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Risk Analysis of Work Accidents in Underground Mining

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ABSTRACT

Mining is the most dangerous occupational sector in the world. Based on statistical data from the Ministry of Energy and Mineral Resources, in 2019 there were mining accidents that resulted in the death of 24 people, 105 workers heavy, and 28 workers light. The cause of work accidents in the workforce is related to exposure to underground mining toxic gases. This study used the Literature Review (LR) methodology where the data source was obtained from "Scopus" with search keywords the year of publication was limited from 2019 - 2023. From a literature review, predeposition factors consisting of age, work experience, work location, and body parts affect work accidents in workers, risk assessment factors are the most important factors applied to prevent work accidents in the workplace and the role of the company in influencing work accidents. Based on the research questions, it can be concluded that the causes of work accidents include: lack of knowledge and motivation in using personal protective equipment and not carrying out work permit compliance procedures, not using personal protective equipment, and not having a work permit socialization. Factors such as worker age, and work experience are not positively correlated with work accidents while work location and body parts influence the causes of work accidents. Risk assessment factors can be carried out to minimize the occurrence of work accidents. In addition, it is known that many companies have prioritized safety issues as evidenced by the many studies conducted by companies to prevent work accidents in the workforce.

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INTRODUCTION

In recent years, along with the development of the national economy, the demand for coal has continued to increase. However, Indonesia's coal filtration and processing technology is still at a low level, the dust is very serious, seriously pollutes the environment, threatens public health, and hinders Indonesia's economic development. Hundreds of millions of workers exposed to dust around the world are exposed to the risk of pneumoconiosis in coal workers, and the situation is more serious in developing countries. Coal plays an important role in Indonesia's energy structure and plays an important role in Indonesia's economy and development. There are many coal mines and many employees in Indonesia, so the incidence of lung disease in Indonesia is very high. The induced airflow generated by coal transport is one of the main causes of dust at the point of transfer flowing after the carbon material falls, and the surrounding air will move with the carbon material. The dust in the center is precipitated by negative pressure and diffuses into the surrounding air.

The scientific evaluation method for new construction, expansion, reconstruction, and other construction projects is the research direction of industrial health care technical service personnel. The establishment of appropriate risk assessment models and comprehensive analysis of various aspects can improve on the past. Using exposure levels (including Mac, STEL, and TWA) over different periods, we were able to assess defects caused by workplace opinion more objectively, scientifically, and comprehensively. We can evaluate employment locally, and provide a scientific basis for workforce health management to meet current workforce health developments in Indonesia's needs.

In occupational health risk assessment studies of exposure to toxic substances, studies (Fan and Xu 2021) investigate the content of polycyclic aromatic hydrocarbons (PAHs) in the work environment of coal tar pitch industrial sites and evaluate workers' occupational health risks. His method took coal tar field companies as the object of research and conducted on-site occupational health investigations and examinations. He used high-performance liquid chromatography (HPLC) to detect 16 types of polycyclic aromatic hydrocarbons (PAHs) in samples. At the same time, he analyzed the dose of PAHs exposed to field workers and used the cumulative toxicity equivalent method, the life expectancy loss method, and the carcinogenic risk factor method to evaluate the workers' occupational health risks. The accuracy of the method is not high.

The production and hazards of the five types of toxic and hazardous gases in coal mines, and also explain the dangers of dust. The study also describes the content of risk management assessment, the formation of mathematical models, and comprehensive evaluation. In this study, four mining areas of the mining environment and the physical condition of employees as research objects, using dust sampling methods and establishing occupational hazard assessment criteria for risk assessment. Combined with experiments, risk impact analysis, trend analysis of dust concentration changes, dust concentration measurement results, and risk assessment analysis of various types of work were carried out. (Mondou et al. 2021)

Toxic materials and deep learning risk assessment models from coal mines Produce toxic and hazardous gases Carbon monoxide sources spray Coal mines, spontaneous combustion of coal, fire, gas explosion, coal dust explosion, etc. The source of hydrogen sulfide is in the coal seam. As coal falls, it releases gaseous hydrogen sulfide. Corrosive materials will release hydrogen sulfide gas. Sulfide will decompose hydrogen sulfide gas upon contact with water. Oxidation and burning of minerals will release hydrogen sulfide gas.

The source of nitrogen dioxide will be generated by underground blasting in coal mines. Source of sulfur dioxide: sulfur-containing coal is produced from oxidation, spontaneous combustion of coal, and is produced from the blasting of sulfur-containing coal seams. Sources of carbon dioxide Respiration workers, release, inherent coal, coal seam or rock oxidation, organic matter oxidation, underground blasting, fire combustion, carbonate and water decomposition, natural combustion of coal, gas explosion, coal dust explosion, plants. In addition, some coal seams continue to emit carbon dioxide gas or emit carbon dioxide gas that causes accidents. (Darda et al. 2023)

Dangers of toxic and dangerous gases There are many toxic and dangerous gases in the underground working environment of the coal industry, such as carbon monoxide, nitrogen dioxide, hydrogen sulfide, carbon dioxide, and gas. Carbon monoxide: its physical properties are colorless, odorless, odorless, lighter than air, insoluble in water, but easily soluble in ammonia, does not react with acids and alkalis, a small amount is absorbed by activated carbon, burns with blue flames, is highly toxic. on the way. Helium from oxygen-carrying cells in the human body combines with carbon monoxide very easily.

The binding capacity of carbon monoxide is 250-300 times that of oxygen. Therefore, the human body breathes carbon monoxide, and helium almost combined, it cannot transport oxygen. When the concentration of carbon monoxide in the air of asphyxia death is 0.08%, the human body in the environment will cause dizziness and vomiting after 40 minutes. When the concentration of carbon monoxide in the air is 0.32%, the human body will be dizzy and lightheaded after 5~to 10 minutes in the environment. Symptoms of vomiting and vomiting, if exposed to the environment for 30 minutes, can lead to coma or death. If the concentration of carbon monoxide in the air reaches 0.4%, people will lose consciousness and die in a short time.

People who die from poisoning are characterized by pink lips and face, and small red spots under the skin of the thighs and armpits. The concentration of carbon monoxide in coal mines should not exceed 0.0024%. Nitrogen dioxide: its physical properties are red-brown gas, with a strong pungent odor, its relative density is 1.59, soluble in water, heavier than air, and located under the road. Nitrogen dioxide dissolves in water and reacts to form nitric acid. Nitric acid is highly corrosive and toxic. It can cause strong excitability and corrosive damage to the eyes, respiratory tract, and lungs, and cause pulmonary edema, pulmonary heart disease, and other diseases. The process of No poisoning will be delayed and will strike after 4-6 hours. Symptoms of poisoning in the form of yellow spots on the fingers that must be considered.

The pure gas nitrogen dioxide is reddish-brown. It looks white when blown by the wind, and it smells pungent. When the concentration of nitrogen dioxide in the air is 0.01%, it will cause serious poisoning. When the concentration of nitrogen dioxide in the air is 0.025%, it will die in a short time. The concentration of nitrogen dioxide in underground coal mines should not exceed 0.00025%. Sulfur dioxide: colorless physical

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properties, strong sulfur, and sour taste, relative density 2.22, soluble in water, heavier than air, located under the road. When sulfur dioxide is dissolved in water, it will produce a sulfuric acid reaction, which can cause severe irritation to the human eye and respiratory tract. (Carlson et al. 2023)

When the concentration of sulfur dioxide in the air is 0.002%, it will cause irritation and pain in the eyes and respiratory tract; When the concentration of nitrogen dioxide in the air is 0.05%, it will cause pulmonary edema and bronchitis, and serious cases will die. The concentration of sulfur dioxide in coal mines should not exceed 0.0005%. Hydrogen sulfide: physical characteristics colorless, slightly sweet, rotten egg taste, relative density 1.19, flammable, water solubility, heavier than air, under the road. When the concentration of the olfactory range exceeds 0.0001%, especially in the case of high concentration, olfactory paralysis has no taste.

Hydrogen sulfide is highly toxic. After inhaling hydrogen sulfide, it enters the blood from the lungs. Part of it is oxidized by sulfide salts, and the non-oxidized part is harmful to the human body. There is moisture on the surface of the human mucous membrane. Hydrogen sulfide readily dissolves to form sodium sulfide, which can irritate and damage mucous membranes and cause eye inflammation, respiratory tract inflammation, and pulmonary edema. Hydrogen sulfide also reacts in the human body, so Spirulina does not undergo bio oxidation and can cause hypoxia. (Colbourne et al. 2022)

If the concentration of hydrogen sulfide in the air reaches 45.5%, it will be the cause of the explosion. If the concentration of hydrogen sulfide in the air is 0.005–0.01%, it will irritate the eyes and respiratory tract after 1.2 hours; If the concentration of hydrogen sulfide in the air is 0.01%, it will die in a short time. The concentration of hydrogen sulfide in coal mines should not exceed 0.00066%. Carbon dioxide: its physical properties are colorless, slightly acidic, with a relative density of 1.52, flammable, and easily soluble in water, on the lower slopes of roads and tunnels. If the concentration of carbon dioxide in the lungs increases, the concentration of acid in the blood increases, stimulating the respiratory center. (Colbourne et al. 2022)

When the concentration of carbon dioxide in the air is 1%, the respiratory rate of humans will increase. When the concentration of carbon dioxide in the air is 5%–8%, it is more than twice the respiratory rate of humans. If the concentration of carbon dioxide in the air exceeds 10%, it can lead to coma or death. Symptoms are purple-red on the face and mouth, and purple patches on the thighs and armpits. Limit the concentration of carbon dioxide in underground coal mines: the concentration of carbon dioxide flowing in the air at the mine front entrance is less than 0.5%, the concentration of backflow in the mine face is less than 1.5%, and the full concentration of the return gas tunnel is less than 0.75%. (Colbourne et al. 2022)

Dust generation and dust formation The dust produced in mining techniques are collectively referred to as coal mine dust. In the process of crushing, loading coal, transporting coal, and lifting spraying concrete, the powder flying when blasting the coal seam is the cause. Different coal mines have different geological environments, mining technologies, coal quality, and coal dust quality. After studying the dust protection measures, the surface of the coal mine produces the largest amount of dust, accounting for 45% to 80% of the total dust, and the tunnel surface accounts for 20%–38% of the total dust. (Vearrier et al. 2012)

In general, the degree of mechanization of coal mine work is directly proportional to the amount of dust produced. Most coal mining methods in Indonesia. is an underground mine. As a result, the amount of dust generated in the workplace will also increase due to the limited level of ventilation by the road stone walls. Pneumoconiosis caused by workers exposed to dust is the most important risk to the human body caused by dust. (Vearrier et al. 2012)

Human lungs are mainly inhaled by breathing dust while working, which causes tissue fibrosis. One of the causes of high lung death is that although it can be prevented, it cannot be cured. If the lungs cannot be cured, then the lung cleansing method can relieve some of the patient's pain and symptoms, but cannot cure the lungs. The lung symptoms of fiber patients are mainly manifested in chest compressions, chest pain, cough, asthma, and even weakness of the whole body, which will eventually cause pain. As a result, you can not lie down, you can only die on your knees, accompanied by extreme pain. (Hu et al. 2019)

Another major danger of dust is the explosion of coal dust. Coal dust explosions and gas explosions are major disasters in the coal mine production process. After the explosion of coal dust, it will not only produce a maximum explosion inflammation of 2000 degrees Celsius, but also produce a large amount of poisonous and harmful gas, and even continuous explosions will occur in serious cases. Compared with gas explosions, coal dust explosions are more dangerous. (Torres, Ruivo, and Machado 2021)

Risk management assessment According to the definition of risk management, there are three aspects. One of them is to determine risk first in risk management. The so-called risk determination refers to determining the types of risks that can affect the safety of the enterprise. The most important thing is to measure the level of uncertainty and loss caused by each risk. Second, risk management should focus on risk management and implement positive countermeasures to manage risk. Risk management objectives should be realized by reducing the likelihood and scope of losses caused by risk. The most effective way to manage risk is to create an actual contingency plan to deal with maximum risk. In the event of a risk, losses should be controlled to a minimum according to a predetermined plan. The third is risk management to avoid risks. Provided that the established safety production objectives have not been changed, the implementation line of the safety production plan should be changed to fundamentally eliminate risk management of certain risk factors. (Colbourne et al. 2022)

RESEARCH METHODOLOGY

This study used the Literature Review method. With the help of LR methods, it is possible to conduct a systematic review and identification of journals, with each step of the process involving the application of a specific predefined set of rules. In addition, LR methods can distinguish between subjective and objective, with the hope that the latter results will be used to expand the literature on the use of LR methods in international journals. The questions used in this study are made by the needs of the chosen topic.

Research questions that will be used include what are the factors that cause work accidents in labor, how the influence of age and experience, work, location, body parts with work accidents on labor, work systems (gas warning systems, ventilation systems, risk assessments, training, procedures, and supervision) affect work accidents exposed to toxic gases and the company's role in the occurrence of work accidents.

The results of searching for documents related to the research topic to be carried out through https://scholar.google.com/ with the search keywords 'work system, predisposition factor, management role, underground mines, toxic gas' publication year are limited from 2019 – 2023 so that a total of 10 journals are obtained. Literature study is a data collection technique in this study. The data analysis technique used in this study is qualitative descriptive. This technique is used because it can support the achievement of research objectives, namely providing an up-to-date understanding of the effect of job rotation in increasing employee productivity. This research includes a description of research questions, search strategies, inclusion criteria, data extraction, and evaluation criteria using systematic literature review methods.

RESULTS AND DISCUSSION

Health risks of occupational exposure to toxic chemicals in coal mine workplaces based on search results Exposure to hazardous chemicals, such as coal dust containing hazardous chemicals, can cause health problems for workers in coal mines Hazardous field conditions and unsafe work actions can lead to the creation of unsafe working conditions and increase the risk of work accidents. Exposure to hazardous chemicals can cause poisoning, irritation, and allergies in workers in coal mines. Inadequate use of personal protective equipment (PPE) can increase the risk of exposure to hazardous chemicals in coal mine workers. Chemical hazards include exposure to chemicals present in the workplace that can cause health problems such as heavy metals. (Crossroads et al. 2022)

In the field of coal mining, the health risks of occupational exposure to toxic chemicals are important because they are related to the occupational safety and health of workers, as well as the productivity and efficiency of the company's work. Companies need to pay attention to the health risks of occupational exposure to toxic chemicals and implement appropriate measures to create a healthy and safe work environment for workers.

Health risk assessment and occupational exposure analysis to toxic chemicals in coal mines. Analysis of the health risk impact of occupational exposure from different types of work According to the different types of dust exposure, coal miners are divided into coal mine group, tunnel group, and auxiliary group. To analyze the effect of this type of work on lung function, we must first study the influence of age, length of service, and other factors related to lung function. Therefore, based on different types of work, it is necessary to analyze whether there are differences in age, length of service, and smoking experience. Since age and length of service are continuous quantitative data, the analysis was performed using dispersion analysis, and the conclusion is that the age difference between types of work is not significant.

The difference in duration between types of work is not statistically significant. Since smoking experience is a hierarchical variable data, the chi-square test was used in the analysis, and it was found that there was no significant difference in smoking experience between different types of occupations ($P>0.05$). FVC forced breathing capacity, number of forced breaths/sec (FEV1). Analysis of different types of miners on lung function shows that different types of miners have different levels of lung function damage.

The most serious pulmonary dysfunction was found in the group of coal mine workers, followed by the auxiliary group. Through dispersion analysis, the FCC difference between different types of work was not statistically significant ($P>0.05$), but the difference between FEV1 and FEV1/FVC was statistically significant ($P<0.05$) time-weighted mean concentration (CTWA) and short-term exposure concentration/allowable time-weighted average concentration of the inhalable dust concentration in the coal mining group's workplace was higher than the mover group and auxiliary group (for materials chemical hazardous factors without PC-STEL, provided that they meet the weighted average concentration of 8 hours), the concentration of exposure in a short time (15 minutes) should not be exceeded.

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In addition, the CTWA belt driver in the coal mining group exceeded the time-weighted average concentration allowed (PC-TWA = 2.5 mg/m3), while the other group was lower than the weighted mean time allowable concentration (PC-TWA = 2.5 mg/m3) and multiples of CSTEL/PC-TWA (2.5 mg/m3), and the dust distribution of the coal mining group was greater than that of the other groups. Therefore, it may be due to the higher dust concentration, longer exposure time, and greater dust dispersion in the coal mining group than in other types of work, resulting in more serious lung function injuries than in other types of work.

Coal preparation and surface production restriction transportation system, except for the manually selected dust detection results exceeding field investigations, it was found that the inlet of the vibrating screen was sealed, less than 50 mm fell on the lower scraper conveyor belt through firing, and the manual filtering belt and the overlapping part was half sealed. Because the size of the vibe can be easily separated from the semi-closed overlapping interface, the t on the raw coal classification screen exceeds the limit.

The excavator works for the coal block disposal port on display. It is a gray coa 50 mm or more unit meeting standard health requirements. According to the results nd outlet is divided into two. Coal more than 50 mm of charcoal enters breast milk, coal powder with small particles calculated the amount of old coal dust on the manually selected belt l screen. Working hours of each shift m production transfer tunnel work area of underground mining units, in addition to belt drivers in the first area of the tunnel, tunnel lining with bolt fastening, and excavator work exposed to coal dust and cement dust, the staff of the three tunnel secret tunnels are exposed to coal dust concentration (H), and the rest of the screwdriver loading head, loading head and belt

The concentration of coal mashed from the screwdriver exceeds the standard value. Due to the different maintenance work of each shift, the coal dust concentration of the maintenance level will change greatly. This test stage is focused on coal dust concentrations that exceed the standard, except for the dust concentration of all kinds of work in the maintenance category t According to field investigations, during the tunneling process of the tunnel, side, to clean the water curtain along the tunnel airflow, and to spray can wet the chisel. Coal dust is released in the process of spreading coal. The head rod of the production team, the weighted average concentration of time c to various degrees.

Toxic chemicals that are often found in coal mine workplaces include coal dust containing hazardous chemicals, which can cause health problems for workers in coal mines. Other hazardous chemicals that can be found in coal mine workplaces, such as heavy metals. Workers in coal mines can be exposed to hazardous chemicals, such as coal dust, which can cause poisoning, irritation, and allergies. Exposure to hazardous chemicals can increase the risk of workplace accidents in coal mines. The need for the use of adequate personal protective equipment (PPE) in working with hazardous chemicals in coal mines

In the field of coal mining, companies need to pay attention to toxic chemicals that are often found in the workplace and implement appropriate measures to create a healthy and safe work environment for workers. This includes the use of adequate PPE, risk control of exposure to hazardous chemicals, as well as training and education for workers on chemical hazards and how to avoid the risk of work accidents.

How to handle exposure to toxic chemicals in a coal mine workplace based on search results Use appropriate personal protective equipment (PPE), such as masks, protective goggles, and gloves, to reduce the risk of exposure to hazardous chemicals. Conduct hazard identification and risk assessment as a preventive measure in the workplace, including chemical hazards that can cause health problems such as heavy metals. Read and understand the instructions for use and warnings on chemical labels before using them, and pay attention to how to apply chemicals. Reduce the risk of exposure to hazardous chemicals by applying safe chemicals and paying attention to proper handling of chemical waste. Supervise and control chemicals used in the work environment, such as the use of safe chemicals and proper handling of chemical waste. (Gonz 2022)

In the field of coal mining, companies need to pay attention to how to deal with exposure to toxic chemicals in the workplace and implement appropriate measures to create a healthy and safe work environment for workers. This includes the use of adequate PPE, risk control of exposure to hazardous chemicals, as well as training and education for workers on chemical hazards and how to avoid the risk of work accidents.

CONCLUSION

Based on research questions, it can be concluded that the causes of work accidents include: a lack of knowledge and motivation in the use of personal protective equipment and not carrying out procedures, not using personal protective equipment, and the absence of socialization of work permits. Factors such as the age of workers, and work experience are not positively correlated with work accidents while work location and body parts affect the cause of work accidents. Risk assessment factors are factors that can be done to minimize the occurrence of work accidents. In addition, it is known that many companies have prioritized K3 problems as evidenced by the many studies conducted by companies to prevent work accidents in the workforce

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