ATLANTIS PRESS
Advances in Health Sciences Research, volume 25
2nd Sriwijaya International Conference of Public Health (SICPH 2019)

Concentration of Total Suspended Particulate on X Coal Mining in Kutai Kartanegara District

Hansen
Environmental Health Program
Universitas Muhammadiyah Kalimantan Timur
Samarinda, Indonesia
han440@umkt.ac.id

Ratna Yuliawati
Environmental Health Program
Universitas Muhammadiyah Kalimantan Timur
Samarinda, Indonesia
ry190@umkt.ac.id

Deddy Alif Utama
Environmental Health Program
Universitas Muhammadiyah Kalimantan Timur
Samarinda, Indonesia
dau475@umkt.ac.id

***Abstract*—The quality of inhaled air is determined by the amount of pollutant gases and by particulates in the air. Particulate especially total suspended particulate (TSP) contains heavy metal elements that can have serious health effects. Among all the processes that produce particulates, the coal mining process is one of the most dangerous because it produces dust which is included in the type of fibrogenic and very toxic. The purpose of this study was to determine the concentration of total suspended particulate (TSP) at the X coal mining in Kutai Kartanegara. This research was quantitative descriptive type. The population were the ambient air around the "X coal mining area". The samples were the ambient air measured at six sampling point namely "Jetty", "WD 7", "Pit West", "Stockpile", "Desa Bakaran", and "RT 09". The results revealed the sampling point "WEST PIT" had the highest concentration of TSP that was 414 µg/m^3 for measurements in January whereas for measurements in June was 325 µg/m^3. In January measurement, the TSP concentration was around 78.26%, whereas in June the TSP concentration was around 72.30% compared to the TSP threshold limit value based on government regulations which was 90 µg/m^3 for 1-hour measurement. Monitoring of ambient air quality around the mine site especially in coal mining still needs to be done but must be supported by additional efforts such as routine health checks for workers at the mine site thus it can anticipate the onset of occupational diseases and other health complaints due to particulate exposure.**

Keywords: coal, mining, total suspended particulate

I. Introduction

The quality of air inhaled by humans is determined by the amount of pollutant gases and the presence of particulates in the air[1]. At present, air quality in every country including developing countries deteriorates due to population growth, increasing number of vehicles and industries[2]. These problems as results of development progress and usually followed by an increase in demand for energy[3]. Differences in energy sources result in differences in the type and level of pollution. Currently the cheapest energy source is produced from coal. Coal is a type of mining product which provides 29.6% of the world's energy resources. However, the presence of mines whose production processes are mostly carried out on the surface is considered to be one of the main causes of increased pollution because it produces large amounts of pollutant materials such as dust, carbon monoxide, and other substances that are hazardous and pose a threat to the environment[4, 5]. The coal mining process will produce coal dust which is included in the type of fibrogenic, this is very poisonous and able to damage the lungs, one of which is pneumoconiosis. Some activities responsible for this increase are drilling, blasting, smoke removal from engine activities and coal combustion processes[6]. Although technological advances have been able to reduce the total burden of air pollution associated with anthropogenic activities including mining, much more needs to be done to overcome these increasing health risks[7].

Among all pollutants scattered in the air, particulate matter is one material that is closely related to environmental factors and health aspects from various points of view. One of these aspects is that particulates contain many hazardous substances which can be inhaled by humans and enter the respiratory system resulting in serious health effects including cardiovascular disease[8-10]. Particulates which have a diameter of 0.1 to 100 μm or called total suspended particulate (TSP) contain a number of dangerous heavy metals that are carried through the air, some of these metals are strong triggers of carcinogenesis, teratogenesis, and mutagenesis in a number of living things including humans[11-13]. It is also evident that high concentrations of these particulates cause high early mortality[14].

A number of studies have reported that prolonged exposure to high concentrations of suspended particulate can cause an increase in hospital visits, high incidence of respiratory diseases, cancer, and deaths from cardiovascular disease[15]. Some other effects due to particulates include a decrease in visibility, this is because the particulate absorbs and breaks down the light entering the atmosphere[16]. In China, the condition of visibility has become an important issue for the public and the scientific community. In China, the condition of visibility has become an important issue for the public and the scientific community. This can be seen from the increase in Shanghai mortality due to accidents caused by decreased visibility[17]. Other studies have revealed that heavy metal accumulation contained in inhaled particulates can cause cancer, nerve damage, and decreased immunity[18].

In Indonesia, especially in East Kalimantan, based on data from the East Kalimantan Environmental Protection Agency, several parameters such as SO_2, NO_2, CO, O_3, TSP, and Pb still meet quality standards in accordance with regulation. However, based on the results monitoring activities for some time in two cities (Samarinda and Balikpapan) carried out by the Indonesian Ministry of Environment, showed that specifically for the TSP parameters tended to increase almost three times compared to the TSP parameters in the City of Balikpapan[19]. In addition, based on data in 2017 in Samarinda City, the highest number of mining business permits is in Kutai Kartanegara Regency, which is 625 mining business licenses out of a total of 1404. The details are as follows: 366 mining business licenses terminated, 7 evaluated, 89 in process, 159 permission received, 1 permission revoked[20].

II. MATERIAL AND METHODS

A. *Studi area overview*

This research was conducted at Mine X in the Sanga-Sanga sub-district area of Kutai Kartanegara. The determination of research location is based on the high potential of air pollution because Mine X manages coal as the main source of income. Measurements were carried out twice, in January and June 2019 in six locations namely "Jetty", "WD 7", "Pit West", "Stockpile", "Desa Bakaran", and "RT 09".

B. *Sampling and analysis methods*

This research is an analytic observational type with cross sectional approach. The population in this study is ambient air around the mine site. While the sample is ambient air measured at six sampling points. The time span for conducting the research is January - June 2019.

Data collection was carried out through measurement of the concentration of TSP at the study site. This field sampling is a type of active sampling conducted in accordance with the sampling stages listed in the Indonesian National Standard number 7119-3:2017 concerning the Total Suspended Particulate (TSP) test for ambient air with gravimetric methods, using filter media with High Volume Air Sampler (HVAS).

In principle, HVAS will suck ambient air using an HVAS filter (paper filter) with the help of a high flow rate vacuum pump. Then, the number of particles collected was analyzed using the gravimetric method. The filter paper in the HVAS device used in this study was a micro fiberglass filter with porosity <0.3 μm with particulate collection efficiency of 95% with a diameter of 0.3 μm. The duration of sampling was included in the short-term sampling because it is measured for 1-hour.

Measurements were carried out twice, in January and June 2019 at all 6 sampling locations. For more accurate results, each location was determined by 5 sampling points. 4 points based on the cardinal direction and 1 point in the middle of the location. Measurements were made once, during peak hour production thus the total sampling points were 60 points. The collected TSP concentration data from each sampling point then compared with the air quality standard according to government regulations number 41 of 1999 with TSP threshold limit value was 90 µg/m^3 for 1-hour measurement.

III. Results and Discussion

A. Results

Total suspended particulate concentrations obtained from the measurement of ambient air samples for 1 hour at the study site. Based on the data in picture 1, among all measurement points, both at the first stage (January) and the second stage (June), the "PIT WEST" sampling point has the highest TSP concentration level of 414 µg/m^3 for measurements in January and 325 µg/m^3 for measurements in June. The lowest TSP concentrations among all measurement points were found at the "JETTY" sampling site with a concentration level of 9.52 µg/m^3 at the first stage measurement (January) and 7.42 µg/m^3 at the second stage of measurement (June).

The average value of TSP concentrations for all sampling point in the first stage (January) was 95.98 µg/m^3, while in the second stage measurement (June) that is 83.22 µg/m^3. When compared with the first stage measurement, there was a decrease of 13.29% in the second stage measurement.

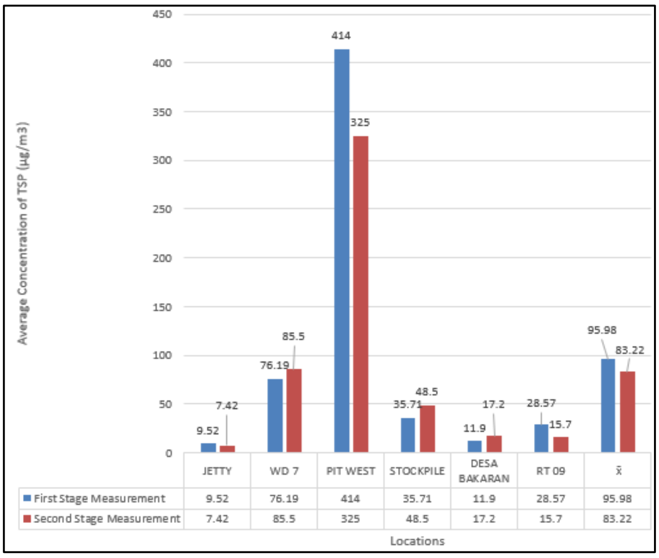

Fig. 1. Average Concentration of Total Suspended Particulate in All Sampling Points

B. Discussion

1. Factors affecting the concentration of Total Suspended Particulate (TSP)

Our results showed that the average TSP pollutant concentration for each sampling point in the first stage measurement is higher than the measurement in the second stage. This means that there has been a decrease in the concentration of TSP at the location of the study area. For each point, the decrease in the concentration of TSP pollutants ranged from 21.5% - 45.04%. However, specifically for the "Pit West" sampling point, the concentration of TSP in both the first and the second stages of measurement has exceeded the threshold limit value. In the first stage measurement, the TSP concentration was higher around 78.26% while in the second stage was higher around 72.30% when compared to the TSP threshold limit value based on the national ambient air quality standard of 90 µg/m^3 for 1-hour measurement. Even in several locations such as "WD 7", "Stockpile", and "Desa Bakaran", the concentration of TSP pollutants in the second stage of measurement increased when compared to the first stage measurement. Although, if compared with the air quality standard, the TSP concentration at those locations were still within safe limits. The increase in TSP concentrations ranged from 10.88% - 30.81%. This can occur due to several factors such as size, shape, density and meteorological conditions. From all of these factors, direction and speed of wind along with meteorological conditions are considered to be the main cause of the spread of particulates from one place to another [21].

The lack of environmental monitoring efforts carried out by mining companies is also one form of threat to the mining environment associated with open coal mining activities, such as processing and transporting coal from the mining location [22]. Each of these activities, enter into certain types of processing. Different types of processing will produce different types of particulates. The top layer removal is the first stage in the formation of particulates in surface mines. At this stage, the material on the surface of the stone/soil layers is removed, resulting in 7% of the total particulates in the mining process. The second stage is drilling, because it lasts for a long time, at this stage the largest number of particulates is produced compared to other stages[23]. The third stage is the blasting, at this stage the mining area is blown up so that the rock fragments are easily removed by the excavator.

Indonesian Ministry of Research and Technology

Although it lasted a short time, the number of particulates produced was quite large. These two stages produce 73% of the total particulate matter in the mining process. The fourth stage is extraction, the stage of removing coal from the soil layer that has been dug before. This stage produces 3% of the total particulates in the mining process. The last stage is the transportation and transfer of material, at this stage the particulates are produced from the process of moving lumps of land to the coal processing equipment and the interaction between the transport vehicles and the road resulting in 17% of all particulates in the mining process[24, 25].

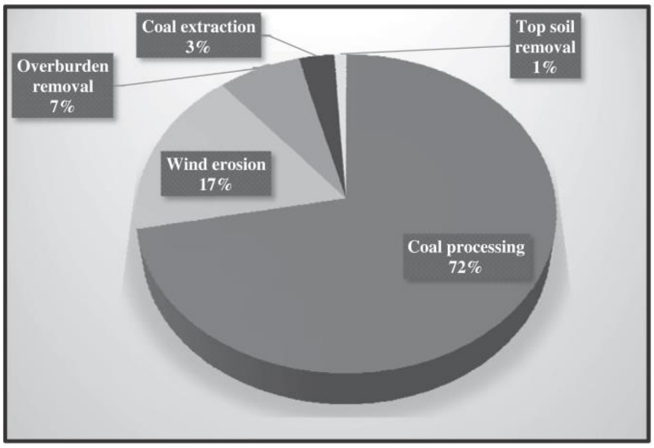

Fig. 2. The mining operations and their corresponding contributions to the formation of PM

2. Environmental health aspects of Total Suspended Particulate (TSP) exposure

Several studies related to the effect of Total Suspended Particulate on the environment and health have been carried out in various parts of the world. The effects of dust exposure on agriculture and the ecological aspects of an area are determined by the concentration of dust particles in ambient air, the amount of pollutant distribution, deposition rate, and the presence of chemical particles. These factors can influence the chemical elements of the soil and penetration into the body of the plant, causing metabolic disorders[26]. While the health effects of dust exposure on mining workers from surface mining activities generally include nasal congestion, sneezing, coughing, asthma, silicosis, asbestosis, inflammation of the respiratory tissue, bauxite fibrosis and siderosis[27, 28].

In addition, dust with a metal composition will be very dangerous to health because it produces a type of reactive oxygen on the surface of the lungs that can injure the lungs. Particulates specifically derived from coal mines also have an impact on the respiratory system and can cause respiratory diseases for example pneumoconiosis[29]. Pneumoconiosis is a disease that often occurs in coal mine workers caused by inhaling dust, causing sedimentation in the lungs[30, 31]. The body's inability to remove the accumulation causes inflammation, fibrosis, and in the worst cases becomes necrosis[32]. Some types of coal such as peat, lignite, bituminous, and anthracite also have different rates of pneumoconiosis for mine workers[33-35]. Other studies have shown variations in the impact caused by particulate matter exposure resulting from coal mining on human health in terms of gender, age group and distance of mining locations[36].

Children and women have a higher level of vulnerability when compared to men due to differences in biological and physiological characteristics of the body. In addition, the miners working time also shows an increased level of vulnerability to exposure to dust and other hazardous materials [37, 38]. In addition to health impacts, the potential for early death is very likely to occur if a worker inhales too many particulates from coal mining. Research in China reveals that burning from coal that produces PAHs is a major source of increased early death in the country[39]. Other studies have revealed that in addition to causing eye irritation, TSP also has the potential to cause death in humans[28].

IV. CONCLUSION

Among all measurement points, both at the first stage (January) and the second stage (June), the "PIT WEST" sampling point has the highest TSP concentration level of 414 $\mu g/m^3$ for measurements in January and 325 $\mu g/m^3$ for measurements in June. This means, the concentration of TSP in both the first and the second stages of measurement has exceeded the threshold limit value. In the first stage measurement, the TSP concentration was higher around 78.26% while in the second stage was higher around 72.30% when compared to the TSP threshold limit value based on the national ambient air quality standard of 90 μg/m^3 for 1-hour measurement.

ACKNOWLEDGMENT

This study was supported by Indonesian Ministry of Research and Technology and Universitas Muhammadiyah Kalimantan Timur. Authors thank to Environmental Health Department in Universitas Muhammadiyah Kalimantan Timur for providing valuable assistance during the study.

REFERENCES

[1] M. A. Awan, S. H. Ahmed, M. R. Aslam, and I. A. Qazi, "Determination of total suspended particulate matter and heavy metals in ambient air of four cities of Pakistan," *Iranica Journal of Energy,* vol. 2, no. 2, pp. 128-132, 2011.

[2] A. S. Mobarakeh, B. F. Nabavi, M. Nikaeen, M. M. Amin, A. Hassanzadeh, and K. Nadafi, "Assessment of suspended particulate matters and their heavy metal content in the ambient air of Mobarakeh city, Isfahan, Iran," *International Journal of Environmental Health Engineering,* vol. 3, no. 1, p. 36, 2014.

[3] K. Kaygusuz, "Energy for sustainable development: A case of developing countries," *Renewable sustainable energy reviews,* vol. 16, no. 2, pp. 1116-1126, 2012.

[4] N. Lilic, A. Cvjetic, D. Knezevic, V. Milisavljevic, and U. Pantelic, "Dust and noise environmental impact assessment and control in Serbian mining practice," *Minerals,* vol. 8, no. 2, p. 34, 2018.

[5] B. Pandey, M. Agrawal, and S. Singh, "Assessment of air pollution around coal mining area: emphasizing on spatial distributions, seasonal variations and heavy metals, using cluster and principal component analysis," *Atmospheric pollution research,* vol. 5, no. 1, pp. 79-86, 2014.

[6] A. Tripathi and M. Gautam, "Biochemical parameters of plants as indicators of air pollution," *Journal of Environmental Biology,* vol. 28, no. 1, p. 127, 2007.

[7] N. A. Alnawaiseh, J. H. Hashim, and Z. Md Isa, "Relationship between vehicle count and particulate air pollution in Amman, Jordan," *Asia Pacific Journal of Public Health,* vol. 27, no. 2, pp. NP1742-NP1751, 2015.

[8] J. G. Wallenborn, M. J. Schladweiler, J. H. Richards, and U. P. Kodavanti, "Differential pulmonary and cardiac effects of pulmonary exposure to a panel of particulate matter-associated metals," *Toxicology applied pharmacology,* vol. 241, no. 1, pp. 71-80, 2009.

[9] Z. BLAŽEK, L. ČERNIKOVSKÝ, B. KREJČÍ, and V. VOLNÁ, *The atmospheric particle contamination in region of Ostrava and Karviná* (Prague: Czech Hydrometeorological Institute). 2008.

[10] K. Donaldson and P. Borm, *Particle toxicology*. CRC Press, 2006.

[11] R. Hetland, O. Myhre, M. Låg, D. Hongve, P. Schwarze, and M. Refsnes, "Importance of soluble metals and reactive oxygen species for cytokine release induced by mineral particles," *Toxicology,* vol. 165, no. 2-3, pp. 133-144, 2001.

[12] K. Donaldson *et al.*, "The pulmonary toxicology of ultrafine particles," *Journal of aerosol medicine,* vol. 15, no. 2, pp. 213-220, 2002.

[13] A. T. Sastrawijaya, *Pencemaran lingkungan*. Rineka Cipta, 2009.

[14] K. Karar, A. K. Gupta, A. Kumar, and A. K. Biswas, "Seasonal variations of PM 10 and TSP in residential and industrial sites in an urban area of Kolkata, India," *Environmental monitoring and assessment,* vol. 118, no. 1-3, pp. 369-381, 2006.

[15] B. K. Lee and G. H. Park, "Characteristics of heavy metals in airborne particulate matter on misty and clear days," *Journal Hazard Mater,* vol. 184, no. 1-3, pp. 406-16, Dec 15 2010.

[16] V. Ramanathan and P. J. Crutzen, "New Directions: Atmospheric Brown"Clouds"," *Atmospheric Environment,* vol. 28, no. 37, pp. 4033-4035, 2003.

[17] G. WenZhen, C. RenJie, S. WeiMin, and K. HaiDong, "Daily visibility and hospital

admission in Shanghai, China," *Biomedical Environmental Sciences*, vol. 24, no. 2, pp. 117-121, 2011.

[18] T. Fortoul *et al.*, "Health effects of metals in particulate matter," in *Current air quality issues*: IntechOpen, 2015.

[19] BLHD Kota Samarinda, "Rencana Strategis Badan Lingkungan Hidup Provinsi Kalimantan Timur Tahun 2013-2018," Badan Lingkungan Hidup Kota Samarinda, Samarinda2013.

[20] M.Ghofar, "Kutai Kartanegara Miliki Izin Pertambangan Terbanyak," in *Antara Kaltim*, ed. Samarinda, 2017.

[21] S. Gautam, A. K. Patra, S. P. Sahu, and M. Hitch, "Particulate matter pollution in opencast coal mining areas: a threat to human health and environment," *International Journal of Mining, Reclamation Environment*, vol. 32, no. 2, pp. 75-92, 2018.

[22] A. K. Yadav and A. Jamal, "Suspended particulate matter and its management system surrounding opencast coal mines," *Environmental Quality Management*, vol. 28, no. 2, pp. 123-128, 2018.

[23] D. Tripathy, T. Dash, A. Badu, and R. Kanungo, "Assessment And Modelling Of Dust Concentration In An Opencast Coal Mine In India," *Global Nest Journal*, vol. 17, no. 4, pp. 825-834, 2015.

[24] S. Gautam, B. K. Prusty, and A. K. Patra, "Pollution due to particulate matter from mining activities," *Health*, vol. 4, p. 5, 2012.

[25] M. K. Ghose and S. Majee, "Assessment of dust generation due to opencast coal mining–an Indian case study," *Environmental Monitoring Assessment*, vol. 61, no. 2, pp. 257-265, 2000.

[26] V. Sastry, K. R. Chandar, K. Nagesha, E. Muralidhar, and M. S. Mohiuddin, "Prediction and analysis of dust dispersion from drilling operation in opencast coal mines," *Procedia Earth Planetary Science*, vol. 11, pp. 303-311, 2015.

[27] G. Singh, A. Pal, and R. Khoiyanbam, "Impact of mining on human health in and around Jhansi, Bundelkhand region of Uttar Pradesh, India," *Journal of Ecophysiology Occupational Health*, vol. 9, no. 1/2, p. 47, 2009.

[28] P. K. Rai, "Multifaceted health impacts of particulate matter (PM) and its management: an overview," *Environmental skeptics critics*, vol. 4, no. 1, p. 1, 2015.

[29] Z. Liu *et al.*, "Role of ROS and nutritional antioxidants in human diseases," *Frontiers in physiology*, vol. 9, 2018.

[30] C. Potera, "Black Lung Disease Resurges in Appalachian Coal Miners," *AJN The American Journal of Nursing*, vol. 119, no. 4, p. 14, 2019.

[31] A. D. Harrington, S. E. Tsirka, and M. A. Schoonen, "Inflammatory stress response in A549 cells as a result of exposure to coal: evidence for the role of pyrite in coal workers' pneumoconiosis pathogenesis," *Chemosphere*, vol. 93, no. 6, pp. 1216-1221, 2013.

[32] T. Davies and H. Mundalamo, "Environmental health impacts of dispersed mineralisation in South Africa," *Journal of African Earth Sciences*, vol. 58, no. 4, pp. 652-666, 2010.

[33] C. H. Torres Rey *et al.*, "Underground coal mining: relationship between coal dust levels and pneumoconiosis, in two regions of Colombia, 2014," *BioMed research international*, vol. 2015, 2015.

[34] V. Castranova and V. Vallyathan, "Silicosis and coal workers' pneumoconiosis," *Environmental health perspectives*, vol. 108, no. suppl 4, pp. 675-684, 2000.

[35] A. Cimrin and Z. Erdut, "General aspect of pneumoconiosis in Turkey," *Indian journal of occupational environmental medicine*, vol. 11, no. 2, p. 50, 2007.

[36] T. Pless-Mulloli *et al.*, "Living near opencast coal mining sites and children's respiratory health," *Occupational Environmental Medicine*, vol. 57, no. 3, pp. 145-151, 2000.

[37] J. Ailshire, A. Karraker, and P. Clarke, "Neighborhood social stressors, fine particulate matter air pollution, and cognitive

function among older US adults," *Social science medicine*, vol. 172, pp. 56-63, 2017.

[38] J. A. Entwistle, A. S. Hursthouse, P. A. M. Reis, and A. G. Stewart, "Metalliferous mine dust: human health impacts and the potential determinants of disease in mining communities," *Current Pollution Reports*, pp. 1-17, 2019.

[39] R. B. Finkelman and L. Tian, "The health impacts of coal use in China," *International Geology Review*, vol. 60, no. 5-6, pp. 579-589, 2018.