INDOOR AIR POLLUTION: MISTRUST & HEALTH EFFECTS: INTERVENING IN A COMPLEX PROBLEM SITUATION

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Plain facade, complex problems. (Photo: **Hutter**)

INTRODUCTION

After the construction of a new office building the employees of a large hospital moved in successively during a period of several months. Although employees participated in the selection of furniture and equipment, and despite improvements concerning comfort and space, complaints were reported to the occupational physician and workers' council soon after moving in. The complaints concerned dust, bad smells, room climate, and health problems. There were observations of a white powdery dust that stuck to shoes, garments and furniture, and that continued to occur despite daily wet cleaning. Health complaints, particularly the irritation of eyes, nose and throat were reported.

In order to clarify this issue, air and dust samples were taken. However, the management did not inform its employees about the results of the measurements, which contributed to decline in morale and led to suspicion and mistrust that initially hampered the assessment of the problem and endeavors to find its solution. A working group from outside was appointed to investigate indoor air pollution and health complaints.

PROCEDURES AND METHODS

1. Measurements of indoor air pollutants

Air levels of VOC and formaldehyde were tested in 3 different rooms, where dust samples were also taken, in the morning.

VOC air samples were taken by using adsorption tubes containing a special activated charcoal (SKC, Anasorb 747). Sample flow rates were about 2 liters per minute. VOCs were extracted from activated carbon with 1 milliliter of CS_2 and analyzed by gas chromatography / mass spectrometry (Shimadzu QP 5000), using a 60 meter fused silica capillary column (HP-VOC) following the Austrian Standard ÖNORM M 5700-2, proposal (Austrian Standard Institute, 2002). Fifty target VOCs were selected for analysis. As internal standards cyclooctane and toluene-d8 were used.

Formaldehyde was measured using active air sampling in accordance with the German Standard VDI 4300 part 3E (VDI, 1997). Analyses were subsequently performed by using the acetylacetone photometric method following the Austrian Standard ÖNORM EN 717-1 (Austrian Standard Institute, 1995).

2. Analysis of house dust and assessment of sources of exposure

House dust samples were taken after one week sedimentation without wet and vacuum cleaning. Samples were collected by using a vacuum cleaner with an inserted particle filter. House dust samples were tested four times as a mixed sample of three rooms during a period of 8 months. These rooms were selected due to the health complaints of employees working in them. Samples from five other rooms where no complaints were reported were tested as reference.

Samples were tested for semivolatile to nonvolatile organic compounds. Among the substances tested were 55 biocides including PCP, lindane, and pyrethroids, PAHs, polychlorinated biphenyls, phthalates and trisphosphates.

Samples were extracted using n-hexane and a preliminary purification step (silicagel, SPE). Aliquots of the extract were analyzed by capillary gas chromatography with an electron-capture-detector/flame-ionization-detector (GC/ ECD/FID). α-HCH and 2,4,6-tribromphenol served as internal standards for quantification.

Specimen of wall-papers, extended ceiling, curtains, rubber floor tiles and coating were taken and checked for same substances found in house dust samples.

3. Visual inspection

Initially the building, including the ventilation system, was scrutinized by a team consisting of occupational and environmental medicine experts and technicians. During this inspection the rooms where measurements should take place were chosen. Additionally, personal interviews with employees working in different parts of the building were conducted to examine the general pattern of complaints. This information was used to design a questionnaire that was to be delivered to all employees.

4. Questionnaire

The questionnaire consisted of three parts: Items about the environmental conditions in the room the subject occupied, questions about symptoms (respiratory and unspecific ones like headaches, fatigue etc.) before and after moving in, spells of illness during this period, and earlier chronic diseases (allergies and asthma), the third part was about proposals and suggestions for improving working and environmental conditions. Additionally, socio-demographic data were collected.

5. Statistical analysis

Comparison of the symptoms before and after moving in were done by sign tests and McNemar tests. To determine the contribution of the evaluation of environmental factors by employees to the symptoms after moving in, and for the change in these reported symptoms a score was computed for all respiratory symptoms as well as for unspecific symptoms. This score was area transformed to obtain normal distribution. Scores were subjected to regression analyses with room temperature, humidity, draught, visible dust, bad smells, environmental tobacco smoke and sex and age as predictors. For all statistical tests a p-value below 0.05 was considered significant.

RESULTS

1. Indoor air pollutants and dust samples

Formaldehyde levels were 0.046, 0.047 and 0.051 ppm in the three rooms selected initially. Hence all three samples were around 0.05 ppm, the WHO (1983) level of no concern. Total VOC levels ranged from 360 to 740 micrograms/m³. VOC-levels were within interquartile range of those in a random sample of Viennese households (Hutter et al., 2002).

In dust samples initially high levels of tris-(2-butoxyethyl)-phosphate (TBEP) of 2900 to 7800 mg/kg were detected. The coating of the floor tiles was identified as the source of TBEP. Furthermore, in areas of heavy use, floor coating caused visible and atypically high amounts of dust. After removing the coating, dust concentration of TBEP was reduced to an average of 410 mg/kg and after another three months to 90 mg/kg.

Dietylhexylphthalate (DEHP) has been identified in considerable amounts of 770 to 4100 mg/kg. DEHP was identified in PVC material used for floor ledges. Despite removal of this material, dust concentration of DEHP declined only slightly.

2. Questionnaire

Overall 65 subjects returned the questionnaire (63% of employees in the new building). Distribution of respondents did not deviate considerably concerning age, sex and occupational categories from the total work force.

Upper and lower respiratory tract diseases did not increase significantly after moving into the new building. However, symptoms of irritation (sore throat, burning eyes, dry nose) as well as unspecific symptoms (tiredness, exhaustion, headaches, decreased alertness) showed marked and significant increases.

Room climate was rated uncomfortable by approximately half of the employees concerning humidity and air velocity, and by about 20% concerning air temperature. Air quality was described as stale and odors as annoying. More than half of the employees rated visible dust as a nuisance.

Regression analysis revealed a significant influence of humidity and a tendency for smoking in office rooms on the increase of respiratory symptoms. No influence of visible dust and only a slight tendency for bad smells on increase in unspecific symptoms was noted.

DISCUSSION

Overall the concentrations of total VOC and formaldehyde were fairly low. The highest values of formaldehyde were of about 0.05 ppm (WHO level of no concern).

Organophosphate esters are frequently applied as a flame retardant in building products and other materials for indoor use. Exposure of residents to flame retardant mainly results from the accumulation in house dust and indoor air. TBEP concentration was rather high (Hansen et al., 2000, Federal Environmental Agency, 2002) but could be reduced significantly by removing the floor coating.

In a German survey (1998) house dust specimens were also analyzed for phthalates. Diethylhexylphthalate had a median concentration of 416 mg/kg and a 90 percentile of 978 mg/kg, maximum was 7530 mg/kg. Concentrations measured in our study in the dust of offices were in the upper range of the distribution obtained in households (770 to 4100 mg/kg). Although one source of phthalates has been detected and removed, concentration did not decline significantly. This points to the broad range of usage of phthalates in the office environment.

CONCLUSIONS & IMPLICATIONS

The unusually high TBEP values that were found show that more attention should be dedicated to the sealing of floors, particularly those in constant use.

Fine particles that are not visible are probably scattered around the entire house, their concentration could not be obtained throughout this measuring campaign. Therefore, it cannot be excluded that an explicit increase in ailments is linked to the concentration of TBEP-containing dust.

Although there was no significant association between the increase of complaints after moving in and visible dust exposure - making an attribution effect unlikely - it cannot be ruled out that fine particles together with unfavorable indoor factors (unpleasant odor, high temperature, dry air) are responsible for the development of the complaints.

The fact that DEHP concentrations in dust remained high even after intensive remedial actions highlights the problematic situation that stems from the ubiquity of this substance. Based on the sensory impressions we believe that DEHP was at least in part responsible for the unpleasant odor. In which way DEHP contributed to the health complaints of the employees we can only speculate.

Due to the high complexity of the connection between the exposure and the ailments, a measuring process regarding the early involvement of those concerned has to be organized. According to our experience we emphasize the importance of thorough information concerning the employees about the planned interventions in the sense of gaining transparency through procedures.

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