

TOXICITY OF PM 10 PARTICLES FROM COAL DUST AND FACTORS ASSOCIATED WITH THE INCIDENCE OF PULMONARY FUNCTION IMPAIRMENT AND IN COAL MINE WORKERS

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ABSTRAK

Debu batu bara bersifat fibrogenik, yaitu jenis debu yang sangat beracun dan telah terbukti menyebabkan beberapa gangguan kesehatan, terutama gangguan fungsi paru-paru. Pekerja tambang batubara merupakan kelompok yang paling berisiko mengalami gangguan kesehatan karena berada di lingkungan kerja dan terus menerus menghirup debu batubara. Terjadinya gangguan fungsi paru pada pekerja tambang batubara dapat dipengaruhi oleh beberapa faktor. Penelitian ini bertujuan untuk mengidentifikasi risiko paparan debu batubara terhadap gangguan fungsi paru pada pekerja tambang batubara. Penelitian ini dilakukan melalui metode systematic review dari berbagai artikel. Pencarian artikel dilakukan melalui situs jurnal Science Direct, JSTOR, SpringerLink, Scopus, PubMed, Google Scholar, Sinta, dan Garuda Portal. Kriteria inklusi adalah variabel dependen pada artikel penelitian adalah gangguan fungsi paru pada pekerja, variabel independen pada artikel penelitian adalah pajanan debu batu bara, full text open access dan artikel yang dipilih adalah artikel dengan tanggal publikasi tidak lebih dari sepuluh tahun terakhir. Terdapat 7 artikel yang direview. Hasil penelitian menunjukkan adanya hubungan yang signifikan antara kadar debu total, kebiasaan merokok, masa kerja, penggunaan APD dengan gangguan fungsi paru pada pekerja tambang batubara. Tidak ada hubungan antara umur pekerja, status gizi, kebiasaan olahraga, masa kerja, dengan gangguan fungsi paru pada pekerja tambang batubara. Pajanan debu batubara berhubungan secara signifikan dengan kejadian gangguan fungsi paru pada pekerja tambang batubara, terlihat dari hasil analisis statistik pada masing-masing penelitian yang menunjukkan bahwa nilai $p < 0,05$. Gangguan fungsi paru yang dialami adalah gangguan fungsi paru restriktif.

Kata kunci : faktor yang berpengaruh, gangguan fungsi paru, kapasitas paru, paparan debu batu bara

ABSTRACT

Coal dust is fibrogenic, a type of dust that is highly toxic and has been shown to cause several health problems, especially lung function disorders. Coal mine workers are the most at risk of health problems due to being in the work environment and continuously inhaling coal dust. The occurrence of lung function disorders in coal mine workers can be influenced by several factors. This systematic study aims to identify the risk of coal dust exposure to lung function disorders in coal mine workers. This research was conducted through a systematic review method of various articles. The search for articles was carried out through the journal sites Science Direct, JSTOR, SpringerLink, Scopus, PubMed, Google Scholar, Sinta, and Garuda Portal. Inclusion criteria are the dependent variable in the research article is lung function disorders in workers, the independent variable in the research article is coal dust exposure, open access full text and the selected articles are articles with publication dates not more than the last ten years. There were 7 articles reviewed. The results showed a significant relationship between total dust levels, smoking habits, work period, use of PPE with impaired lung function in coal mine workers. There is no relationship between workers' age, nutritional status, exercise habits, length of work, with impaired lung function in coal mine workers. Coal dust exposure is significantly associated with the incidence of lung function impairment in coal mine workers, seen from the results of statistical analysis in each study which shows that the p value < 0.05 . Pulmonary function impairment experienced is restrictive pulmonary function impairment.

Keywords : coal dust exposure, influential factors, lung capacity, lung function disorders

INTRODUCTION

Mining activities starting from processing materials to packaging and distributing processing results produce residue in the form of processed coal dust. Coal dust is a complex mixture of various minerals, trace metals and organic matter with different degrees of coal particulates (Hafsari, Ramadhian, and Saftarina 2015). Coal dust is included in substances that are toxic and proven to cause several health problems, especially lung disorders and respiratory disorders including: shortness of breath, dry cough and cough with phlegm, asthma, chest complaints, decreased lung vital capacity, obstructive and restrictive lung disease and Pneumoconiosis (Vitasasmiari 2013).

Coal is considered the cheapest fuel in the world. However, coal is also the dirtiest and most polluting fuel. Despite this, many countries continue to mine it and build power plants from burning coal. The benefits of this fuel in general are many but coal also causes all the misery it causes. Every step of processing this coal fuel from its mining to its final combustion has consequences. Losses include toxic pollution, loss of livelihoods, displacement of communities, health impacts on respiratory and nervous systems, acid rain, air pollution and reduced agricultural yields. But worst of all are the consequences of climate change that will affect all countries and peoples of the world, especially developing countries. (Maryuningsih 2015)

The accumulation of dust, in the lungs can result in a reduced ability of the lungs to inhale and expel air or blockage of the respiratory pathways, so that the volume of inhaled air in the lungs is reduced. This causes a decrease in lung capacity and function. According to the International Labor Organization (ILO), 21% of respiratory diseases are occupational diseases as well as the number 2 cause of death in workers. Meanwhile, WHO data states that lung function disorders have become the third most deadly disease in the last 10 years (Handari, Sugiharto, and Pawenang 2018).

Coal dust is coal material that forms powder, which comes from the destruction of coal during its processing (breaking, blending, transporting, and weathering). The specific gravity of coal ranges from 1.25 g/cm³ to 1.70 g/cm³. Based on color, coal can be divided into two types, namely bright coal and dull coal. Uj regarding coal analysis has been regulated in ASTM/ISO. As a result, 1 gram of coal that has 15% moisture content produces more heat energy than coal that has 17% moisture content. This is because a 2% increase in the moisture content of 1 gram of coal (the weight increases by 0.02 grams) does not produce heat (Setyaningrum, Khairiyati, and Sholihah 2018).

Dust with a small size has the potential to cause lung problems in mine workers. This is because dust that has a size of less than 1 micro can enter through the respiratory tract by inhalation into the alveoli, while dust with a size of less than 0.1 micro can move in and out of the alveoli freely, but does not stick to the surface of the alveoli. During inhalation, larger particles, >10 micro, are filtered out at the nose itself by very fine hairs in the nose (Setyaningrum et al. 2018).

One case of pollutants bringing health problems can be seen from the impact of air pollution on respiratory health in residents of coal mining areas in Odisha, India. Most of the people living in the coal mining areas of Odisha have problems with lung and chest health, coughing, bronchial asthma, bronchitis, TB and other diseases chest, cough, bronchial asthma, bronchitis, TB and other lung-related diseases (Trianisa, Purnomo, and Kasiwi 2020).

In Indonesia, the threshold value (NAB) of coal dust levels is regulated in the SNI 19-0232-2005 regulation on the NAB of chemical substances in workplace air, stating that the NAB for coal dust is 2 mg/m³. The threshold value (NAB) of dust content is a standard set for work environment factors that are permitted in the workplace, with the aim that workers can still accept it without causing health problems (National Standardization Agency 2005). Coal

dust exposure is related to several factors including airborne dust concentration, duration of exposure, and coal characteristics (Beer et al. 2017). The safety and health of coal miners can be started from a healthy workplace, this can be obtained by controlling potential hazards in the workplace or work environment, one of the potential hazards that are often found in coal miners is dust. (Winarti and Samsudin Surialaga 2022).

The occurrence of impaired lung function in coal mine workers can be influenced by several factors. The first is individual factors including gender, age, smoking habits, nutritional status, body weight, and exercise habits. The second is work environment factors including length of work, working time, inhaled dust levels and use of PPE. Therefore, the author is interested in conducting a Systematic Review study that summarizes the results of various sources and previous research results, in order to identify the risk of coal dust exposure to any factors that affect lung function disorders of coal mine workers, so that solutions and strategies are obtained to reduce and prevent lung function disorders and occupational diseases in coal mine workers. (Puspitasari 2018)

This systematic study aims to identify the risk of coal dust exposure to lung function disorders in coal mine workers.

METHOD

This research was conducted through a systematic review method of various articles. Based on 187 relevant articles, 7 main articles met the criteria and are discussed further in this article. The articles that have been obtained will then be collected, tabulated, compared, then summarized, and concluded. Articles were searched using several keywords, for Indonesian language journals including: "Coal dust exposure in mine workers" "impaired lung function in coal mine workers". Indonesian articles were obtained from accredited journal sites (Sinta and Garuda Portal). Meanwhile, international journals were obtained from the databases: Science Direct, JSTOR, , SpringerLink ,Scopus, PubMed.

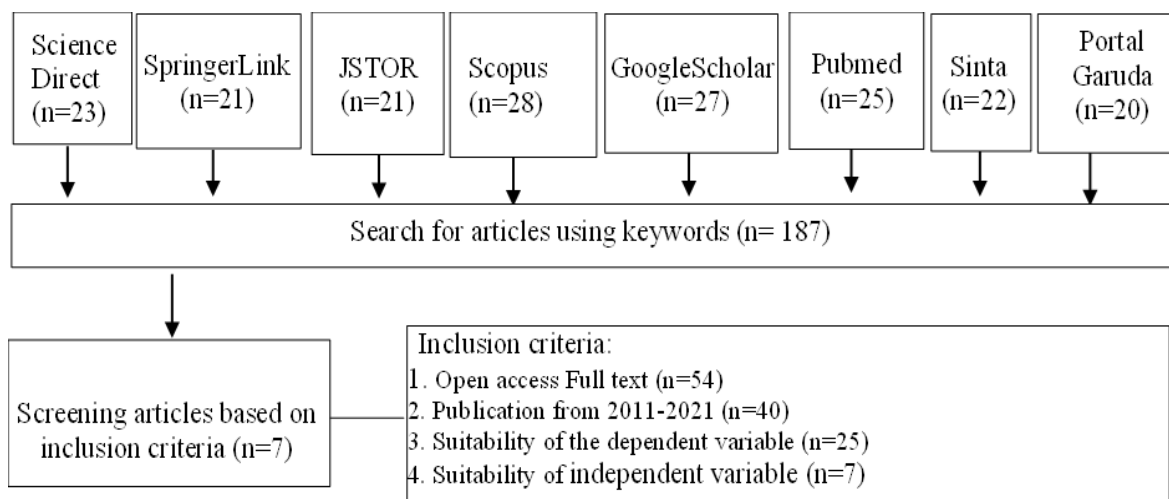


Table 1. Article Flow Selection

The next step is to conduct an analysis to assess the relevance of the literature found. The data/information obtained from the articles will be recapitulated and displayed in the form of a synthesis matrix table. The analysis is presented in the form of a narrative. The research design in 6 articles was cross sectional, and 1 article with a case control design. 7 articles were selected, the number of samples in the study varied, ranging from 40 to 3771 samples of coal mine workers. The type of research is analytic observational. The research locations were taken from several countries with Indonesia dominating. Four studies were located in Indonesia

spread respectively in the regions of Makassar, Jepara, East Kalimantan and South Kalimantan. While one study each was conducted in India, the United States and China. Based on the results of the review of the 7 selected articles, all articles state that coal dust exposure is significantly associated with the incidence of impaired lung function, seen from the results of statistical analysis in each study which shows that the p value <0.05 . Variables that are stated to have a significant relationship (significant) are coal dust exposure, dose of coal dust exposure, work shift, total dust content, smoking habits, work period, use of PPE.

RESULTS

Table 1. Result Synthesis Matrix
Result of Research on Pulmonary Function Impairment

1.	Total dust content	The results of existing studies indicate that total and respirable coal dust levels are associated with impaired lung function in coal mine workers.	Source s 2,3,5
2.	Age of Worker	The results of existing studies show that the age of workers has no effect / relationship with impaired lung function in coal mine workers.	Source s 2,5
3.	Nutrition Status	The results of existing studies show that nutritional status has no effect / relationship with impaired lung function in coal mine workers.	Source s 2,3
4.	Exercise habits	The results of existing studies show that exercise habits do not affect/relate to lung function disorders in coal mine workers.	Source s 2
5.	Smoking habit	The results of existing studies show that smoking is associated with impaired lung function in coal mine workers.	Source s 2,3
6.	Working period	The results of existing studies show that the working period has an effect / relationship with abnormal lung capacity in coal mine workers.	Source s 3
7.	PPE use	The results of existing studies show that the use of PPE is associated with impaired lung function in coal mine workers	Source s 3
8.	Length of work	The results of existing studies show that work duration does not affect/relate to lung function disorders in coal mine workers.	Source s 3,5

From the results of spirometry measurements that have been carried out, it is known that 74.86% have restrictive lung function disorders. There are no respondents who experience obstructive lung function disorders. Based on the results of the analysis of inhaled dust levels with impaired lung function carried out, the p-value for impaired lung function = (0.000, 0.034)

with a significance level of $\alpha = 0.05$. This means that there is a relationship between inhaled dust levels and impaired lung function in coal mine workers. The results of this study are in accordance with the theory that dust particles entering the alveoli will focus and gather at the beginning of the pulmonary lymph channels. This dust will be phagocytosed by macrophages. Dust that is toxic to macrophages such as free silica stimulates the formation of new macrophages. The new macrophages phagocytose the free silica, resulting in autolysis, a situation that occurs repeatedly. The continuous formation and destruction of macrophages is important in the formation of collagenous connective tissue and hyaline deposition in the connective tissue. This fibrosis occurs in the parenchyma. The lung is on the walls of the alveoli and interstitial tissue. As a result of lung fibrosis, it will become stiff and cause lung development disorders, namely restrictive lung function disorders (Rahayu Simanjuntak 2013), (Cahyana, Djakusli, and Rahim 2012), (Prasad et al. 2021).

DISCUSSIONS

Based on the results of the analysis of age with the value of lung function disorders carried out, the p-value for lung function disorders = 0.533 with a significance level of $\alpha = 0.05$. These results indicate that there is no relationship between age and lung function impairment. Age is an important variable in terms of the occurrence of lung function impairment. Air pollutants harm lung development and cause certain lung diseases and can even exacerbate previous respiratory diseases (Jayadipraja et al. 2016).

The results of this study are not in accordance with research conducted by Fakhur on coal mine workers in the system excavation section in South Sumatra that age does not show a statistically significant relationship to complaints and impaired lung function, although usually people aged 35 years will tend to experience a decrease in body power and are increasingly vulnerable to various risk factors associated with pulmonary and cardiovascular disease. (Simanjuntak, Suwondo, and Wahyuni 2013)

Based on the results of the analysis of nutritional status (BMI) with impaired lung function, the p-value for impaired lung function = (0.101, 0.595) with a significance level of $\alpha = 0.05$. These results indicate that there is no relationship between nutritional status (BMI) and impaired lung function. According to theory, it states that continuous food deficiency will cause the physiological makeup to be disrupted and can interfere with a person's lung vital capacity. Nutritional status can theoretically affect the respondent's resistance to the effects of dust, so that someone with good nutritional status is less likely to suffer from respiratory disease than someone who has a poor nutritional status. If a person's nutritional status is poor, his organs cannot develop and function properly, while in people who have more nutritional status (obesity), the work of the respiratory organs will be disrupted due to excessive fat accumulation which hinders the breathing process so that a person needs extra energy to respire. Good nutritional status will affect labor productivity which means increased company productivity and national productivity. (Rahayu Simanjuntak 2013), (Cahyana et al. 2012).

Another study conducted by Fujianti showed that there was no significant relationship between the nutritional status of workers and the onset of respiratory symptoms ($p = 1,000$). This is possible because most of the respondents have normal nutritional status compared to respondents with abnormal nutritional status, where conditions of poor nutritional status or malnutrition nutritional deficiencies can reduce the immune system and antibodies so that people are susceptible to infections such as coughs, colds, and diarrhea as well as the body's ability to detoxify foreign bodies detoxify foreign objects. (Fujianti, Hasyim, and Sunarsih 2015)

Based on the results of the analysis of smoking habits with impaired lung function, the p value for impaired lung function = (0.000, 0.021) with a significance level of $\alpha = 0.05$. These

results indicate a relationship between smoking habits with impaired lung function in coal mine workers. When smoking occurs a process of burning tobacco and nicotine tabacum by releasing solid particle pollutants and gases. Among them that endanger health both for smokers and people around them are tar (balangkin), nicotine, carbon monoxide (CO) or cigarette smoke, nitrogen cyanide, benzopirin, dimethyl nitrosamine, N-nitrosone nicotine, catechol, phenol and acrolein. Cigarette smoke stimulates mucus secretion while nicotine paralyzes the cilia, inhibiting airway clearance. The consequence is the accumulation of mucus secretions that cause coughing, a lot of phlegm and shortness of breath.(Rahayu Simanjuntak 2013),(Cahyana et al. 2012).

Research conducted by Gholami showed that smoking has a relationship with decreased lung function in workers Iron ore mine workers in Iran Workers who have a habit of smoking have a risk of developing complaints subjective complaints of respiratory tract or pulmonary disorders in workers. Smoking can cause changes in the structure, function of the airway and airway tissue. tissue. Mucosal cell enlargement (hypertrophy) and mucus glands increase in number (hyperplasia) which occurs in the large airways, in addition to inflammation to narrowing due to the addition of cells and accumulation of mucus in the small airways.(Gholami 2020)

There is no relationship between length of work and the incidence of lung function impairment and obtained a value of $p = 0.084$ ($p > 0.005$), thus H_0 is accepted and H_a is rejected. This means that there is no significant relationship between length of work and the incidence of lung function. Coal mine workers who work on average do not meet the requirements in accordance with Labor Law No.25 of 1997 Article 100 Paragraph 2 regarding working hour rules are workers who are <30 years old or young, while lung function disorders are chronic or accumulated effects that have only been experienced for a long period of time (Cahyana et al. 2012).

The results of this study are in line with research conducted by Fauziah in 2020, statistical analysis obtained a value of $p = 0.645$, thus indicating that there is no relationship between working period and subjective complaints of respiratory disorders in respondents. The condition of the work area that is dusty in concentration and a long enough period of time will jeopardize the effects felt due to dust. Harmful effects felt due to dust inhalation can be in the form of coughing, shortness of breath and sneezing that disturbs the respiratory tract. However, it is possible that inhaled dust takes time to cause respiratory problems, where each type of dust respiratory problems, where each type of dust has a different different timeframes then depending on concentration or level and size of dust as well as workers' susceptibility to pollutants.(Fauziah, Budiyo, and Raharjo 2020)

Exposure to hazardous chemicals can increase the risk of occupational accidents in coal mines. The need for adequate use of personal protective equipment (PPE) in working with hazardous chemicals in coal mines In the coal mining sector, companies need to pay attention to the toxic chemicals often found in the workplace and implement appropriate measures to create a healthy and safe working environment for workers. This includes the use of adequate PPE, controlling the risk of exposure to hazardous chemicals, and training and educating workers on chemical hazards and how to avoid the risk of workplace accidents.(Irfansyah and Susilawati 2023)

CONCLUSION

There is a significant relationship between total dust content, smoking habits, working period, use of PPE with impaired lung function in coal mine workers. There is no relationship between workers' age, nutritional status, exercise habits, length of work, with impaired lung function in coal mine workers.

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