**Health Risk of Workers Exposed to PM2,5 in Fish Smoking Industry Bandarharjo Semarang**

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***Abstract***

*Workers in fish smoking industry are exposed continuously to high concentration of PM2,5. The present study conducted PM2,5 concentration measurement in 8 sampling points and administered questionnaire to 109 active workers in smoking fish industry Bandarharjo Semarang to collect information about age, sex, BMI, duration and years of work, smoking habit, and alcohol and supplement consumption. The results showed difference in PM2,5 concentration based on the scale of smoking house. The small-scale house had higher concentration of PM2,5 than the big-scale one. While the questionnaire showed some characteristics that might increase the health risk caused by PM2,5 exposure like most of workers suffered obesity (44,0%), had long duration of work with average 8,32 hours per day, years of work 16,72 years, and only 30,3 % workers consumed supplements. These findings need to be followed up by formulating some improvement in smoking room setting and working hours, so, workers would suffer less health impacts.*

**Key words:** health risk, PM2,5, workers, fish smoking

**Abstrak**

Pekerja di industri pengasapan ikan terus terpapar oleh konsentrasi tinggi PM2,5. Penelitian ini melakukan pengukuran konsentrasi PM2,5 di 8 titik sampel dan memberikan kuesioner kepada 109 pekerja aktif di industri pengasapan ikan Bandarharjo Semarang untuk mengumpulkan informasi tentang umur, jenis kelamin, IMT, durasi dan tahun kerja, kebiasaan merokok, konsumsi alkohol dan suplemen. Hasil penelitian menunjukkan perbedaan konsentrasi PM2,5berdasarkan skala rumah pengasapan. Rumah skala kecil memiliki konsentrasi PM2,5 yang lebih tinggi daripada skala besar. Sedangkan hasil kuesioner menunjukkan beberapa karakteristik yang dapat meningkatkan risiko kesehatan yang disebabkan oleh paparan PM2,5 seperti sebagian besar pekerja menderita obesitas (44,0%), memiliki durasi kerja yang panjang dengan rata-rata 8,32 jam per hari, masa kerja 16,72 tahun, dan hanya 30,3% pekerja mengkonsumsi suplemen. Temuan ini perlu ditindaklanjuti dengan merumuskan beberapa perbaikan dalam pengaturan ruang pengasapan dan jam kerja, sehingga risiko kesehatan pada pekerja dapat diminimalisasi.

**Kata kunci: risiko kesehatan, PM2,5, pekerja, pengasapan ikan**

1. **Introduction**

Particulate Matter (PM) is a mixture of solid particles and liquid droplets found in the air. Particulates with a diameter of less than 2.5 µm (PM2.5) can deeply enter the lungs and some may even enter the bloodstream. Based on these characteristics, PM2.5 is known to pose the greatest risk to human health (US EPA, 2009). Various studies have been carried out to determine the health effects caused by exposure to PM. Long-term exposure to PM2.5 is associated with an increased long-term risk of cardiopulmonary death by 6-13% per 10 μg/m3 PM2.5 (Beelen et al., 2008). The increased PM2.5 concentration was associated with the increase in respiratory diseases such as Chronic Obstructive Pulmonary Disease (COPD), lung cancer and cardiovascular disease (WHO, 2013). According to The Global Burden of Disease Study, the prevalence of COPD globally in 2016 was 251 million cases. It was estimated that 3.17 million deaths are caused by COPD or 5% of all deaths worldwide with more than 90% of deaths occurring in middle to lower income countries (WHO, 2017). In Indonesia, the prevalence of COPD reaches 3.7% per mil, where the majority of sufferers are male (Balitbangkes, 2013).

Industrial activity is one of the largest sources of PM2.5 emissions in the environment. The fish smoking industry, for example, involves the burning process in its production process that produces dense smoke which is released directly into the air. Smoke produced from burning biomass fuels such as wood and coconut shell, produces antimicrobial compounds that can be used to prevent fish in decaying. This is a traditional method that people still use to preserve fish (Harahap, 2011). Today, the fish smoking industry is developing into one of the small and medium enterprises specifically for people living in the coastal area. One that is still managed to operate is fish smoking industry in Bandarharjo, Semarang. Besides polluting the environments, the real impact of fish smoking industry is received directly by workers exposed to emissions resulting from the industrial activities. Most of the work is done indoors so the smoke is inhaled directly by the workers.

In 2007, a study about particle induction to the lung capacity of Bandarharjo fish smoking workers showed that chemicals were found in smoke which resulted in decreased lung function. Health problems attended on workers consists of coughing, coughing with phlegm, shortness of breath, and chest pain (Pranowowati, 2007). Similar conditions were also discussed in the study for workers in fish smoking in Tambak Wedi Village Surabaya. The results of the study showed that PM2,5 concentration in 8 fish smoking rooms had increased environmental quality standards. Health complaints were also felt by workers, while 100% of workers felt painful eyes and 80.8% complained of shortness of breath (Nirmala & Prasasti, 2014). The results of other studies also showed workers exposed to PM2.5 in the environment examined the risk for COPD or cardiovascular disease (Han, Liu, Chuang, Pan, & Chuang, 2016).

This study investigates the concentration of PM2,5 in the workplace and other factors that may contribute to the increase of health risk on workers exposed to PM2,5.

1. **The Methods**
	1. **Study Locations and Subjects**

The study was conducted among workers in fish smoking industry Bandarharjo Semarang, located on the banks of the Semarang river with an industrial area of ​​approximately 4 hectares. This industry has been widely known as the center of fish smoking in Semarang (Widowati, Febbiyana, Ismail, Fatmawati, & Hudaya, 2013). The number of fish smoking business owners who are still operating currently is 25 people, consisting of 20 small-scale and 5 large-scale smoking house with total 150 active workers.

Subjects who were participated in this study are 109 workers who met the inclusion criteria as follows: subjects are not undergoing treatment for chronic diseases such as COPD, cancer, and others, existed at the location during working hours, do not suffer from hearing and speech impairments, do not have memory / senility problems, not pregnant, and willing to be interviewed.

* 1. **Exposure assessment – PM2,5**

The assessment of PM2.5 concentration in the workspace air is carried out by the professional technician from Environmental Laboratory using a tool named *Particle Counter* with direct reading method. Measurements were made at 8 different sampling points with details as follows: 2 points each at the entrance and exit gate of the industry, 2 points at the location of small-scale smoking house, 2 points at medium scale, and 2 points in large-scale smoking house. Measurements at each point are carried out for approximately 15 minutes. The PM2.5 measurement results will appear immediately on the tool.

* 1. **Questionnaires**

Questionnaires were administered by direct interview in the working hours to collect information about other health risk factors such as age, Body Mass Index (BMI), duration of work per day, years of work, smoking and drinking alcohol habit, and supplement consumption. BMI data were obtained by measuring weight and height of subject, using appropriate and standardized tools, scales and microtoise.

1. **Results and Discussion**

The assessment results of PM2,5  concentrations at 8 different points showed some differences in concentration in small, medium and large scale smoking houses. Before conducting this study, literature studies were carried out and the results showed that there were differences in PM2,5  concentrations on different smoking scales, where the greater the scale of smoking house the higher the concentration of PM2,5  resulted in the work environment. The concentration of PM2,5 was influenced by the number of fish smoking stoves in each smoking houses. In small-scale houses, there are approximately 3-5 stoves, medium scale has 6-8 stoves, and large scale has 10-15 stoves.

However, different findings are shown in the present study. The concentration of PM2,5  on a small and medium scale is actually greater than that of a large-scale smoking house. This is shown as consistent results from measurements at different sampling points as presented in Table 1. Concentration of PM2,5 in each small and medium scale house showed the same number that was 500 µg/m3. It happened because the real concentration of PM2,5 in both houses exceed the ability of tools to measure. So it can be concluded that both small and medium scale houses have concentration of PM2,5 ≥ 500 µg/m3.

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Table 1. Concentration of PM2,5 in 8 different sampling points

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sampling point** | **Location coordinate** | **Concentration of PM2,5****(µg/m3)** | **Tempe-rature****(ºC)** | **Relative Humidity****(%)** | **Wind Direction to (º)** | **Wind Speed****(m/s)** | **Air pressure****(mmHg)** |
| Entrance gate | S: 06⁰57'22.58"E: 110⁰24'43.87" | 23 | 32,3 | 48,4 | 235 | 2,3 – 4,5 | 755 |
| Small-scale A | S: 06⁰57'18.27"E: 110⁰24'36.69" | 500 | 33,1 | 51,3 | 270 | 0,1 – 0,7 | 755 |
| Small-scale B | S: 06⁰57'17.46"E: 110⁰24'36.12" | 500 | 34,2 | 54,3 | 235 | 0,1 – 0,8 | 755 |
| Medium-scale A | S: 06⁰57'21.73"E: 110⁰24'41.31" | 500 | 31,9 | 56,6 | 270 | 0,1 – 0,3 | 755 |
| Medium-scale B | S: 06⁰57'17.75"E: 110⁰24'36.69" | 500 | 35,4 | 57,9 | 270 | 0,1 – 0,2 | 755 |
| Big-scale A | S: 06⁰57'22.08"E: 110⁰24'42.57" | 271 | 33,2 | 56,5 | 270 | 0,1 – 0,3 | 755 |
| Big-scale B | S: 06⁰57'21.53"E: 110⁰24'40.51" | 332 | 33,3 | 56,1 | 270 | 0,1 – 0,2 | 755 |
| Exit gate | S: 06⁰57'16.34"E: 110⁰24'34.92" | 350 | 33,2 | 53,8 | 235 | 0,3 – 3,3 | 755 |

While the results of questionnaire on 109 subjects showed that the average age was 47.06 years with female workers as majority (72.5%). The results of BMI measurements showed that most workers were obese (44.0%). The average duration of work per day was 8.32 hours (95% CI 7.82 - 8.82) while the years of work on average was 16.72 years (95% CI 15,19 – 18,24). Results related to worker habits or lifestyle showed that most workers were non smokers (84.4%), 100% did not consume alcohol, and most of them did not consume supplements (69.7%).

Table 2. Characteristics of Subjects

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Variables** | **Frequencies** | **Percentage** | **Mean** | **SD** | **Min – Max** | **95% CI** |
| Age |  |  | 47,06 | 9,826 | 20 - 65 | 45,19 - 48,92 |
| Sex* Female
* Male
 | 7930 | 72,527,5 |  |  |  |  |
| BMI* Normal
* Overweight
* Obesity
 | 412048 | 37,618,344,0 |  |  |  |  |
| Duration of work per day |  |  | 8,32 | 2,635 | 4 - 13 | 7,82 – 8,82 |
| Years of work |  |  | 16,72 | 8,034 | 1 - 35 | 15,19 – 18,24 |
| Smoking habit* Non smoker
* Ex smoker
* Active smoker
 | 92215 | 84,41,813,8 |  |  |  |  |
| Alcohol consumption* No
* Yes
 | 1090 | 1000 |  |  |  |  |
| **Variables** | **Frequencies** | **Percentage** | **Mean** | **SD** | **Min – Max** | **95% CI** |
| Supplement consumption* Yes
* No
 | 3376 | 30,369,7 |  |  |  |  |

* 1. **Concentration of PM2,5**

Different from the previous studies, the present study did not show any increase in PM2.5 concentration along with the increase in the number of stoves in smoking houses. It showed contradictary results that small-scale houses with fewer stoves actually have higher PM2.5 concentrations. It can be caused by several factors such as the area of ​​the room, inadequate ventilation system, the direction of the wind, and the presence of the chimney. From the observations, small-scale houses had a narrower room area, limited air ventilation, and only one chimney. In contrast to large-scale smoking houses that had a wider area and more chimneys. In addition, air circulation on a large scale is more adequate because the space are more open, there are many air holes and smoke could directly flowed through the chimney so that the concentration of smoke in the room decreases.

However, this cannot be used to generalize the results of other studies at different location and times. The limitation of this study was that measurements of PM2.5 were only conducted once at each sampling point with one type of tool, Particle Counter. The measurements should be carried out using several different types of measuring instruments to ensure the validity and reliability of the results. Further studies need to be conducted to ascertain whether it is true that PM2.5 concentrations in small-scale homes are actually higher than large-scale houses. If so, then workers in small-scale homes have a higher risk of suffering from health problems so it needed to formulate a new fish smoking room design that can minimize PM2.5 concentration in indoor space.

**3.2 Age and Sex**

Children, parents and people with a history of pulmonary and cardiovascular disease are more vulnerable to suffer health problems due to exposure to PM2,5. While men are known to be more at risk of developing COPD disease than women in Indonesia. This might be supported by the habit of men who prefer smoking than women. The present study showed that the average age of workers in fish smoking industry was 47.06 years and the majority of workers are women. This age is still categorized as productive age to work so it is not considered as factor that contributes to the increase in health risks to workers. However, there are some workers over the age of 60 who should no longer do heavy and risky work. People in this age have a weaker immunity system and degeneration on organ function. Continuous exposure to high concentration of PM2,5 could decrease the health condition especially on their lung function.

* 1. **Body Mass Index (BMI)**

BMI is commonly used to classify overweight (overweight) and obesity in adults. The results of study showed that most of workers in fish smoking industry were categorized as overweight and obese. This condition could be caused by the sedentary habit in work and lack of physical activity. Workers especially women who have duty on smoking fish, spend most of their time sitting in front of the stove to keep the fish from burning. However, they don’t sit in an ergonomic way so many of them complained about muscle and joint pain. It was different from men workers who had duty on cutting and wahing fish. They did not spend most of time sitting, but also walking and moving the fish from cutting to smoking area. In addition, it was found that all workers have a low physical activity besides their work. Most of them did not do sports and always riding motorcycle from place to place. This condition might result in abnormal fat accumulation in the body which can interfere with health.

* 1. **Duration and Years of Work**

The duration of work per day and years of work spent in fish smoking industries affect the level of exposure to PM2,5. The longer the exposure, the higher the health risks caused. In average, workers spent 8.32 hours per day in smoking house for 7 full days. Most workers have worked for decades, with an average of 16.72 years. The duration of work in this industry is considered to exceed the normal working time limit of 8 hours. In addition, workers also do not have a day off. This continuous exposure to PM2.5 will surely eventually have an impact on respiratory health and even more serious diseases such as cancer. According to Anderson (1998), workers who have worked more than 5 years have the potential to experience greater lung function disorders compared to workers who have a working period of less than 5 years. Regulation on working hours is needed to reduce the intensity of exposure and so that workers have more adequate rest periods in a day.

* 1. **Smoking, Alcohol and Supplement Consumption**

Smoking and consuming alcohol can worsen lung health conditions and other vital organs. While consumption of supplements is believed to increase the body's ability to ward off free radicals produced from smoke from combustion. This study showed that most workers do not smoke and no one consumes alcohol. This is probably because most workers are women who tend not to have these kind of habits. However, more valid instrument to measure alcohol level in body is needed to ascertain the answer of subjects.

The workers who regularly consume supplements such as vitamin E and B are only 30.3%. With the condition of a heavy and risky workload, consumption of supplements is useful for maintaining the resilience of the worker's body. Supplements are a form of antioxidants that can prevent oxidative stress in the body. Research shows that taking vitamin supplements provides protection against the adverse effects of O3 on lung function and in adults who suffer from asthma. Most antioxidants come from food, associated with the potential role of antioxidants in reducing inflammation. Research shows that nutrients from supplements can reduce the effects of air pollutants or may interact with the immune response.

1. **Conclusion**

PM2.5 concentrations were found differeent on the scale of fish smoking house where small-scale houses had higher PM2.5 concentrations than large scale one. This can be influenced by the area of ​​the room, the ventilation system, the direction of the wind, and the number of chimneys. Other factors found to increase health risk due to exposure to PM2.5 in workers include overweight and obese in Body Mass Index, the long duration and years of work, and lack in supplement consumption. Further studies are needed to follow up on these findings. The next study could investigate the health effect of PM2,5 exposure by measuring some biomarkers from body to gain more valid and reliable result.

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