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Dust Concentration in Office Environment

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Abstract – *A Malaysian worker spent almost eight hours of his daily life inside his office and if the dust concentration inside the office is too high, this worker might be exposed to poor indoor air quality (IAQ). The main objective of this study is to examine the dust concentration accumulated inside carpeted offices and the effect of the concentration with the environmental parameters. The measurement was carried out physically at four offices in Universiti Tun Hussein Onn (UTHM) having enclosed or open space and big and small volume and evaluation is re-measured inside chamber room that mimmicked the actual offices. There are three environmental parameters investigated in this study; air temperature, relative humidity and air velocity and measured using Dust Trak Monitor 8520 and Velocicalc Meter model 8386-M-GB. It was found that in enclosed space, big volume office the air temperature is 25°C, relative humidity is 66.8%, air velocity of 0.19m/s and dust concentration of 0.058mg/m^3. As for simulation in chamber room, it was found that the air temperature is 23.4°C, relative humidity 66.1%., air velocity of 0.18m/s and dust concentration is 0.050mg/m^3. The enclosed, big size of building produced higher dust concentration due to the frequent movement happening daily. In conclusion, carpet is not a main factor that can cause dusty problem. Generally, there are several causes that can increases the dust level which are dust comes from outdoor, equipment's or furniture in the work station. Dust also depending from frequently movement from people or occupants in a working station. However, due to aany factors, the increasing dust concentration will increase the relative humidity, and air velocity comparing to the value recommended by the ASHRAE and DOSH Malaysia standard.*

Keywords: Dust Concentration, Humidity, Temperature, Velocity, ASHRAE, Carpeted office

1.0 INTRODUCTION

The implementation of air quality (IAQ) control to protect public health contibutes to the emerging of many researches on the impact of air pollution to human health. In Malaysia, a recent research by [1] reported that several pollutants exist in air were significantly associated with natural mortality and respiratory mortality. It is often mistaken that human were to be exposed to harmful air pollutants if they stayed outdoor; there exists a major gap in our understanding of the impact of the air quality indoor where people spend most of their times daily. Recently, scientific and public interest on the IAQ has risen in order to bridge this gap [2-6]. There are several factors that cause indoor air pollution including building location and air flow; building design such as materials and furnishings; and indoor activities such as

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cooking. In addition, a poorly designed, maintained or operated air-conditioning and mechanical ventilation (ACMV) systems also give rise to poor IAQ.

Most of Malaysian adults spent almost eight hours of their daily life in a ventilated office for five days a week. A ventilation system required the inside of an office to be sealed tightly, thus limiting the amount of fresh air to come inside. This phenomenon further cause the air inside of the office to become stagnant and harmful pollutants such as dust and bacteria may contributes to sick building syndrome (SBS). The World Health Organisation (WHO) defined SBS as certain medical syndrome faced by occupants in buildings with indoor environment problems (Ref WHO) and can be characterized by few symptoms from eyes, facial skin, headhace and tiredness. Therefore IAQ control becomes significant concern as good IAQ promotes workers health and enhances work productivity. Fang et al. [7] reported in their recent study that Dermatophagoides farinae (Der f 1), an allergen found in dust in office is a high risk factor of SBS [7].

In other literature, Fraser et al. [8] reported on the high exposure of workers to polyfluorinated compunds (PFC) found in the collected dust in the office. The PFC is a manmade compunds and this chemical is not able to breakdown in environment, thus cause harmul effect to occupants with prolong exposure to it. The author later suggested that this compundes were discovered higher in office dust than the one collected from home and vehicles [9].

A review by Destaillats et al. [10], suggested that essential equipments found in office environments such as computers, printers and copiers were significant contributers to pollutants such as volatile organic chemicals (VOC) and ozones. Besides electronic equipments found in the offices, the type of floor is a significant factor that leads to unhealthy IAQ. Several authors conducted studies on the dust and pollutants accumulated based on floor types and it was suggested that carpeted floor introduced more dust and harmful pollutants [11-14]. Moreover, the findings suggest that there are two major aspect that further influenced bad IAQ; frequency cleaning of carpet [4] and the age of carpet (new and old) [11, 12]. However, those studies were conducted in Canada, New Zealand and Nigeria respectively, which is not in the same climate as in Malaysia. To date, there are inadequate literatures conducted on the effect of carpeted floor to IAQ in Malaysia, limiting to Suhana [15] and most recent study conducted by Fang et al. [7]. Fang and his team examined the associations between respiratory problems with pollutants contained in office dust and reported that Der f 1is a risk factor of daytime breathlessness.

A number of research on IAQ conducted in Malaysia demonstrated on the association of dust collected in a building with the occupants health [7, 16-19], without comparing the dust concentration to the The American Society of Heating, Refrigeration and Air- conditioning Engineers (ASHRAE) standard or investigate the effect of dust concentration to the environment, hence the question of ‘is an office Malaysian worker spend his 8 hours a day in a good IAQ?’ is not thoroughly answered. Therefore, in this paper, we aim to examine the effect of dust concentration in carpeted floor in offices to the indoor enviroment. Besides, the measurement is later to be re-simulated in chamber room and compared with the ASHRAE standard.

2.0 METHODOLOGY

Study on dust concentration on the carpet in 4 different offices was implemented using a physical measurement method. Dust Trak Monitor and Velocicalc was used to determine the

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parameter quantity and quality of environment such as air temperature, air velocity, air flow rate, relative humidity with dust concentration. Meanwhile, a simulation was done inside the chamber, where the air temperature and relative humidity were adjusted according to the condition of the highest dust concentration location, FKMP. A simulation will be done using the data attained from the chamber and correlated with the result measured in the office.

2.1 Locations of experiment

There are four location selected which are FKMP with building volume (6.8m x 6.37m x 3.65m), Continuing Education Centre Office with volume (16.94m x 11.7m x 3.5m), Lecturer Office with volume(4.32m x 8.4m x 3m) and Secretary Of Dean Office with volume (4.32m x 4.2m x 3m). Figure 2.1 shows the actual workplace.
The measurement was being conducted in four different offices, which are:

i) Measurement at Lecturer Office (Enclosed space with air conditioner system, using carpet, small area and volume).
ii) Measurement at FKMP's Academic Office (open space with air conditioner system, using carpet, big area and volume).
iii) Measurement at Continuing Education Centre, CEC Office (Enclosed space with air conditioner system, using carpet, big area and volume).
iv) Measurement at Secretary of Dean Office (Enclosed space with air conditioner system, using carpet, small area and volume).

Figure 2.1: Four different office selected; (a) FKMP Academic office, (b) CEC office, (c) Lecturer Office, and (d) Secretary of Dean Office.

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Table 1: Specification of environmental chamber.

Particular	Specification
Temperature range (°C)	10 deg C and 50 deg C
Accuracy(±°C)	3 deg C
Humidity range (%)	30% to 95%
RH Accuracy (%)	5%
Supply Voltage (V)	415 V- 3 phase-50 HZ
Max Current (A)	60 Amp
Compressor	10 HP 240V 50HZ
Refrigerant Gas	R 134a
Dimensions (m) (L x D x H)	4.8m x 4.8m x2.88m
Controller	Watlow F4
Sensor temperature / humidity	KIMO TH100

Figure 2.2: The Current Chamber used to measure the indoor environmental quality.

The environmental chamber facilities nowadays are established to conduct a multi-purpose testing to evaluate the performance of full scale building envelope system. A chamber facilities consists a structural components, heating, cooling and humidification systems, control systems, sensors, instruments, data acquisition and supporting setup and apparatus. It has multi purposes testing but the main purpose for this study is to investigate the indoor environmental quality. The specifications of environmental chamber can be summarizing as Table 1. Results obtained from the chamber were simulated, evaluated and were then compared with the data measured in the office.

2.2 Materials and Equipment

In the physical measurement there are two types of equipment that recently used that has their own specialty and uses, namely (i) Dust Trak Aerosol and (ii) Velocicalc. This measuring equipment is used to obtain the distribution level of parameter in more practicality. The data obtain from physical measurement will be compared with simulation and assessment value standard (ASHRAE, DOSH Malaysia and Code of Practice), to study the relationship between parameters involved.

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Figure 2.3: Equipments Used (Dust Trak Monitor and Velocicalc)

2.2.1 Dust Trak Monitor

Dust level and particle measurement in internal air space was measured using Dust Trak Monitor. The suitable measurement taken is at temperature between 0 °C to 50 °C. This measuring instrument is from TSI model 8520 that use scattered-like laser beam. Dust and particle were traced during across the laser beam.

Before conducting the dust measurement, Dust Trak Monitor was calibrated using a zero filter so it can suit with the environment conditions. The air flow also must be set up at 1.7 L/min and adjusted using Flow meter to ensure that the measurement is in the right and accurate scale.

Dust Trak Monitor has a three operation modes which are Survey, Sample and Data Log. The measurement obtained was recorded by using Data Log Mode. This mode was set up by using Track Pro Software. Data on the dust concentration were collected for three parameters; (i) air velocity, (ii) temperature and (iii) relative humidity.

2.2.2 Velocicalc

The Velocicalc plus air velocity meter (8386-M-GB) use heater concept which has one detector or probe (Anemometer) to measure the air velocity inside a building space. The probe is elongation-controlled in order to be able to practice in any from any height. Air velocity range that can be assessed with this tool is among 0 m/s to 30 m/s. Other than measuring the air velocity, this equipment can be also used to measure the air temperature, air flow rate, pressure, relative humidity and to calculate the flow rate from velocity and duct size. This type of flow rate calculation applies to any measurement that occurs in a duct or pipe. Plus use the hot wire sensor in the permanently attached probe or by a Pitot tube that is attached to the pressure ports.

2.3 Measurement of Dust Concentration

The physical measurement started with pilot test. The pilot test is important to ensure the location chosen was appropriate. Following the test, a measurement was taken within eight hours in the four different offices and data obtained were collected and analyzed.

Meanwhile, the chamber was then set up like an actual workplace. All of the parameters were measured and a simulation was done. During the measurement, the temperature and humidity inside the chamber was adjusted to simulate a real outdoor working place environment. Carpet was used as a medium to get a distribution of dust in working environment. The measurement

was done by setting an air temperature and relative humidity. The value will be taken maybe six or eight hours per day to get only one result of dust distribution.

The measurement in a WIS chamber was done in several times. The main purpose of using a chamber is to do some simulation and compared the value with the measurement in the actual workplace. In the chamber the temperature and relative humidity were adjustable regarding to the temperature and humidity in a real workplace environment. In addition, the chamber was set up as FKMP's Academy Office and when the measurement was implemented, several students were stay in the chamber and does the office stuff act like in the working environment.

Figure 2.4: Velocicalc plus air velocity

3.0 RESULTS AND DISCUSSION

3.1 Comparison of Dust Concentration and Environmental Parameters in a Different Office Environment

The measurement of dust concentration and all the environmental parameters is carried out on four different types of office. The first measurement was implemented at Lecturer Office. Table 2 shows the value of air velocity in Lecturer Office is between 0.00 m/s to 0.9 m/s with average value 0.23 m/s. The maximum value of temperature is 22.5 °C with minimum temperature 20.9 °C and the average value is 24.7 °C. The value of relative humidity in this office is 58.8 % for the minimum and 80.1 % for the maximum which given the average value is 66.1 %. For dust concentration, it shows average reading 0.057 mg/m^3 with maximum value 0.07 mg/m^3 and minimum value 0.044 mg/m^3. For the FKMP Academic's Office, the value of air velocity in FKMP Academic's Office is between 0.00 m/s to 0.63 m/s with average value 0.19 m/s as shown in Table 3. The maximum value of temperature is 25.4 °C with minimum temperature 23 °C and the average value is 24.7°C. The value of relative humidity in this office is 55.1% for the minimum and 83.2 % for the maximum which given the average value is 66.5%. For dust concentration, it shows average reading 0.056 mg/m^{3}with maximum value 0.075 mg/m^{3}and minimum value 0.042 mg/m^3.

By reviewing Table 4, the average value for the velocity at CEC office taken is 0.23m/s with the maximum value 0.77m/s and minimum value 0.00m/s. Then, the minimum temperature in

this office is 21.8ºC, while maximum temperature is 25.8ºC with their average temperature 24ºC. For the relative humidity value, it shows 70.5% for maximum value, 61.9% for minimum value and the average relative humidity 66.4%. Next, for the dust, it shows the minimum value is 0.026 mg/m^3 and the maximum value for dust is 0.043 mg/m^3 which the average value is 0.088 mg/m^3. Based on Table 5, the value of air velocity in Secretary of Dean Office is between 0.00 m/s to 0.43 m/s with average value 0.08 m/s. The maximum value for temperature is 32.5 °C with minimum temperature 25.3 °C and the average value is 25.7°C. The value of relative humidity in this office given 47% for the minimum and 64.8% for the maximum which given the average value is 63.6%. For dust concentration, it shows average reading 0.012mg/m^{3}with maximum value 0.016 mg/m^3 and minimum value 0.01 mg/m^3.

From Figure 3, it show comparison made between four Offices, the result obtained was the higher dust concentration level is in FKMP and CEC Office. The higher dust is because most of the students and lecturers spent a few minute to settle their own task and also adding with the staff in those offices. Further, frequently movement, often enter and exit of people also can influenced of a high dust level.

Table 2: Result of measurement at Lecturer Office (Enclosed space and small volume)

Parameter	Unit	Minimum	Maximum	Average
Velocity, V_1	m/s	0.00	0.9	0.23
Temperature, T_1	^{0}C	20.9	22.5	24.7
Relative Humidity, RH_1	%	58.8	80.1	66.1
Dust , $Dust_1$	mg/m^3	0.044	0.07	0.057

Table 3: Result of measurement at FKMP Academic's Office (Open space and big volume)

Parameter	Unit	Minimum	Maximum	Average
Velocity, V_2	m/s	0.00	0.63	0.19
Temperature, T_2	^{0}C	23	25.4	24.7
Relative Humidity, RH_2	%	55.1	83.2	66.5
Dust , $Dust_2$	mg/m^3	0.042	0.075	0.056

Table 4: Result of measurement at CEC Office (Enclosed space and big volume)

Parameter	Unit	Minimum	Maximum	Average
Velocity, V_2	m/s	0.00	0.77	0.23
Temperature, T_2	^{0}C	21.8	25.8	24
Relative Humidity, RH_2	%	61.9	70.5	66.4
Dust , $Dust_2$	mg/m^3	0.026	0.043	0.034

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Table 5: Result of measurement at Secretary of Dean Office (Enclosed and small volume)

Parameter	Unit	Minimum	Maximum	Average
Velocity, V_2	m/s	0.00	0.43	0.08
Temperature, T_2	^{0}C	25.3	32.5	25.7
Relative Humidity, RH_2	%	47	64.8	63.6
Dust , $Dust_2$	mg/m^3	0.01	0.016	0.012

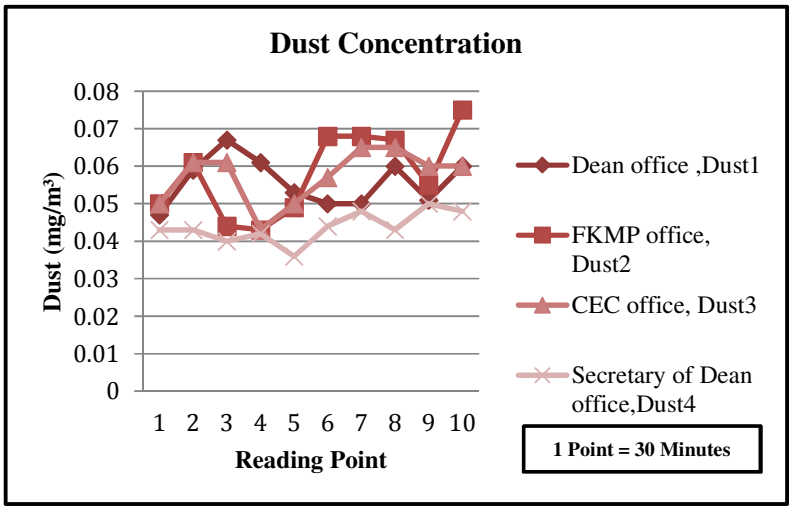

Figure 3: Comparison of dust concentration between four offices

3.2 Comparison between the real measurement values with the simulation values

The measurement has been done at the real workplace and also in the chamber. FKMP's Academic Office was selected for real measurement to compare with the simulation values since from previous analysis shows that FKMP has higher dust concentration compare to the others office.

Table 6: Comparison between the Real Measurement Values with the Simulation Values

Parameter	Real Measurement	Simulation	Ratio value (%)
Dust (mg/m^3)	0.058	0.050	13.8
Air Temperature (°C)	25	23.4	6.4
Relative Humidity (%)	66.8	66.1	1.05
Air Velocity (m/s)	0.19	0.18	5.3

From the both results obtained which are from experimental and simulation shows that the results were approximately. The results obtain from real measurement compared with the simulation result in the chamber. The comparison made can be referred in Table 5. According to the Table 5, the value of dust measured in actual workplace is 0.058 mg/m^3, while the simulation value is 0.050 mg/m^3, so the ratio between these two dust values is 13.8%. Next, for the value of temperature in a real measurement is 25°C with the simulation value is 23.4°C

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and the ratio calculated is 6.4%. The simulation value of relative humidity is 66.1%, it is nearest to the real measurement which is 66.8% and the ratio is only 1.05%. Further, the Air velocity value is 0.19m/s in a real measurement and 0.18 in simulation, so the ratio between these values is 5.3%.

3.2 Comparison between the real measurement values with the simulation values

Table 7: Comparison between the Results of Study with Standard Values

Parameters	Real Measurement	Simulation	Standard Values	Standard Used
Dust (mg/m^3)	0.058	0.050	0.15	**DOSH Malaysia (2005)**
Air Temperature (°C)	25	23.4	22.5-26.0	**ASHRAE 62.1-2007**
Relative Humidity (%)	66.8	66.1	30-60	**ASHRAE 62.1-2007**
Air Velocity (m/s)	0.19	0.18	0.125	**ASHRAE 62.1-2007**

Table 7 showed that the 60% increase of dust concentration measured in real and simulation compared to the recommended standard leads to almost 50 % increase of relative humidity and air velocity. Therefore, it is suggested that the high concnetration of dust in FKMP affect the environmetal and might consequently contributes to poor IAQ.

4.0 CONCLUSSION

Dust existence has been identified. Carpet is not a main factor that can cause dusty problem. From the entire measurement that has been conducted in different locations of office shows that carpet is not the main sources of producing dust because dust that trapped in the carpet can be cleaned by using a vacuum cleaner. The dust concentration were reduce if the vacuum process more often. Generally, there are several causes that can increases the dust level which are dust comes from outdoor, equipment's or furniture in the work station. Next, a lot of furniture or equipment's in working space can produce the dust. Dust also gave a higher rate in a natural aeration compared when using air conditioner. In addition, occupant also can influence dust concentration and higher dust occurred when many people using one workspace. Dust also depending from frequently movement from people or occupants in a working station. However, even though carpet was not majorly affecting the dust concentration in the office, it concluded that the increasing dust concentration due to any factors will increase the relative humidity, and air velocity comparing to the value recommended by the ASHRAE and DOSH Malaysia standard.

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