

# MEASUREMENT AND ANALYSIS OF CONCENTRATIONS OF VOLATILE ORGANIC COMPOUNDS IN A NEWLY PAINTED ROOM

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## Abstract

Since, people spend most of their times indoors, either at home or at work, it is essential to maintain a high level of health and safety inside all types of buildings. If the health conditions of occupants are adversely affected due to the indoor environment, it is called the sick building syndrome (SBS). The main causes of SBS are, bad planning of a building, which leads to, poor ventilation, higher temperature, higher humidity, poor building operational practices and emissions from building materials. Air pollutants due to building materials can include paints and coatings which may emit harmful chemicals. Further the emissions from building maintenance chemicals, such as, detergents, disinfectants, antiseptics and air fresheners can pollute the indoor environment.

The main objective of the research covered in this paper is to measure concentrations of gaseous emissions from water based and solvent based paints, during the painting process and immediately after painting and to compare results with air quality standards.

The Indoor Air Quality Monitor (IQM60/Environmental Monitor V5.0) was used to measure concentrations of gaseous emissions. The results indicated that the concentration of TVOC (Total Volatile Organic Compounds) has increased during the painting process and the time taken for the emissions to get dispersed and the air quality of the room to get back to the permissible level has been found to be more than two hours.

**Key words:** Indoor Air Quality (IAQ), Volatile Organic Compounds (VOC), Water Based Paint, Solvent Based Paint

## **1. Introduction**

In modern building design and construction, people prefer to use modern synthetic building materials, rather than the conventional building materials, along with, modern building operational practices, such as, air conditioning, rather than natural ventilation, which restricts fresh air circulation in the building [1,3]. While these designs and practices have created more aesthetically appealing buildings, they have also led to contaminated indoor environments, with much higher air pollutant concentrations compared to outdoor environment.

Paint has been identified as one of the building materials, which pollutes indoor air, adversely affecting the health of painters and occupants. Studies [2] have shown that emissions from paints could cause illnesses, such as, headaches, lethargy, sleepiness, dizziness, nausea, fatigue, sneezing, dry throat and allergies. It has also been found that long term exposure to these emissions could cause serious health effects, such as, respiratory diseases and some types of cancers.

Two types of paints are used in buildings, namely, water based paint (emulsion paint) which could be applied on walls and solvent based paints (enamel paint and varnish) applied on metal, plastic and wooden surfaces.

Water based paints (WBP) contain polymers emulsified in water (hence the name emulsion paint), due to which they can be diluted with water before use. Water can be used to clean brushes and other utensils after painting.

Solvent based paints (SBP) contain organic solvents (OS) [4, 5] that are essential to dissolve water insoluble polymers and to achieve required chemical and physical properties of the paint. Before application, these paints are diluted with OS to the required consistency. During the application and the drying process, OS evaporates into air, causing an increase of the VOC concentration, leading to strong odors and an unhealthy indoor environment in the building [6]. After the painting process is over, brushes and other utensils have to be cleaned with OS which further increases evaporation of OS and VOC concentration in air.

This paper presents the results of a research that was carried out, to measure and analyse VOC concentrations in a newly painted room during and after the painting process.

## **2. Objectives**

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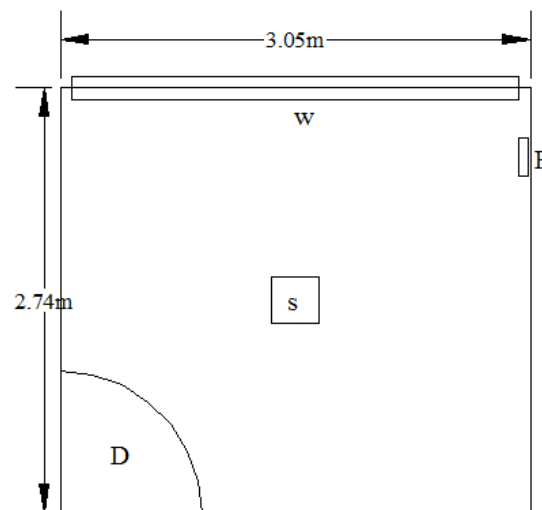
The main objective of the research was to measure concentrations of VOC, emitted by water based and solvent based paints, during the painting process and immediately after painting and to compare results with air quality standards, with a view to making

recommendations on best practices to minimize adverse health effects on painters and occupants.

### 3. Methodology

#### 3.1 Description of the Experimental Site

A room in the ground floor of the Civil Engineering Department of the University of Moratuwa, which has a floor area of  $8.4 \text{ m}^2$  and a volume of  $25.5 \text{ m}^3$  was used to conduct the experiment. The door and window locations and their dimensions are shown in Figure 01.



**Figure 01:** Plan view of the office room: Window (W) =  $2.9 \text{ m} \times 2.1 \text{ m}$ , Door (D) =  $0.9 \text{ m} \times 2 \text{ m}$ , Position of the Fan (F), Sample collector (S), Floor to Floor height =  $3.05 \text{ m}$

#### 3.2 Measuring Instruments

Indoor Air Quality Monitor (IQM60 Environmental Monitor V5.0) was used to measure the concentration level of TVOC in air.

### 3.3 Experimental Programme

IQM was placed at the centre of the working space at a height of 1m from the ground. In order to enhance the accuracy of measurements, the instrument was kept for one hour before commencement of readings.

Three painters were employed to paint the room. WBP was applied on the walls and the roof and SBP was applied on the door. The total area of application WBP was 27.42 m<sup>2</sup> and the total area of application of SBP was 1.8 m<sup>2</sup>. WBP was applied using 5" wide paint brushes, by two painters while SBP was applied using a 2" wide brush by one painter. Although there was a ceiling fan in the room, it was switched off during the painting process. Surface preparation activities, such as, leveling with sand paper, etc., was not carried out during the painting process. Hence, there was no dust formation due to the painting procedure.

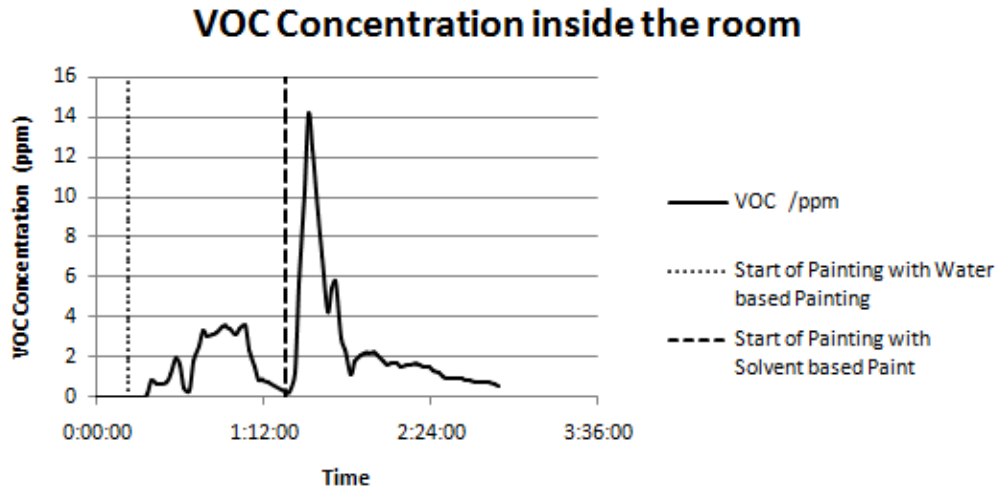
There were three identical rooms selected for the experiment to apply both types of paints. This was carried out over a period of three days, in order to get the average of three sets of results.

## 4. Experimental results and discussion

The instrument was switched on approximately 1 hr before applying the paints and the initial values of TVOC were considered as the base line measurements for the experiment. The average results for the variation of TVOC concentration with two types of paints, applied over a period of three consecutive days are shown in Figure 02. Due to practical constraints and also to be consistent with the study area, WBP and SBP were applied in the same room. This in turn has given a proper comparison for the results of both types of paints.

Results given in Figure 02 indicated that the concentration of TVOC in the room has increased from zero, 1 hr before commencement of painting, due to opening of paint cans and mixing, with water in the case of WBP and with solvent in the case of SBP. TVOC has reached a peak value, just after commencement of painting with SBP beyond the ambient indoor condition (Figure 02). Furthermore, it was observed that the effect of SBP on TVOC was 4 times higher than that of WBP and that the TVOC concentrations have exceeded the permissible value for indoor TVOC (0.75 ppm- OSHA) [9]. Figure 02 also shows that TVOC concentration decreases to initial levels 2 hrs after painting with SBP. In order to quantify the toxicity levels of TVOC, the following equation has been used [7];

$$\text{Toxicity Index} = \frac{\text{Concentration of the pollutant}}{\text{Permissible concentration}}$$



*Figure 02: VOC Concentration inside the room*

The Table 01 presents the toxicity index of TVOC agents on indoor air quality.

**Table 01: Toxicity index of the pollutants**

Causative Agent	Toxicity Index	
	WBP	SBP
TVOC	4.79	18.91

## 5. Concluding Remarks

This study has revealed that both WBP and SBP cause indoor air pollution by increasing the concentration of TVOC, while, the effect of SBP is 4 times higher than that of WBP. The findings are based on the average results of a study conducted in three identical rooms over a period of three days.

Hence, it could be concluded that WBP is much more eco friendly and has lower adverse effects on IAQ compared to SBP. Following guidelines are proposed for better indoor air quality with respect to paint work:

- Introduce a building flush out period, depending on the paints that have been used, before the building is handed over to the occupants.

- Promote WBP for maintenance of the building rather than SBP [10].
- Comply with the safety regulations in order to minimize the health risks for painters and labourers. For an example use of personal protective equipment (PPE) such as safety goggles, dust mask or respirators and gloves during the scraping, wire-brushing, sanding, leveling and painting [11].

However, more studies are needed to investigate the effect of different types of paints on indoor air quality to arrive at a set of recommendations.

## 5. Acknowledgements

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## References

- 1.A.P. Jones "Indoor air quality and health", *Atmospheric Environment* 33 (1999) 4535-4564
- 2.W. Cheung and T. de Silva, "YESTERDAY'S LUXURY, TODAY'S NECESSITY"INDOOR AIR QUALITY" CAN NO LONGER BE NEGLECTED", *International Journal on Architectural Science, Volume 1, Number 3, p.116-119, 2000*
3. Perera, T.M., Jayasinghe, C., Perera, S.A.S., Rajapaksha, S.W., "Effect of Operational Practices and Indoor Air Quality", 5<sup>th</sup> National Symposium on Air Resource Management in Sri Lanka. pp 18-19
- 4.<http://www.paintquality.com/going-green/resources/index.html>
- 5..DeryaDursun,FusunSengul"Waste minimization study in a solvent-based

Paint manufacturing plant “, Resources, Conservation and Recycling 47 (2006) 316–331.

6. Jin-A Kima, Sumin Kim , Hyun-Joong Kim , Yong-Shik Kim , “Evaluation of formaldehyde and VOCs emission factors from paints in a small chamber: The effects of preconditioning time and coating weight” , Journal of Hazardous Materials 187 (2011) 52-57

7. Indoor and Outdoor Air Quality in Offices and the atmosphere of a University of Benin Teaching Hospital (UBTH) Edo state.

8. [www.ashrae.org](http://www.ashrae.org)

9. [www.osha.gov](http://www.osha.gov)

10. National Resource Defense Council  
([www.nrdc.org/policy](http://www.nrdc.org/policy))

11. National Institute for Occupational Safety and Health, [www.cdc.gov/niosh/](http://www.cdc.gov/niosh/) - *United States*