Measurement of Air Quality during a Decorating Engineering

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ABSTRACT

Air quality studies during a decorating engineering in northern Taiwan were carried out. Sampling was undertaken during the decorating engineering including the dismantling old decorating, water and electrical pipe engineering, tiling engineering, window installation, pre-system furniture installation, flooring engineering, post-system furniture installation and finishing engineering. The levels of carbon monoxide (CO), carbon dioxide (CO₂), formaldehyde (HCHO), temperature, relative humidity and bacterial/fungal concentrations were recorded during the decorating engineering. Results show that the averaged CO concentrations ranged from 1.05 to 22.1 ppm during various engineering. The averaged HCHO concentrations ranged from 0.08 to 0.69 ppm and the HCHO increased apparently after system furniture installation. The averaged PM₂.⁵ and PM₁₀ concentrations ranged from 97.2 to 6,445 µg/m³ and 129 to 6,837 µg/m³, respectively. The PM concentrations for the tiling engineering were more than two times of the recommended exposure limit (REL) of respirable particles of 5 mg/m³. The mean respirable fractions, R_b and R_f, for bacteria and fungi, ranged from 27.8%–97.0% and 29.4%–93.8%, respectively. It should be noticeable that over 75% of R_b and R_f were higher than 50% during the decorating engineering. The relatively high respirable fractions of bioaerosols and the high PM concentrations for some specific decorating engineering probably implies a higher adverse health risk for sensitive workers. There are limited information about the air quality for the decorating engineering and this preliminary study can provide references to the Taiwan government on air quality management for workplaces.

Keywords: Decorating; Formaldehyde; Bacteria; Fungi.

INTRODUCTION

Donkelaar et al. (2010) mapping global ground-level PM₂.⁵ concentrations made people around the world deeply impressed by the health impact of air pollutions. WHO reports that around 7 million people died in 2012- one in eight of total global deaths – as a result of air pollution exposure (WHO). Pope et al. (1995) indicated particulate air pollution was associated with cardiopulmonary and lung cancer mortality. There should be more focused on the indoor air quality. Because many people might spend up to 90% of daytime indoors whatever at home, work or school. WHO also reminded a total of 3.3 million deaths linked to indoor air pollution and 2.6 million deaths related to outdoor air pollution in the WHO South-East Asia and Western Pacific Regions (WHO). The quality of the air we breathe indoors pose a strongly direct impact on our health (Bruce et al., 2000).

Many people are aware of the environmental health risk by air pollutions, especially the indoor air pollutions. Most of the studies investigated the indoor air quality of offices (Lee et al., 2002; Fang et al., 2004), houses (Bruce et al., 2004; Taneja et al., 2008), hospitals (Nordstrom et al., 1995; We Jr., 1993), shopping malls (Li et al., 2001), dental clinics (Godwin et al., 2003; Helmis et al., 2007) and classrooms (Lee and Chang, 1999; Daisey et al., 2003). People pay more and more attention on the exposure under new decorated house. However, the information of air quality for a decorating workplace is very limited and it’s probably much worse for the working labor. Liu et al. (2012) indicated if children moved to the new interior decoration house as soon as possible, therefore, the proportion of having cough, sputum and asthma will increase. Mo et al. (2012) investigated 30 residential buildings and 5 office buildings after decorating in Guangxi Nanning city for formaldehyde, benzene, total volatile organic compounds (TVOC), ammonia and radon. 80.0% of the measured building for TVOC concentration exceed the national standard. Some VOCs, including formaldehyde, in combination might result in sensory irritation under certain environmental and occupational
conditions. The TVOCs, PM, O₃, CO HCHO are always the measurement targets for most sampling sites, but the bacterial and fungal concentrations are often excluded.

This study was to evaluate the air quality of a decorating workplace during the decorating engineering. The distribution of air quality during the decorating engineering was monitored and compared. This preliminary study can provide references to the Taiwan government and other countries on the management for the air quality of workplaces.

MATERIALS and METHODS

**Sampling Information**

A decorating workplace in an apartment was selected in northern Taiwan. The apartment was 64 square meter on the fourth floor. The sampling location was shown in Fig. 1. The CO, CO₂, temperature, and relative humidity were monitored for 5 minutes by an AirBoxx monitoring system (KD Engineering, USA), marked by sample A1–A6. Airboxx recorded data every 15 seconds. The level of HCHO was monitored for 5 minutes by a Formaldemeter htv monitoring system (PPM, United Kingdom), also marked by sample A1–A6. Formaldemeter recorded data every 50 seconds. Two six-stage microbial cascade impactors (TE-10-830, Tisch Environmental, Inc.) were used to sample airborne bacteria and fungi, marked by sample M1–M3. The aerodynamic diameter ranges include > 7 µm (stage 1), 4.7–7 µm (stage 2), 3.3–4.7 µm (stage 3), 2.1–3.3 µm (stage 4), 1.1–2.1 µm

![Fig. 1. Sampling location for the decorating engineering.](image)
(stage 5), and 0.65–1.1 µm (stage 6). The sampling flow rate was 28.3 L/min, the sampling time was 5 minutes, and the sampling height was approximately 150 cm. Two personal particle samplers PEM was located on the living room and study room, marked by sample P1–P2 and the sampling time was 24 hours.

Sampling was undertaken during the decorating engineering including the dismantling old decorating, water and electrical pipe engineering, tiling engineering, window installation, pre-system furniture installation, flooring engineering, post-system furniture installation, and finishing engineering. The windows were always open during all decorating engineering. Airboxx and HCHO sampler were set in the living room, corridor, guest room, study room, bedroom and back porch. Microbial cascade impactors were set in the living room, study room, and back porch. As PEM sampler was set in the living room and study room. The sampling location was showed in Fig. 1. The diagram of the apartment is the as-built drawing.

**Measurement and Analysis**

Trypticase soy agar (TSA) with cycloheximide and malt extract agar (MEA) with chloramphenicol were used for capturing bacteria and fungi samples, respectively. Field blanks were also tested during the sampling. After sampling, the Petri dishes were incubated for 48 hrs at 37°C (Taiwan EPA method E301.11C) for bacteria and 120 hrs at 25°C (Taiwan EPA method E401.11C) for fungi. The concentrations of airborne bacteria and fungi (CFU/m³) were calculated by dividing the total colonies counts on agar plate by air volume. The fractions for each stage of bacteria and fungi were defined as follows:

\[ B_i = \frac{C_i}{C_b} \times 100\% \]  

B: bacterial fraction (%)

\[ C_i: \text{the } i \text{ stage concentration for bacteria, which is 1 for the first stage (> 7 µm), 2 for the second stage (4.7–7 µm), 3 for the third stage (3.3–4.7 µm), 4 for the fourth stage (2.1–3.3 µm), 5 for the fifth stage (1.1–2.1 µm), and 6 for the sixth stage (0.65–1.1 µm)} \]

\[ C_b: \text{total concentration of bacteria} \]

\[ F_i = \frac{C_i}{C_f} \times 100\% \]  

F: Fungal fraction (%)

\[ C_i: \text{the } i \text{ stage concentration for fungi} \]

\[ C_f: \text{total concentration of fungi} \]

\[ R_b = \frac{C_3 + C_4 + C_5 + C_6}{C_b} \times 100\% \]  

(3)

\[ R_b: \text{Respirable fraction for bacteria} \]

\[ R_i = \frac{C_3 + C_4 + C_5 + C_6}{C_f} \times 100\% \]  

(4)

\[ R_i: \text{Respirable fraction for fungi} \]

**Data Analysis**

This study uses SPSS 13.0 to calculate the descriptive statistics and the spearman’s rank correlation test. It is a nonparametric measure of statistical dependence between the indoor air pollutants pairs. The test assesses how well the relationship between the indoor air pollutants pairs can be described using a monotonic function.

**RESULTS AND DISCUSSION**

**Level of CO and CO₂ Concentration**

The individual CO₂ concentration ranged from 334 to 711 ppm during the decorating engineering. The averaged CO₂ concentration for various engineering was between 378 and 586 ppm, happening in the windows installation and finishing engineering, respectively (Table 1). The variation of

<table>
<thead>
<tr>
<th>Engineering</th>
<th>CO  (ppm)</th>
<th>CO₂ (ppm)</th>
<th>HCHO (ppm)</th>
<th>PM₂.₅ (µg/m³)</th>
<th>PM₁₀ (µg/m³)</th>
<th>Bacteria (CFU/m³)</th>
<th>Fungi (CFU/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 dismantling old decorating</td>
<td>1.05 ± 0.21</td>
<td>451 ± 11.4</td>
<td>0.11 ± 0.08</td>
<td>108 ± 59.0</td>
<td>396 ± 250</td>
<td>85 ± 32.8</td>
<td>390 ± 176</td>
</tr>
<tr>
<td>2 water and electrical pipe engineering</td>
<td>22.1 ± 16.2</td>
<td>494 ± 122</td>
<td>0.13 ± 0.02</td>
<td>6445 ± 6333</td>
<td>6837 ± 6427</td>
<td>973 ± 445</td>
<td>495 ± 305</td>
</tr>
<tr>
<td>3 tiling engineering</td>
<td>14.3 ± 3.01</td>
<td>457 ± 25.5</td>
<td>0.51 ± 0.16</td>
<td>431 ± 250</td>
<td>1490 ± 427</td>
<td>652 ± 277</td>
<td>306 ± 24.9</td>
</tr>
<tr>
<td>4 window installation</td>
<td>6.67 ± 1.36</td>
<td>378 ± 44.7</td>
<td>0.16 ± 0.06</td>
<td>347 ± 299</td>
<td>399 ± 309</td>
<td>468 ± 313</td>
<td>1067 ± 423</td>
</tr>
<tr>
<td>5 pre-system furniture installation</td>
<td>3.10 ± 0.69</td>
<td>450 ± 10.8</td>
<td>0.24 ± 0.20</td>
<td>97.2 ± 48.6</td>
<td>129 ± 59.0</td>
<td>145 ± 64.9</td>
<td>576 ± 106</td>
</tr>
<tr>
<td>6 flooring engineering</td>
<td>3.43 ± 0.96</td>
<td>471 ± 57.2</td>
<td>0.08 ± 0.02</td>
<td>629 ± 295</td>
<td>910 ± 20.8</td>
<td>495 ± 259</td>
<td>484 ± 108</td>
</tr>
<tr>
<td>7 post-system furniture installation</td>
<td>4.32 ± 0.59</td>
<td>543 ± 53.1</td>
<td>0.69 ± 0.43</td>
<td>350 ± 300</td>
<td>400 ± 310</td>
<td>253 ± 222</td>
<td>530 ± 57.7</td>
</tr>
<tr>
<td>8 finishing engineering</td>
<td>7.60 ± 2.43</td>
<td>586 ± 97.4</td>
<td>0.55 ± 0.32</td>
<td>2229 ± 1028</td>
<td>3434 ± 712</td>
<td>151 ± 90.0</td>
<td>149 ± 30.6</td>
</tr>
</tbody>
</table>
Acknowledgements

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Reference


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