of 2–5 μg/m^3 [6]. These results are similar to the results obtained in our study.

The standard for transfluthrin concentration in indoor air in the living space has not been established; consequently, it is not possible to refer the results of measurements and evaluate the toxicity of the insecticide. Respiratory exposure to transfluthrin was therefore assessed by means of the formula described in the section concerning Material and Methods. The exposure values calculated in this way were 0.0134 mg/day for the gel preparation and 0.0317 mg/day for the liquid preparation, respectively. The studies conducted show that the use of insect repellents in living spaces, outside agriculture, results in the presence of insecticides in the air and may constitute a source of exposure to its toxic effect.

Although the concentration of the agent is low, the toxic effect cannot be excluded, especially in more susceptible individuals. It was confirmed that transfluthrin and other pyrethroids exert a genotoxic and potentially cancerogenic effect. These studies were conducted on human nasal mucosal cells [14, 15]. Moreover, the risk of occurrence of an interaction which may be toxic cannot be ignored. It should be remembered that various pesticides have been identified in house dust and on the surface of objects inside living spaces [7, 10, 11].

In association with an attempt to explain the causes of the occurrence of Gulf War Syndrome a number of studies were conducted concerning interactions between various chemical agents, including insecticides and repellents. After concurrent exposure to non-toxic doses of pyridostigmine bromie, DEET, and chlorpyrifos or permethrin, a strong toxic effect was observed in hens [2, 3]. Similarly, the combination of DEET and permethrin, malathion and permethrin, or the 3 chemicals together resulted in neurobehavioural deficits and neuronal degeneration in the brain of rats [1]. Therefore, it should be borne in mind that various pesticides have been identified in house dust and on the surface of objects inside living areas [7, 10, 11].

A separate problem resulting from the indoor use of pesiticdes is their possible effect on children and pregnant women. The data concerning this problem are scarce because in agriculture the performance of work activities with pesticides is prohibited for pregnant women and children. In literature, there are no reports pertaining to the effect of transfluthrin on pregnant women and children.

Data from literature obtained from the studies of other pesticides indicate that children's exposure to the hazardous effect of pesticides residues in the home environment is high, because they spend most of their time at home, and the presence of pesticides residues was confirmed not only in house dust, but also on the surface of children's toys [8, 9].

As long as standards are developed regulating the content of insecticides in the air of living spaces and utility rooms, the most important method of preventing their potential hazardous effect is informing the users of these preparations about the occurrence of active substances in indoor air, and eventual risk of exposure to the effect of pesticides during their application at home.

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