

Health Risk Assessment of Human Exposure to Volatile Organic Compounds (VOCs) at the National Archive of Chanthaburi Province Branch

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Abstract

Indoor air pollution has recently become a public concern and studies into Volatile Organic Compounds (VOCs) exposure level are rather limited. This study investigated the concentration of total Volatile Organic Compounds (TVOCs) in six rooms with different functions in the National Archive of Chanthaburi Province Branch. These six rooms were: (1) Documents receiving room, (2) Documents classifying room, (3) Exhibition room, (4) Office, (5) Film collecting room, and (6) Document storage room. The researchers evaluated staff members' personal exposure to TVOCs in personal inhalation in each room. Air samples were collected and analyzed by *Portable Air Samplers* (GrayWolf Sensing Solutions), and then the obtained data were used to determine health risks. The results indicated that VOCs concentrations in the work place varied, depending on the room size and its ventilation system. The highest TVOCs concentration was found in the Documents receiving room ($2.26 \pm 1.58 \text{ mg/m}^3$), whereas the lowest level was found in Exhibit room ($0.30 \pm 0.04 \text{ mg/m}^3$). Poor air circulation and ventilation in the Documents receiving room was the cause of high TVOCs levels. The results on personal exposures indicated that the majority of staff members were exposed to TVOCs at the level exceeding the TVOC guidelines issued by the German Federal Environmental Agency.

Key Words: *Volatile organic compounds, indoor air pollution, health risk assessment*

1. Introduction

The volatile organic compounds (VOCs) refer to a large group of air pollutants, such as benzene, toluene, xylene, hexane, and heptane, to name but the major ones. Exposure to VOCs is associated with allergies and adverse respiratory effects, frequently expressed as asthma or chronic obstructive pulmonary disease (COPD). Recent studies have confirmed VOCs as one of the main sources of tropospheric ozone, which may cause irritation of the airways (Tanaka et al., 2000).

The study of indoor air is necessary due to its large number of internal sources of emission, and to the fact that in modern urban areas most people spend over 70% of their time indoor either at home or at their work place (Guo et al., 2004; Ohura et al., 2006; Wang et al., 2007). The situation gets worse with the wide range of indoor environments, such as homes, schools, restaurants, photocopy machine stores, and the like.

The National Archive of Thailand is a governmental organization responsible for collecting important documents related to Thailand's historical culture (Fine Art Department, 1999). This organization normally gathers documents in the forms of texts, audio-visual cartographics, and machine readable archives. The important documents collected by this organization are maintained for their physical condition by means of inspecting, preserving, and fixing to prevent damage (Prachakul, 1996). In the process of maintaining the quality of the documents, it is unavoidable to get in contact with a lot of

chemical substances (i.e., methyl alcohol, acetone and toluene) inherent in the documents (Kataoka et al., 2012). Therefore, for health reasons, it is necessary to assess the extent to which those working in this organization being exposed to such chemical substances. This study aimed to study the concentration of total volatile organic compounds, (TVOCs) in the National Archive and health risk of various VOCs exposure scenarios. This was for the organization to estimate risks involved to make decision on the risk-based regulations and to formulate mitigation measures for better staff protection in the National Archive.

2. Research Objectives

There were two research objectives; (1) to study the concentration of total Volatile Organic Compounds (TVOCs) in various rooms of National Archive of Chanthaburi Province Branch, and (2) to assess health risks from breathing in volatile organic compounds.

3. Material and Methods

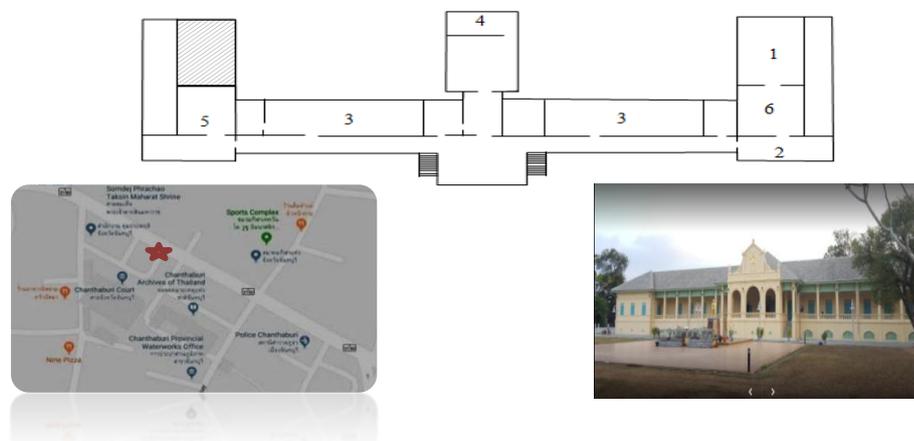
3.1 Study Area

This research was conducted at the National Archive of Chanthaburi Province Branch. The National Archive has two stories. The use of space in the building is in 6 categories by function: (1) the documents receiving room, (2) the documents classifying room, (3) the exhibition room, (4) the Office, (5) the film collecting room and (6) the document storage room.

3.2 Monitoring Method

Six rooms in the National Archive of Chanthaburi Province Branch were investigated (see Figure 1). All fourteen positions in six rooms cover the entire area of the National Archive. The selected rooms were used to investigate the effects of two factors on the concentrations of total VOCs in the National Archive: (1) different characteristics of the room, and (2) different types of work. The air sampling period was from 8:00 am to 4:00 pm. The samples monitored in each room were recorded/ collected every hour for the total of three hours, consecutively from May 1-2, 2018 at the respiratory level in the middle of the room. Portable air samplers, GrayWolf Sensing Solutions were used to collect samples after entering the National Archive. Total VOC or TVOC, CO₂, CO, temperature, relative humidity, sampling time were recorded.

Figure 1: Position used in the collection of the National Archives



4. Results and Discussion

4.1 Levels of TVOCs concentration in the National Archive

The total VOCs concentrations (TVOCs) in different room are listed in Table 1. The highest total VOCs concentration was observed in room 1 ($2.26 \pm 1.58 \text{ mg/m}^3$), whereas the lowest level was observed in room 3 ($0.30 \pm 0.04 \text{ mg/m}^3$). The results indicated that the VOCs concentration levels varied with different characteristics of the room and different types of work conditions.

Based on the obtained results, the first room had a higher level of TVOCs than the other rooms as shown in Figure 2. The first room was for receiving and collecting a large number of important papers and films, which were mainly glue and ink. These materials increased the level of TVOC in the room to a high level.

Another possible explanation was that the ventilation system in Room 1 was not working. Thus, air mass inside the room did not circulate inside or take in outside air, resulting in the accumulation of TVOCs in high concentration in this room (Pegas et al., 2011).

However, all measured values still did not exceed the Guidelines for good Indoor Air Quality in Office Premises, Ministry of the Environment (Singapore).

Figure 2: Mean concentrations of TVOCs in different room in the National Archive

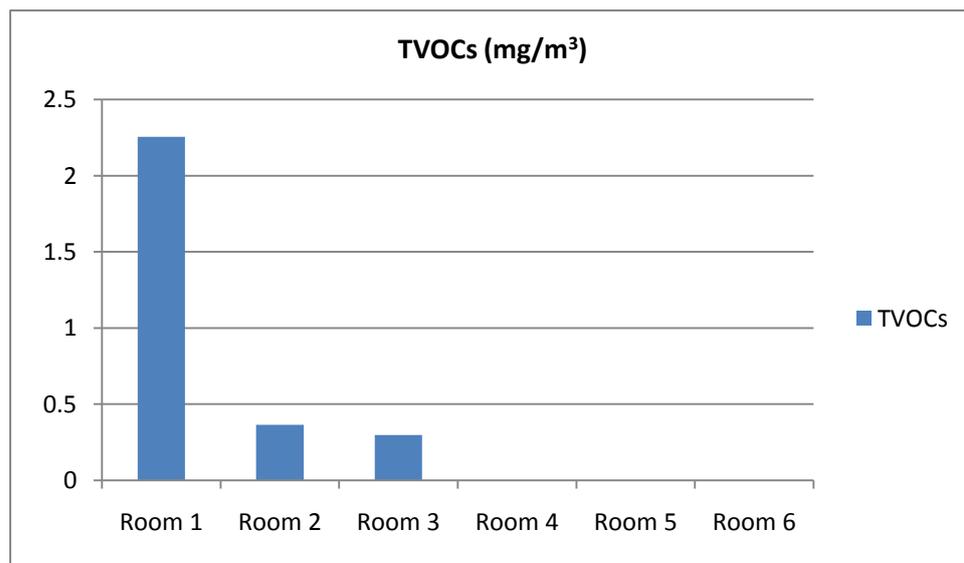


Table 1: The total VOCs levels in different National Archives room

characteristics of the room	Mean concentration ± S.D. (mg/m ³)					
	Room 1	Room 2	Room 3	Room 4	Room 5	Room 6
	Documents receiving	Documents classifying	Exhibit	Office	Film collecting	Document storage
The total VOCs	2.26 ± 1.58	0.36 ± 0.16	0.30 ± 0.04	ND	ND	ND
Temperature °C	33.1	33.9	32.6	33.3	31.3	29.6
Relative Humidity %RH	60.7	57.5	59.0	58.9	69.2	68.0

4.2 Exposure and Health Risk

Individual exposures and cancer risk to the VOCs in the National Archive were calculated by EPA (1992) and OEHHA (2003):

$$E_i = C_j \times IR_i \times t_{ij}$$

where E_i is the personal exposure to pollutant i (mg/day), C is the concentration of the pollutant (mg/m^3), IR is the inhalation rate (m^3/h), t is the exposure time (h/day), and j is the microenvironment.

The results for personal exposure were estimated in different conditions to calculate the estimated health risk shown in Table 2.

Table 2: Personal exposure risks of TVOCs in the National Archive of different room

characteristics of the room		Room 1	Room 2	Room 3	Room 4	Room 5	Room 6
Gender		Center of documents	Examination	Display	Office building	Collect films	Files storage room
Male	Exposure ($\mu\text{g}/\text{day}$)	410.35	1784.53	1456.00	ND	ND	ND
Female		9848.33	1593.33	1300.00	ND	ND	ND

The personal exposures of TVOCs in the National Archive in different rooms are shown in Table 2 which reports as microgram per day ($\mu\text{g}/\text{day}$). The results showed that the largest amount was observed in Room 1, especially in male staff members.

According to the health risk assessment from personal exposure to TVOCs, the highest concentrations were arranged in a descending order as follows: Room 1 > Room 2 > Room 3. This was because Room 1 had less ventilation than other rooms. Thus, the staff members were exposed to the higher amount of total volatile organic compounds through respiration. Moreover, the result revealed that men were exposed to higher TVOCs than women in the same age group. This could result from the average inhalation rate of men was higher than that of women.

When E_i values of TVOCs in Room 1, Room 2 and Room 3 were compared to the TVOC guidelines issued by the German Federal Environmental Agency (Bundesgesundheitsbl, 2007) (see Table 3), the researchers found that the exposure of TVOCs in Room 1, Room 2 and Room 3 had high values when compared to the values of TVOC guidelines issued by the German Federal Environmental Agency. These high values were obviously caused by failure in the ventilation system.

Table 3: TVOCs guidelines issued by the German Federal Environmental Agency

Level	Hygienic Rating	Recommendation	Exposure Limit	TVOC [ppb]
5 Unhealthy	Situation not acceptable	Use only if unavoidable / Intense ventilation necessary	hours	2200 – 5500
4 Poor	Major objections	Intensified ventilation / airing necessary Search for sources	< 1 month	660 – 2200
3 Moderate	Some objections	Intensified ventilation / airing recommended Search for sources	< 12 months	220 – 660
2 Good	No relevant objections	Ventilation / airing recommended	no limit	65 – 220
1 Excellent	No objections	Target value	no limit	0 – 65

5. Conclusion

This research aimed to investigate total volatile organic compounds (TVOCs) exposed to the staff members in the National Archive of Chanthaburi Province Branch. The results from fourteen sample points showed that the concentration of TVOCs in the Room 1 was relatively higher than the others. The obtained results, were compared to the threshold value of indoor TVOCs by the Guidelines for good Indoor Air Quality in Office Premises, Ministry of the Environment (Singapore). The comparison indicated that the average values of all TVOCs did not exceed the threshold ones. However, the personal exposures were at the high level, according to the German Federal Environmental Agency. From these findings, the researchers strongly recommended that the National Archive of Chantaburi Province Branch install an appropriate ventilation system without delay to minimize health risks of its staff members.

6. Acknowledgments

The researchers would like to express their deepest gratitude to the National Archive of Chanthaburi Province Branch for their kind support throughout the study. Special thanks are extended to Mr. Thada Lueangrunroj, a staff member of the Faculty of Public Health, Siam Technology College, for his cooperation and assistance with data collection for the study.

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8. References

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