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BUILDING AND INDOOR ENVIRONMENT: A STUDY ON THREE STAGES OF A NEW BUILDING COMMISIONING

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ABSTRACT

Indoor Air Quality (IAQ) is a part of Building Environment. Nowadays, the construction of new building took place over the world. Upon new building occupancy, a lot of indoors material was used without IAQ concern. This study has been conducted in a new constructed building of National Institute of Occupational Safety & Health (NIOSH) Malaysia. The goal of the study is to monitor on the level of IAQ parameters including chemical and physical parameters within three consequent stages which are before furniture install, after furniture install and during one month occupancy. This study was divided the sampling area into two main facilities which are training room and office room. The contaminants has been measured consist of nine parameters such as Carbon Dioxide (CO_2), Carbon Monoxide (CO), Total Volatile Organic Compounds (TVOC), Formaldehyde, Respirable Particulates (PM_{10}), Ozone, Relative Humidity (RH), Temperature and Air Movement. The result of the Temperature and Formaldehyde show increasing trends in the first and second stages but were reduced significantly the third stage of sampling. These finding indicates that furniture and fittings installed might be a potential sources of indoor air contaminants. The management should be aware to their indoor air status to protect the occupant from the risk of unwanted exposure especially during the early stage of building occupancy.

Keywords : Indoor Air Quality, Indoor Air Parameter, Building Environment, Safety & Health

1.0 INTRODUCTION

The rises of new buildings are took place all over the world nowadays. The growing concerns on the level of indoor air contaminants are become the question among the building owner and the occupants. There are many consequences of poor IAQ, presence of chemical parameters in the air leads to depletion of health status. Malaysia as a tropical climate has hot and humid for the whole year. Therefore, improvement of IAQ needs to be done especially in the new buildings. Concerning on this problem, a case study was performed to investigate and identify the level of IAQ parameters. There are several Malaysian standards regarding the IAQ start from the legislative requirement of Occupational Safety & Health Act 1994 (OSHA 1994) to Industry Code Of Practice On Indoor Air Quality 2010 (ICOP-IAQ 2010). The parameters including six chemicals which are Carbon Dioxide (CO_2), Carbon Monoxide (CO), Total Volatile Organic Compounds (TVOC), Formaldehyde, Respirable Particulates (PM_{10}) and Ozone and three physicals which are Temperature, Humidity (RH) and Air Movements. The objectives of this study were to measure the mean data of nine IAQ parameters in new NIOSH building and comparing the mean level between three consequent stages of new building occupancy that are before furniture install, after furniture install and during one month occupancy. In other hand the aim of this study is to observe the potential sources of build up indoor air contaminants during new building commissioning. Table 1 summarized air conditioning systems inside the new building.

Table 1: Summarized air conditioning systems inside the new building

DESIGN SETTING	LEVEL	SPACE	AIR-CONDITIONING SYSTEM
Office Room	1st Floor	Manager's room	Centralize
		Open Office	
		Receptionist	
	2nd Floor	Open Office	
		Document store	
	3rd Floor	Examination Office	
	4th Floor	Human Resource Office	
	5th Floor	Finance Offices	
	6th Floor	Manager's Room	
		Meeting Room	
		Open Space	
Training Room	3rd Floor	Examination Rooms	Split Unit
	4th Floor	Training Rooms and Computer Laboratory	
	5th Floor	Training Rooms	

2.0 LITERATURE REVIEW

The unsuitable fitting, materials', adhesive and furniture selection are contribute to the sources of poor IAQ. Besides having major correlation with chemical parameters, physical conditions also may affect IAQ. (E.Uhde et.al, 2007) provided some sources for poor indoor air quality, one of the reasons cause depletion of indoor air quality in new building is the presence of chemical substances in modern building products, household products and furnishing. In addition (Sun-Sook Kim et al, 2006) also claimed wrong materials selection and inefficient ventilation strategy can leads into IAQ problems. While (Martin Bohm's, 2012) study provides the presence of Urea-Formaldehyde (UF) adhesive inside the furniture is a significant factor of poor IAQ. However (Dols, 1995) stated that poor indoor air quality can be improved by having a good mechanical ventilation system performance and new building materials.

3.0 METHODOLOGY

This study was conducted in a new building at NIOSH Malaysia. These new building is a multistorey and facilitated with training rooms and office rooms settings. The room's settings are representing a normal typical design of Malaysian buildings. Table 1 shows the specification of the selected space inside the building. This building was selected as an ideal sampling site since it nearly accomplished while this study was proposed. Starting on November 2011 until July 2012, three-time data collection was performed in different stages of building occupancy. The study has divided the sampling period into three consequent stages as figure 1 below.

Sampling duration were performed at 8:00 am until 5:30 pm, in order to imitate the same real working situation as similar exposure as well. The sampling mechanism for this study was measured by calibrated direct reading instruments. The results were presented in part per million (ppm) for Formaldehyde, CO, CO_2, Ozone and TVOC. The result of PM_{10} was presented in mg/m^3. The temperature values were recorded as degree Celsius (°C), RH as percentage (%) and Air Movement as meter per second (m/s). All the equipments used as listed in Table 2 have accuracy of ±10% and were accepted by ICOP-IAQ 2010.

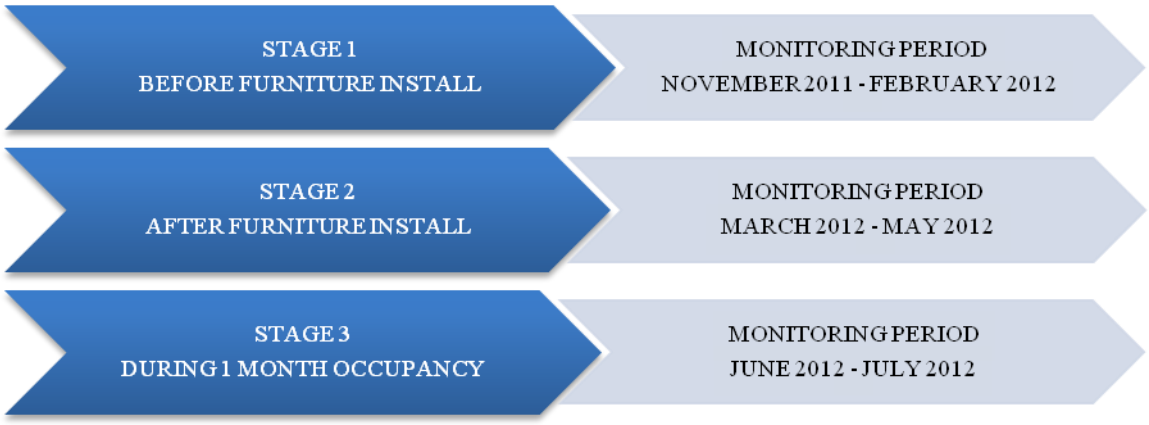

Figure 1: Monitoring stage and period

Table 2: List of instruments used for measurement.

ITEM	CHEMICAL PARAMETER	INSTRUMENT
1	Carbon Dioxide (CO_2), Carbon Monoxide (CO), Temperature, Air Movement and Humidity	Integrated IAQ Meter
2	Respirable Particulates (PM_{10})	Particle Monitor
3	Total Volatile Organic Compounds (TVOC)	Portable VOCs Gas Detector
4	Formaldehyde (HCHO)	Portable Environment Formaldehyde Sensor's
5	Ozone	Ozone Detector

Measurement of these IAQ parameters was established according to ICOP-IAQ 2010. These parameters were then compared with acceptable limit as stated by ICOP-IAQ 2010. The acceptable limits were summarized in the Table 3.

Table 3: List of acceptable limit as comply with ICOP-IAQ 2010, Malaysia.

ITEM	PARAMETER	ACCEPTABLE LIMIT ICOP (DOSH,2010)
1	Carbon Dioxide (CO_2)	1000 ppm (Ceiling)
2	Carbon Monoxide (CO)	10 ppm (Ceiling)
3	Total Volatile Organic Compounds (TVOC)	3 ppm
4	Formaldehyde (HCHO)	0.1 ppm (Ceiling)
5	Respirable Particulates (PM_{10})	0.15 mg/m^3
6	Temperature	23 – 26 °C
7	Humidity	40 – 70 %
8	Ozone	0.05 ppm
9	Air Movement	0.15 – 0.50 m/s

Figure 2 show the monitoring procedure implemented in gathering on-site data. Partial period of

consecutive sampling was performed in three times measurements (morning, noon, and evening) to obtain IAQ status inside the building throughout the day.

Figure 2: Sampling procedure

All instruments were located at the centre of every sampling location and placed 75 cm above the ground. Five chemical parameters as listed above will be measured using instruments as specified in Table 2. The location of all sampling spot was recorded on the layout plan and all instruments were run simultaneously using specific procedure by ICOP-IAQ 2010.

Purposely for data analysis and interpretation, SPSS Statistic version 20 was used to obtain the clear figure of on-site data collected. The appropriate mean ± SD of the test was calculated using this software. The control charts was used to present the data and to be differentiate by plotting the control limits. Purpose of the control chart is to allow simple detection of events which indicate to actual process change.

4.0 RESULTS AND DISCUSSION

4.1 Measurement of mean, μ data

Measuring the mean for IAQ parameters were took place for both rooms setting in a new NIOSH's building. Table 4 shows the data from the measurement. As concern on the IAQ chemical contaminants, Figure 3 show the level of five chemical contaminants were recorded and compared among the three stages involved.

Table 4: represent the mean of chemical contaminants and physical data monitored in each stages.

Majority of the results show an increasing trend of the level as go along the building occupancy. These shows that the building materials used during furniture install contribute the factor toward an increasing level of the contaminants. In other hand, the occupant itself significantly involve in bring in contaminant from outside towards indoor environment.

Parameters	Mean,μ		
	Without furniture	With furniture	With occupancy
Carbon Dioxide (CO_2), ppm	477.35	466.31	837.87
Carbon Monoxide (CO), ppm	2.168	2.778	3.253
Relative Humidity (RH), %	53.716	52.605	59.011
Temperature, °C	24.069	24.467	22.867
Total Volatile Organic Compounds (TVOC), ppm	0.032	0.259	3.869
Formaldehyde, ppm	0.0182	0.0829	0.0531
Ozone, ppm	0.00436	0.00536	0.00918
Respirable Particulates, PM_{10}, mg/m³	0.01785	0.01975	0.03651
Air Movement, m/s	0.1476	0.1065	0.0883

Table 4 Data from NIOSH building

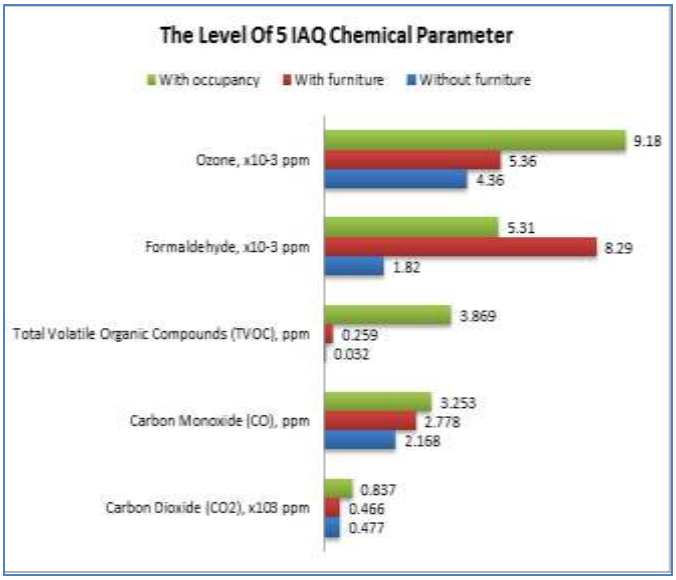

Figure 3: IAQ Chemical Parameter

4.2 Correlation

Study the correlation between relative humidity, temperature, formaldehyde and respirable particulates (PM_{10}) was conducted by Pearson Correlation test. The analysis was used to test whether the parameters have relationship between them. The hypothesis of the test is;

H_0 : There is no relationship between the parameter
H_1 : There is a relationship between the parameter

Based on table 5, it shows that relative humidity, formaldehyde and PM_{10} are significant, which we reject H_o that the p-value < 0.01. This indicates that there is linear relationship between relative humidity, formaldehyde and PM_{10}. There is no association between temperature with other parameter which is the p-value is greater than 0.01.

Table 5: Correlation Test Result

	Relative humidity	Temperature	Formaldehyde	PM_{10}
Rel. humidity				
Pearson Correlation	1	.019	.218	.248
Sig. (2-tailed)		.785	.002	.000
N	199	199	199	199
Temperature				
Pearson Correlation	.019	1	-1.04	.073
Sig.(2-tailed)	.785		.142	.307
N	199	199	199	199
Formaldehyde				
Pearson Correlation	.218	-1.04	1	.089
Sig.(2-tailed)	.022	.142		.210
N	199	199	199	199
PM_{10}				
Pearson Correlation	.246	.073	-.089	1
Sig.(2-tailed)	.000	.307	.210	
N	199	199	199	199

Figure 4 show the graph on relative humidity, formaldehyde and respirable particulates (PM_{10}) in office and training rooms between three phases of NIOSH new building show the percentage of relative humidity in the office rooms is slightly higher than training rooms. Office rooms have shown an increasing pattern in three consecutive stages, and reach approximately 70% after three month of occupancy. Meanwhile, training rooms have shown a decreasing pattern at the second stage with relative humidity of 45%. However, percentage of relative humidity at the third stage increases up to 55%.

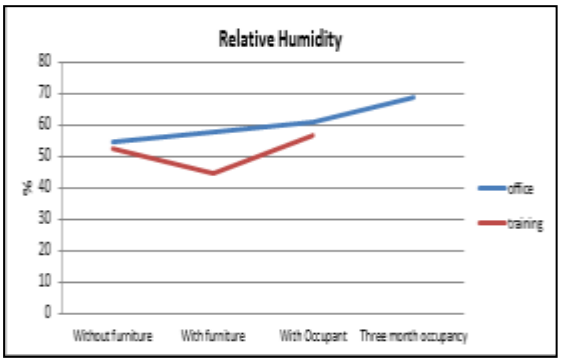

Figure 4: Relative Humidity (RH) concentrations

Figure 5 show the Formaldehyde concentrations for both sections have shown a different outline for all stages. The first sampling site which is Office has shown an increasing pattern from the first stage and reaches peak at 0.125 ppm when furniture is installed. Decrement of formaldehyde level in the office section can be seen for the last two stages. However, training section is showing an oppose pattern from the first outline and Formaldehyde level is increasing to 0.022 ppm at the final stage.

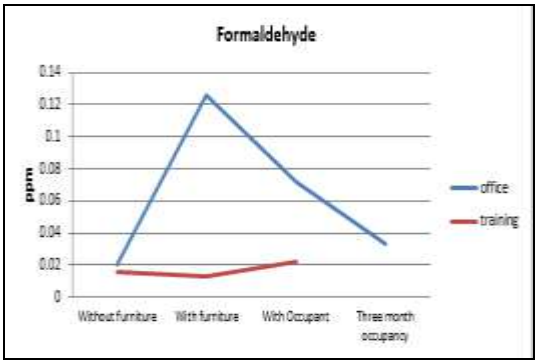

Figure 5: Formaldehyde concentrations

Figure 6 show the Respirable Particulates (PM_{10}) concentrations represents the comparison of PM_{10} between two variables which are office and training sampling site. Based on the graph, office has shown an increment of almost 0.055 mg/m^3 for the last three phases starting at the second stage. However, small declination occurred after furniture has been installed. Meanwhile, training sampling site is increasing for all stages.

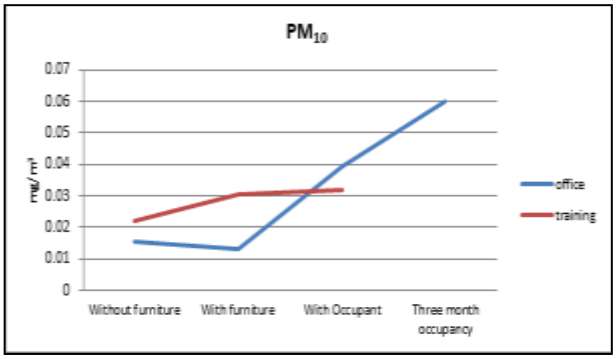

Figure 6: Respirable Particulates (PM_{10}) concentrations

One of the principal methods to mitigate IAQ problems is improving ventilation system, which is mainly composed of active IAQ control by heating, ventilation and air conditioning (HVAC) and passive IAQ control by natural ventilation (Sungho Lee et.al, 2012). Moreover, (Sungho Lee et.al, 2012) stated pollutant control sources in the design stage of finishing materials can improve air quality. It was clearly shown the building material, fittings and human factors are the main contributor towards IAQ level in new building. The proper selection of furniture with low VOCs content, good housekeeping procedure and human behavior can conserve the low level of contaminants exposure.

5.0 CONCLUSION

In conclusion, concentration of Formaldehyde in the new building specifically in office setting is exceeding the acceptable limit as comply by ICOP-IAQ, Malaysia 2010. Installation of furniture and fittings in the new building is the main reason behind this situation. However, other chemical parameters' level such as Carbon Dioxide (CO_2), Carbon Monoxide (CO), Total Volatile Organic Compound (TVOC), and Respirable Particulates (PM_{10}) are within the acceptable limit. The development of future IAQ commissioning guideline is important to improve health standard and safety of the occupants.

6.0 ACKNOWLEDGEMENT

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