Available online at www.sciencedirect.com
SCIENCE DIRECT®
Int. J. Hyg. Environ.-Health 209 (2006) 41–56
International Journal of Hygiene and Environmental Health
www.elsevier.de/ijheh

Aircraft disinsection: Exposure assessment and evaluation of a new pre-embarkation method

Edith Berger-Preiß[a], Wolfgang Koch[a], Susanne Gerling[a], Heiko Kock[a], Jutta Klasen[b], Godehard Hoffmann[b], Klaus E. Appel[c,*]

[a]Fraunhofer Institute of Toxicology and Experimental Medicine, Hannover, Germany
[b]German Federal Environmental Agency, Berlin, Germany
[c]Center for Experimental Toxicology, Federal Institute for Risk Assessment, Thielallee 88-92, 14195 Berlin, Germany

Received 22 June 2005; received in revised form 24 August 2005; accepted 28 August 2005

Abstract

A new "pre-embarkation" method for aircraft disinsection was investigated using two different 2% *d*-phenothrin containing aerosols. Five experiments in aircrafts of the type Airbus 310 (4 ×) and Boeing 747–400 (1 ×) were performed. In the absence of passengers and crew the *d*-phenothrin aerosol was sprayed under the seat rows and in a second step at the height of approximately 1.60 m by moving from one end of the cabin to the other. Concentration levels of *d*-phenothrin were determined at different time periods after application of the aerosol spray. In a B 747–400 with the air conditioning system operating the concentrations ranged between 853 and 1753 $\mu g/m^3$ during and till 5 min after the beginning of spraying at different locations in the cabin. Within 5–20 min after the end of the spraying concentrations of 36–205 $\mu g/m^3$ and 20–40 min thereafter only ca. 1 µg *d*-phenothrin/m^3 were detectable (average values in relation to each period of measurement). On cabin interior surfaces the median values for mainly horizontal areas ranged from 100 to 1160 ng *d*-phenothrin/cm^2. *d*-Phenothrin concentrations in the air were sufficient to kill flying insects like house flies and mosquitoes within 20 min. Horizontal surfaces were 100% effective against insects up to 24 h after spraying. Doses inhaled by sprayers determined by personal measurements were calculated to be 30–235 µg *d*-phenothrin per 100 g spray applied (30% in the respirable fraction for Arrow Aircraft Disinsectant; 10% for Aircraft Disinsectant Denka). If passengers will board, e.g., 20 min after the end of the disinsection operation, inhalation exposure is estimated to be practically negligible. Also possible dermal exposure from residues in seats and headrests is very low for passengers during the flight. Therefore any health effects for passengers and crew members are very unlikely.

Keywords: Aircraft-disinsection; *d*-Phenothrin; Pre-embarkation method; Top-of-descent technique; Air and surface concentrations; Inhalational and dermal exposures; Health risks; Control efficacy

Introduction

Pesticides are applied in aircrafts to prevent the spreading of arthropod vectors and ectoparasites and the diseases they cause in humans, such as malaria,

*Corresponding author. Tel.: +49 1888 412 3614; fax: +49 1888 412 3685.
E-mail address: k.appel@bfr.bund.de (K.E. Appel).

1438-4639/$ - see front matter © 2005 Elsevier GmbH. All rights reserved.
doi:10.1016/j.ijheh.2005.08.009

dengue or yellow fever. For control of insects in aircrafts the World Health Organization (WHO) recommends various disinsection procedures like "blocks away", "pre-flight and top-of-descent spraying" and "residual treatment" (WHO/HQ, 1995) using aerosol spray preparations with different active ingredients like pyrethrins, resmethrin, *d*-phenothrin or permethrin. Furthermore, some countries (e.g., Australia, New Zealand, India) insist that arriving aircrafts have to be disinsected before landing. Methods such as "top-of-descent spraying" and "on-arrival spraying", in which treatment of the aircraft with biocide aerosol sprays takes place while passengers are on board, are recognized as reliable procedures (MQC and AQIS, 2002).

With regard to health risks, aircraft disinsection is necessary to prevent insect transmitted infectious human diseases and the methods used for aircraft disinsection should completely eliminate a possible infestation within a short time. On the other hand, applying pesticides in the aircraft should not inconvenience passengers and crew members or even impair their health. Particularly if pesticides are sprayed as aerosols while passengers are on board, e.g., by using the "in-flight" spraying techniques, passengers and crew members are directly exposed to the aerosol. Considering the level and diversity of exposure (inhalation, dermal, oral) health risks to passengers and crew members cannot be entirely excluded (Appel and Lingk, 1998; Hoffmann, 1998; Schäffer, 1998; van Netten, 2002). In addition, flight attendants and passengers have, in fact, reported health effects after biocide applications in aircrafts. Symptoms mentioned included: headaches, dizziness, nausea, as well as skin rashes and swelling sinuses, a metallic taste, irritation of eyes, throat and upper respiratory tract, inducing respiratory symptoms such as breathing problems, dyspnoea and cough (www.afanet.org; www.pesticideplanes.com; www.usatoday.com; Woodyard, 2001). However, such cases were never reported in the scientific literature and an evaluation is therefore not possible. Investigations with asthmatic subjects however demonstrate that some insecticide aerosols trigger symptoms and falls in lung function and may also increase airway hyperresponsiveness (Salome et al., 2000).

Measurements carried out (Berger-Preiß et al., 2004) during "in-flight" application of SRA spray (standard reference aerosol, simulated at ground level) show that concentrations in the air of the passenger cabin (during and 40 min after spraying) reached values up to 65 $\mu g/m^3$ for pyrethrins (active ingredient) and 485 $\mu g/m^3$ for piperonyl butoxide (synergist). Doses inhaled by sprayers, crew members and passengers were calculated to be 17 μg for pyrethrins and 200 μg for piperonyl butoxide per 100 g spray applied. Twenty-seven percent of the active ingredients were in the respirable fraction. Furthermore, up to 830 μg pyrethrins (8840 μg piperonyl butoxid) were detected on the clothes of passengers or crew members. Concentrations on surfaces of the passenger cabin (floor below seats, seats, headrests) were up to 55.5 ng/cm^2 for pyrethrins and 1162.5 ng/cm^2 for piperonyl butoxide (median values). In order to reduce any possible health risks from these exposures, the German authorities "Federal Institute for Risk Assessment (BfR)" and "Federal Environmental Agency (UBA)" initiated research with regard to the development of alternative disinsection methods in aircrafts. A new "pre-embarkation" technique was investigated in which *d*-phenothrin-containing aerosol sprays were applied in the passenger cabin during the absence of passengers and crew, a certain time period before boarding. In contrast to the "pre-embarkation" method used by Australia and New Zealand, no long-lasting pyrethroids, as for instance permethrin, were used and application methods were changed to guarantee an effective insect control.

In the present paper the new method of aircraft disinsection and its evaluation with regard to exposure and health risks for the operators, passengers and crew members as well as its efficacy in controlling insect vectors are described. Various experiments in parked aircrafts using two different disinsection sprays (Aircraft Disinsectant Denka and Arrow Aircraft Disinsection Spray) were carried out. During the experiments *d*-phenothrin concentrations in the passenger cabin (in the air, on surfaces and in settled dust) as well as inhalational and dermal exposure data were determined and the metabolites of *d*-phenothrin in urine of persons staying in the passenger cabin were studied. For comparison the same measurements were made after performing the established "top-of-descent" spraying technique, which was simulated in experiments at ground level.

Materials and methods

Spray characterization

Two different *d*-phenothrin-containing (2%) aerosol sprays – Aircraft Disinsectant Denka (50 ml cans) and the Arrow Aircraft Disinsection Spray (250 ml cans) – were applied. The Aircraft Disinsectant Denka containing 90% water and compressed air was used for experiments E1 and E4 and the Arrow Aircraft Disinsection Spray, containing 40–60% aliphatic hydrocarbons for experiments E2, E3 and E5. Both sprays were characterized with respect to the particle diameter of the released spray droplets. Measurements were carried out with a laser diffraction spectrometer (Helos (1269), Sympatec GmbH). The cumulative volume distribution, Q_3, as a function of the droplet size is