IOP Conf. Series: Earth and Environmental Science **106** (2018) 012034 doi:10.1088/1755-1315/106/1/012034

The impact of total suspended particulate concentration on workers' health at ceramic industry

M M Sintorini

Environmental Engineering Department, Faculty of Landscape Architecture and Environmental Technology, Universitas Trisakti, Jakarta, Indonesia

Corresponding Author: sintorini@trisakti.ac.id

Abstract. Ceramic production process pollutes the air with particulate matter at high concentration and has negative impact on the workers. The objective of this research was to determine the particulate concentration in the air and to analyse its impact on the workers. This research used cross sectional method to correlate the particulate concentration, temperature, humidity, smoke level and level of workers' compliance with safety regulations. Sampling was conducted from April to May 2012 in three locations, i.e. exposure area (Mass Preparation I, II) and non-exposure area (Forming area). In the exposure area (Mass Preparation I and II) where the particulate concentrations were 22.3673 mg/m^{3}and 14.8277 mg/m^3, and 58.33%, the workers had bad health status. In the non-exposure area, where the particulate concentration was 3.2185 mg/m^3 and 25% the workers had bad health status. The Odds Ratio among the workers in exposure area was 4.2 times higher than the workers in the non-exposure area.
Keywords: ceramic industry, health risk ratio, particulate exposure

1. Introduction

Indoor air quality gets serious attention because of its impact on employee performance.High concentration of Particulate Matter (PM) in air endangers workers' health in the ceramic industry. Respiratory disorders are common in workers who do not use protective equipment while working [1]. Symptoms that occur are headache, loss of concentration, dry throat, respiratory problems and eye irritation.

PM exposure can causes lung and systemic inflammation, which in turn leads to vascular endothelial dysfunction, a key step in the initiation and progression of atherosclerosis. Endothelial dysfunction was assessed by vascular response to acetylcholine (ACh) and sodium nitroprusside (SNP). PM_{10} exposure increased lung macrophages ($P < 0.02$), macrophages containing particles ($P < 0.001$), and activated macrophages ($P < 0.006$) [2].

Relatively low levels of fine particulate exposure from either air pollution or second-hand cigarette smoke are sufficient to induce adverse biological responses increasing the risk of cardiovascular disease mortality. The exposure-response relationship between cardiovascular disease mortality and fine particulate matter is relatively steep at low levels of exposure and flattens out at higher exposures [3]. The meta-relative risk for lung cancer associated with $PM_{2.5}$ was 1.09 (95% CI: 1.04, 1.14). The meta-relative risk of lung cancer associated with PM_{10} was similar, but less precise: 1.08 (95% CI: 1.00, 1.17) [4].

Objective of this study is to determine the concentration of total suspended particulate (TSP) and exposure of TSP to respiratory problems of workers in the tile production unit Indonesian Ceramic Association.

2. Research Method

The research design used is Cross-sectional [5]. The research was conducted on April - May 2012 at Indonesian Ceramic Associations, Bogor.

The conceptual framework used in the study is respiratory distress as dependent variable, total suspended particulate as independent variable, while confounding variable is temperature, humidity, age, length of service, smoking and the use of personal protective equipment (Figure 1).

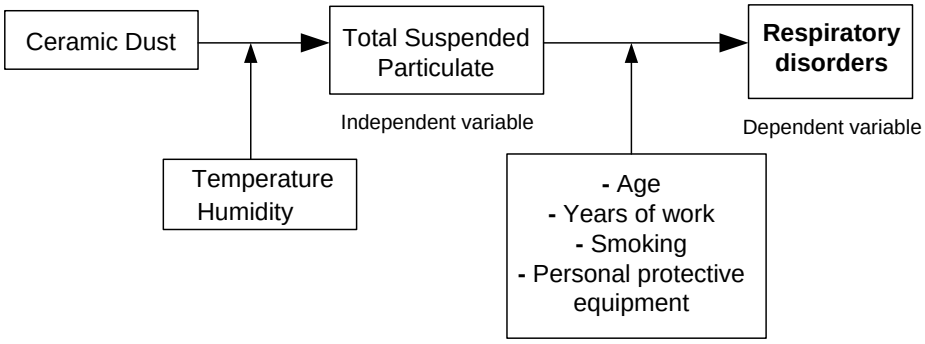

Figure 1. Conceptual framework.

2.1. Data collection

Data collected were total suspended particulate (TSP), temperature, relative humidity, and factory workers interview data of 48 people, ie 20 people in Mass Preparation unit I, 16 people in Mass Preparation unit II, and 12 people in forming unit [6]. The determination of respiratory symptoms is based on the standard Respiratory Symptoms and Patterns of Pulmonary Dysfunction [7].

Respondents were classified with respiratory distress if they complained of more than one cough symptoms, shortness of breath, bronchitis, pneumonia, pulmonary tuberculosis, emphysema and asthma. If the respondent complains about one or none of the above disorders then be classified as workers with good health status. The calculation of probability for a person suffering from respiratory distress, using the following provisions:

$$p = \frac{1}{1+exp^{-(a+bX)}} \quad (1)$$

The formula for measuring dust is:

$$X = \frac{A}{V} \quad (2)$$

X = TSP concentration (mg/m^3)
A = Weight of TSP on filter paper (mg)
V = Volume of air flow through filter x sampling time (L)

3. Results and Discussion

The result shows that all workers (68.75%) are men with the majority of age between 21-30 years. The most of 48 workers (79.17%) worked less than 10 years, but 42.11% of them have already suffered respiratory problems. The majority of workers (68.75%) between 21-30 years of age with respiratory

disorders (51.52%). 52.08% of workers were smokers, with respiratory disorders proportions of 64%. All the workers were dutifully using personal protective equipment (100%) but apparently did not guarantee they were free of health problems [8].

Table 1. Frequency distribution of respondent characteristics in Indonesian Ceramic.

No	Variable	Total	%	Suffer	Proportion	%
1.	Experience :					
	a. < 10years	38	79,17	16	16/38	42,11
	b. > 10years	10	20,83	8	8/10	80
2.	Age :					
	a. <21 years	3	6,25	-	-	-
	b. 21–30years	33	68,75	17	17/33	51,52
	c. > 30 years	12	25	7	7/12	58,33
3.	Smoking					
	a. Yes	25	52,08	16	16/25	64
	b. No	23	47,92	8	8/23	34,78
4.	Using PPE					
	a. Yes	48	100	24	24/48	50
	b. No	-	-	-	-	-

The statistical analysis shows a significant correlation between works place temperature and works place TSP concentration, with p value: 0.000 (Table 2.). Figure 2 shows the concentration of TSP, temperature and humidity in all workspaces where sampling takes place. The highest TSP concentration comes from Mass Preparation room I (MP I). This space is an early stage of soil processing before being processed into tile, i.e. box feeder, crushing, milling and screening. While the space Mass Preparation II (MP II) where the final processing of earth, including crushing and screening, then it put into the Space Forming where the tile model is formed.

Table 2. Correlation between TSP and working room temperature in Indonesian Ceramic.

Model	B	R	R^2	Sig
Constant	-136,484			0,000
Temp. (°C)	4,568	0,869	0,755	0,000

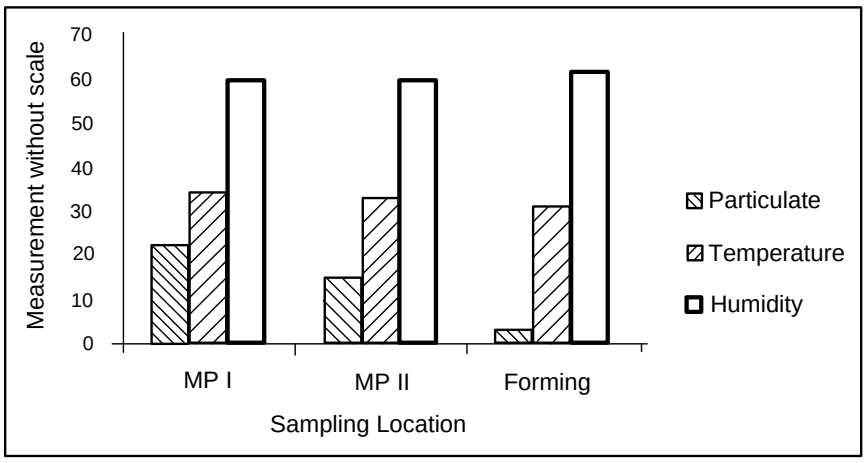

Figure 2. Total suspended particulate concentration, temperature and humidity in Indonesian Ceramic.

From the survey it was found that workers with the most health problems were from MP I unit (Table 3). While in Forming units are unexposed, workers (unexposed).

Table 3. Frequency distribution of worker health status in Indonesian Ceramic.

No.	Health Status	Location			Total	%
		MP I	MP II	Forming		
1.	Good	8	7	9	24	50
2.	Bad	12	9	3	24	50
	Total	20	16	12	48	100

From the on site observation, it is known that the highest respiratory unit is in the unit of MP I, ie 87.04%. This unit has the highest TSP concentration of 22.3673 mg / m^3, while the industry standard is 10,000 mg / m^3 (Table 4).

Table 4. Probability of respiratory disorders in Indonesian Ceramic workers.

Location	TSP (mg/m^3)	Probability (%)
MP I	22,3673	87,04
MP II	14,8277	70,97
Forming	3,2185	34,04

Statistically there is a significant correlation between relative humidity and TSP concentration in the workspace (Table 5.).

Table 5. Correlation between TSP and humidity of workspace in Indonesian Ceramic.

Model	B	R	R^2	Sig
Constant	48,543			0,006
Humidity (%)	-0,536	0,354	0,125	0,055

The development of long-term degenerative diseases such as bronchitis and emphysema is a cumulative response to poor environmental conditions. Total suspended particulate (TSP) may also cause infection in the lower respiratory tract. It is known that chronic bronchitis is suffered by workers exposed to continuous dust in high concentrations, such as workers in the cement industry, ceramics, coal and so on. This chronic bronchitis is diagnosed as a slimy cough throughout the day in 3 months for 1 year or more, without any underlying disease [9].

Respiratory disorders in workers who become dependent variables have a statistically significant relationship with TSP concentration in the workplace with a value of p: 0.004 (Table 6.).

Table 6. Correlation between TSP concentration and respiratory symptoms in workers Indonesian Ceramic.

Model	B	SE	Wald	df	Sig
TSP (mg/m^3)	0,134	0,046	8,332	1	0,004
Constant	-1,093	0,817	6,567	1	0,010

Y = respiratory symptoms

Figure 3. Health problems for workers in Indonesian Ceramic.

Workers who had better health were more in the Forming room, whereas those with the worst health were mostly in MP I room (Figure 3). Because the TSP exposure in the forming space is at least.

Based on multivariate statistic analysis it can be seen that the highest risk of health problems is particulate exposure [10]. The risk is 1,942 times, greater than the exposure that is caused by other variables (Table 7).

Table 7. Correlation between TSP concentration and respiratory disorders in workers Indonesian Ceramic.

Variable	B	SE	Wald	df	Sig	Exp (B)
TSP concentration	1,008	1,389	5,135	1	0,023	1,942
Temperature	0,021	1,003	5,545	1	0,019	1,001
Humidity	0,216	1,088	5,278	1	0,022	1,083
Age	0,179	0,823	0,761	1	0,675	1,078
Years of work	0,077	0,753	6,089	1	0,008	1,010
Smoker	0,601	1,475	0,126	1	0,722	1,295
Constant	-30,9415	3,217	5,885	1		

Compared to all production spaces of MP I, MP II and Forming, the greatest risk exists in MP I and II spaces that are 4.2 times larger than Forming rooms (Odds ratio: 4.2) (Table 8).

Table 8. Health status of workers Indonesian Ceramic.

No.	Health Status	Location MP I & MP II (exposure)	Forming (non exposure)	Total
1.	Good < 1 symptom	15	9	24
2.	Bad > 1 symptom	21	3	24
	Total	36	12	48

4. Conclusion

In the exposure area (Mass Preparation I and II) indicated that the particulate concentration was 22.3673 mg/m^3 and 14.8277 mg/m^3, and 58.33% the workers had bad health status. In the non-exposure area, the particulate concentration was 3.2185 mg/m^3 and 25% the workers had bad health

status. The Odds Ratio among the workers in exposure area was 4.2 times higher than the workers in the non-exposure area.

References

[1] Cho Y, Min Choi, Jun-Pyo Myong, Hyoung-Ryoul Kim, Hye Eun Lee, Tae-Won Jang, Jung Wan Koo. 2015. The association between bronchial anthracofibrosis and pneumoconiosis: A retrospective cross-sectional study. *Journal of Occupational Health*. 57:110–117.

[2] Tamagawa E, Ni Bai, Morimoto K, Gray C, Mui T, Yatera K, Zhang X, Xing L, Li Y, Laher I, Sin D D, Man S F P, Van Eeden S F. 2008. Particulate matter exposure induces persistent lung inflammation and endothelial dysfunction. *American Journal of Physiology - Lung Cellular and Molecular Physiology*. Published 3 July 2008, 295 (1) : 79-85, DOI:10.1152/ajplung.00048.2007

[3] Pope C A, Burnett R T, Krewski D, Jerrett M, Shi Y, Calle E E, Thun M J. 2009. Cardiovascular Mortality and Exposure to Airborne Fine Particulate Matter and Cigarette Smoke Shape of the Exposure-*Response Relationship*. https:/ /doi.org/ 10.1161/ CIRCULATIONAHA. 109.857888. 120(11):941 – 948.

[4] Hamra G B, Guha N, Cohen A, Laden F, Nielsen O R, Samet J M, Vineis P, Forastiere F, Saldiva P, Yorifuji T, Loomis D. 2014. Outdoor Particulate Matter Exposure and Lung Cancer: A Systematic Review and Meta-Analysis. *Environmental Health Perspectives*.122(9), http://nrs.harvard.edu/urn-3:HUL.InstRepos:dash.current.termsof-use#LAA, DOI: 10.1289/ ehp /1408092.

[5] Mori K, Nagata M, Hiraoka M, Nagata T, Kajiki S. 2015. Surveys on the competencies of specialist occupational physicians and effective methods for acquisition of competencies in Japan. *Journal of Occupational Health*. 57:126–141.

[6] Albert A, Matthew R H, Kleiner B M. 2014. Emerging Strategies for Construction Safety and Health Hazard Recognition. *Journal of Safety Health and Environmental Research*, 10(2):152–161.

[7] Thepaksorn P, Pongpanich S, Siriwong W, Chapman R S, Taneepanichskul S. 2013. Respiratory Symptoms and Patterns of Pulmonary Dysfunction among Roofing Fiber Cement Workers in the South of Thailand. *Journal of Occupational Health*. 55:21 – 28.

[8] Noordin F, S J Lewis, P N S O'Donnell, P A J Crosbie. 2014. Manual Work and Lung Cancer Risk in High Risk Populations. *Journal of Occupational Safety and Health*. National Institute of Occupational Safety and Health, Ministry of Human Resources Malaysia. 11(1):5–14.

[9] Boiani J M, Steege A L, Sweeney M H. 2014. Adherence to Safe Handling Guidelines by Health Care Workers Who Administer Antineoplastic Drugs. *Journal of Occupational and Environmental Hygienes*, 11(11):728–740.

[10] Tan Chin Keng, Razak NA. 2014. Case Study on the Safety Management at Construction Site. *Journal of Sustainability Science and Management*. 9(2):90–108.