Overview of Physical and Chemical Factors in an Urea Fertilizer Company in Kalimantan

Gambaran Umum Faktor Fisik dan Kimia di Perusahaan Pupuk Area Kalimantan

Ayu Nurjanah[1], Dhela Iskarina[2]

[1]Department of Occupational Health and Safety, Faculty of Public Health, Universitas Airlangga
Campus C Mulyorejo, Surabaya, East Java 60115 Indonesia
[2]Vocational of Occupational Safety and Health, Faculty of Medicine, Sebelas Maret University
Jl. Ir.Sutami No.36A, Kenting, Jebres, Surakarta, Central Java 57126 Indonesia

ABSTRACT

Introduction: Fertilizer companies are companies that use large amount of chemicals and natural gas as raw materials which helps in the production process. The companies also use the factory equipment with high temperatures and pressures, leaving companies with high levels of risk. The purpose of this study is to determine the general picture of physical and chemical factors in the work environment and the risks that can occur to workers and companies in a fertilizer company in Kalimantan. **Methods:** This research was conducted using descriptive methods, and the objects observed in this study were the physical and chemical factors that existed in a fertilizer company. **Results:** Lighting intensity in all areas of the operational departments of the fertilizer company is only 12%, which is in accordance with the Threshold Limitation Value (TLV). Moreover, the intensity of noise in the area of the company, as much as 17%, is above the Threshold Limitation Value (TLV). Meanwhile, the level of dust in this fertilizer company is 33% of the area, which exceeds the Threshold Limitation Value (TLV). These three factors can increase the risks to health, performance, and even the ppsychology of the workers themselves. In addition to the risks to the workers, these three factors can also be a risk to the productivity of a company. **Conclusion:** All areas of fertilizer companies have risks originating from physical and chemical factors. So, appropriate control in order to reduce the risks that can occur both for workers and companies is highly needed.

Keywords: dust, fertilizer factory, lighting, noise

ABSTRAK

Pendahuluan: *Perusahaan pupuk adalah perusahaan yang menggunakan bahan kimia dalam jumlah besar, gas alam sebagai bahan mentah yang membantu dalam proses produksi. Perusahaan juga menggunakan peralatan pabrik dengan suhu dan tekanan tinggi, sehingga membuat perusahaan memiliki tingkat risiko tinggi. Tujuan dari penelitian ini adalah untuk mengetahui gambaran umum faktor fisik dan kimia di lingkungan kerja dan risiko yang dapat terjadi pada pekerja maupun perusahaan pupuk di Indonesia.* ***Metode:*** *Penelitian ini dilakukan dengan menggunakan metode deskriptif, variabel yang diamati dalam penelitian ini adalah faktor fisik dan kimia yang ada di perusahaan pupuk.* ***Hasil:*** *Intensitas pencahayaan keseluruhan di semua area departemen operasional perusahaan pupuk di Indonesia hanya 12% yang sesuai dengan Nilai Ambang Batas (NAB).Intensitas kebisingan di area perusahaan, sebanyak 17% berada di atas Nilai Ambang Batas (NAB). Kadar debu di perusahaan pupuk ini sebesar 33% melebihi Nilai Ambang Batas (NAB). Ketiga hal tersebut dapat berisiko pada kesehatan, kinerja, bahkan psikologi dari pekerja itu sendiri. Selain berisiko pada pekerja, ketiga hal tersebut juga dapat berisiko pada produktivitas sebuah perusahaan.* ***Simpulan:*** *Semua area perusahaan pupuk memiliki risiko yang berasal dari faktor fisik dan kimia. Sehingga perlu dilakukan pengendalian yang sesuai agar bisa mereduksi risiko yang dapat terjadi baik pada pekerja maupun perusahaan.*

Kata kunci: *debu, kebisingan, pabrik pupuk, pencahayaan*

Corresponding Author:
Ayu Nurjanah
Email : me.ayunurjanah@gmail.com
Telephone : +6282233393943

INTRODUCTION

Indonesia is an agricultural country, and the majority of people work in the agricultural sector. Thus, the community needs high number of fertilizers to support good agricultural yields. Increased market demand has led to developments

©2021 IJOSH All right reserved. Open access under CC BY NC–SA license doi:10.20473/ijosh.v10i1.2021.16-24
Received March 07, 2020, received in revised form April 22, 2020, Accepted March 05, 2021, Published: Maret 2021

in the fertilizer industry sector. In 2016 the growth of manufacturing industry production increased by 4.08% from the previous year (Central Bureau of Statistic, 2016).

Advances in science and technology have affected the industrial world in making efficiencies to increase the fertilizer productivity by using increasingly complex production tools. Yet, work equipment that is usedcan provide potential work hazards if not handled and controlled as well as possible. There are 2.3 million people worldwide who die each year due to cases of occupational diseases and work accidents. However, the majority of the causes are occupational diseases that penetrate up to 2.02 million cases of labor death. Indonesia becomes one of the countries that have a large number of workers. Therefore, this situation should be a concern for every country, including Indonesia. (Ministry of Health, 2015).

Based on this data, it is very important for a work environment to identify what hazards might occur at the work place. In a work environment where employees work, many factors can affect the work environment including physical factors, chemical factors, biological factors and psychological factors. These four factors are very likely to cause disruptions when the employees are working, and and all of them are detrimental to the health and safety of the workers. The expected outcome of a comfortable work environment is that workers can work optimally and productively. Thus, it is very important for an organization or a company to handle or design a work environment in such a way as to obtain a conducive and safe work environment for workers (Tarwaka, 2004).

Physical factors at work include noise, radiation, mechanical vibrations, work climate, working weather, high and low air pressure, lighting at work, and odors at work. In this case the physical factors are no less important to maximize labor productivity. The Measurement and control of physical factors aim to prevent and minimize occupational diseases (International Labour Organization, 2013).

Apart from physical factors, there are chemical factors that also need to be considered in the work environment. Chemical factors in the workplace include dust, metal vapor, and vapor in the workplace. The danger of chemical factors can pose a risk of long-term impacts on health , which will affect the work productivity of employees (International Labour Organization, 2013) .

The assessment of physical factors and chemical factors in the workplace has been regulated in the Regulation of the Minister of Manpower of the Republic of Indonesia Number 5 of 2018 concerning Occupational Safety and Health in the Work Environment. This regulation is made to protect the workforce from various risks that are likely to cause occupational diseases as well as to improve the level of occupational health at work. It is expected that from this regulation the workforce can work optimally, and work productivity can be achieved well through the protection of workers' health and safety (Regulation of the Minister of Manpower, 2018).

The Indonesian government protects workers, production equipment, and the work environment from production process activities in the workplace. This protection is stipulated in Law No. 1 of 1970 concerning Occupational Safety, Law No. 13 of 2003 concerning Manpower, Government Regulation No. 50 of 2012 concerning the Occupational Safety and Health Management System (SMK3). Companies that have a commitment to Occupational Safety and Health (K3) will comply with government regulations and implement OHS regulations in a more supportive manner for the successful establishment of OHS in the company.

Many factors are known to affect health and safety of the workforce. Two of them are physical factors and chemical factors. Physical and chemical hazards can have effects on workplace accidents, occupational diseases and even property or financial loss. One condition of physical hazards is that if the workplace is too noisy, or the noise level exceeds the allowed threshold, it can lead to work stress, hearing loss, fatigue, an increase in systolic blood pressure, and other health effects (Sumardiyono et al., 2020). Likewise, the detrimental effects on health can also be caused bychemical hazards, for example dust. Pneumonomic dust can affect respiratory problems and even can damage the lungs (Nafisa, Joko and Setiani, 2016). Fertilizer companies are companies that use large number of chemicals and natural gas as raw materials which helps in the production process, as well as use factory equipment with high temperatures and pressures, making companies in high levels of risks. Fertilizer companies certainly cannot be separated from the danger of physical and chemical factors. For this reason, periodic inspections of these factors need to be carried out to anticipate the occurrence of occupational diseases in every company including fertilizer companies. The assessment of physical factors and chemical factors is important because it is an obligation of the company to protect its workforce both in terms

of health and safety. The purpose of the assessment of the physical and chemical factors is to prevent occupational diseases. The purpose of this study is to determine the general picture of physical and chemical factors in the work environment and the risks that can occur to workers and companies in fertilizer companies.

METHODS

This research was conducted using descriptive methods, namely methods that aim to provide an exact explanation of a certain condition. This research was conducted from April 20 to June 15, 2017 in one of the fertilizer companies in Indonesia. The objects observed in this study were the physical and chemical factors that existed in the fertilizer company. The physical factors in question were in the form of lighting and noise. Meanwhile, the chemical factor in question was dust.

The measurement of physical hazards was done using various tools. Noise is measured using sound levels, while for lighting used a lux meter. Moreover, the measurements in the local area started from the factory operations department 1 to 7, with a total of 106 location points. In the measurement of chemical hazard, which is dust, the research used secondary data, which were collected by the Department of the Laboratory of the Environment Section at 7 location points suffering from dust.

RESULTS

Measurement of Physical Factors

Factory 1

After measuring several units in the factory area 1,. the lighting value and the actual noise value are found in each unit. The results of these measurements are shown in Table 1. From Table 1, it can be seen that,overall, factory area 1 has an average lighting value of 492 Lux, and the average noise level of 70 dB.

Factory 1A

The results of measurements in Factory 1A are shown in Table 1.it can be seen that overall Factory 1A has an average lighting level of 400 Lux, and the average noise level of 65 dB.

Factory 2

The results of the measurement of physical factors in Factory 2 are shown in Table 2. From Table 2, it can be seen that overall Factory 2 has an

Table 1. Results of the Measurement of Physical Factors of the Fertilizer Operations Department- Factory 1 in 2017

Location	Lighting (Lux)	Noise (dB)
Control Room Utility/ Ammonia K1	450	59
Field Shake Cooling Water Utility K-1	300	66
Field Shake Boiler Utility K-1	235	68
Field Shake Power House Utility K-1	250	66
Factory Area Utility K-1	1000	86
Field Shake Reformer Ammonia K-1	-	-
Field Shake Compresor Ammonia K-1	-	-
Ammonia Factory Area K-1	-	-
Control Room Urea K-1	450	60
Field Shake Urea K-1	250	69
Urea Factory Area K-1	1000	89
Average	492	70

Table 1A. Results of the Measurement of Physical Factors of the Fertilizer Factory Operations Department-1A in 2017

Location	Lighting (Lux)	Noise (dB)
Control Room of Factory 1A	550	62
Field Shake Utility 1 Factory 1A	300	65
Field Shake Utility 2 Factory 1A	250	66
Utility Factory Area Factory 1A	1000	88
Field Shake Compresor CO2 Urea Factory 1A	325	71
Urea Factory Area Factory 1A	300	87
Factory Area Urea Bagging Factory 1A	1000	66
Field Shake Ammonia	250	66
Ammonia Factory Area Factory 1A	250	67
Average	400	65

average lighting level of 473 Lux, andthe average noise level of 71 dB.

Factory 3

The results of the measurement of physical factors in Factory 3 are shown in Table 3. From Table 3, it can be seen that overall Factory 3 has an average lighting level of 525 Lux, andthe average noise level of 76 dB.

Factory 4

The results of the measurement in Factory 4 are shown in Table 4. From Table 4, it can be seen that overall Factory area 4 has an average lighting level of 522 Lux, and the average noise of 74 dB.

Factory 5

The results of measurements in Factory 5 is shown in table 5. From Table 5, it can be seen that overall Factory area 5 has an average lighting levelof 566 Lux, andthe average noise level of 71 dB.

Factory 6

The results of measurements of physical factors in Factory 6 are shown in Table 6. From table 6, it can be seen that overall Factory area 6 has an average lighting level of 394 Lux, andthe average noise level of 63 dB.

Factory 7

The results of the measurement of physical factors in Factory 7 are listed in Table 7. From Table

Table 2. Results of the Measurement of Physical Factors of the Fertilizer Factory Operations Department-2 in 2017

Location	Lighting (Lux)	Noise (dB)
Control Room Utility/ Ammonia/Urea K-2	425	58
Control Room UFC K-2	300	60
Field Shake Demin Utility K-2	250	65
Factory Area Utility K-2	1000	89
Field Shake Reformer Ammonia K-2	225	67
Field Shake Synlop/HRU Amoniak K-2	300	64
Field Shake Compresor Ammonia K-2	250	66
Ammonia Factory Area K-2	1000	91
Field Shake Prilling Urea K-2	225	66
Field Shake Compresor CO2 Urea K-2	225	68
Ammonia Factory Area K-2	1000	92
Average	473	71

Table 3. Results of Measurements of Physical Factors of the Fertilizer Operations Department – Factory 3 in 2017

Location	Lighting (Lux)	Noise (dB)
Control Room Utility/ Ammonia/ Urea K-3	550	66
Field Shake Demin Utility K3	250	65
Field Shake Boiler Utility K-3	250	68
Utility Factory Area K-3	1000	91
Field Shake Reformer Ammonia K-3	275	69
Ammonia Compressor K-3	300	69
Ammonia Factory Area K-3	1000	99
Field Shake Prilling Urea K-3	325	64
Field Shake Compresor CO2 Urea K-3	300	67
Urea Factory Area K-3	1000	97
Average	525	76

Table 4. Results of the Measurements of Physical Factors of the Fertilizer Operations Department - Factory-4 in 2017

Location	Lighting (Lux)	Noise (dB)
Control Room Utility/ Ammonia/ Urea K-4	495	61
Field Shake Demin Utility K4	300	65
Field Shake Boiler Utility K-4	275	66
Utility Factory Area K-4	1000	96
Field Shake Reformer Ammonia K-4	325	68
Field Shake Compresor Ammonia K-4	300	70
Utility Factory Area K-4	1000	91
Field Shake Prilling Urea K-4	275	66
Field Shake Compresor CO2 Urea K-4	250	67
Urea Factory Area K-4	1000	93
Average	522	74

Table 5. Results of Measurement of Physical Factors of the Fertilizer Operations Department – Factory 5 in 2017

Location	Lighting (Lux)	Noise (dB)
Control Room Utility/ Ammonia/ Urea K-5	515	61
Field Shake Utility K-5	300	65
Utility Factory Area K-5	1000	66
Field Shake Reformer Ammonia K-5	311	73
Field Shake Compresor Ammonia K-5	325	68
Ammonia Factory Area K-5	1000	86
Urea Field Shake K-5	325	71
Field Shake Compresor CO2 Urea K-5	315	66
Urea Factory Area K-5	1000	87
Average	566	71

Table 6. Results of Measurements of Physical Factors of the FertilizerOperations Department – Factory 6 in 2017

Location	Lighting (Lux)	Noise (dB)
Control Room Ammonia Storage	300	50
Control Room ASU/ASP	250	55
Factory Area Ammonia Storage/ASU/AS P	1000	90
Control Room Ammonia Storage ex KPA	240	55
Tank Area Ammoniaex KPA	1000	65
Control Room Warehouse I, II	315	54
Warehouse Portal I	125	69
Warehouse Portal II	120	55
Control Room III , IV, V	310	55
Warehouse Portal III	185	52
Warehouse Portal IV	360	65
Warehouse Portal V	300	52
Control Room Coal Boiler	515	65
Field Shake Boiler Coal	325	64
Coal Dome Boiler Coal	250	65
Cabin Reclaimer Coal Boiler	250	72
Coal Crusher for Boiler	285	70
Area Coal Handling System Floor 5	350	70
Factory Area Floor 1 (directing to PT. KPI)	1000	82
Average	394	63

7, it can be seen that overall Factory area 7 has an average lighting level of 388 Lux, and the average noise level of 62 dB.

Measurement of Chemical Factors

The Measurements of dust content are carried out to find out how much dust there is in each unit in this fertilizer company. Dust measurements by the Environmental Laboratory Department and the results as listed in table 8. From table 8 it can be seen the dust levels that exist in each unit in the fertilizer company.

DISCUSSION

Measurements of Physical Factors

The Minister of Manpower makes a regulation regarding the Threshold Limitation Value (TLV) of the recommended lighting level in an industry or in a certain type of work. Based on this regulation, the recommended lighting level is 300 Lux (Minister of Manpower Regulation, 2018).

In the measurements made at the operational departments of Factory 1, Factory 1A, Factory

Table 7. Results of the Measurement of Physical Factors of the Fertilizer Operations Department – Factory 7 in 2017

Location	Lighting (Lux)	Noise (dB)
Control Room NPK Fuse	500	58
Factory Area NPK Fuse (Bagging)	200	70
Warehouse Area NPK Fuse	450	56
Factory Area NPK	311	73
Average	388	62

Table 8. Results of Measurement Result of Dust Content in Fertilizer Plant in 2017

Areas	Test Result (mg/Nm3)
NF CR	0.07
NF L-1102	12.6
Bagging P-1	1.16
Bagging P- 2	12.6
L-2102	42.9
Crusher P-1	4.23
Crusher Plant 2	4.41
Hopper Clay (0101B)	8.82
Hopper ZA	3.51

2, Factory 3, Factory 4, Factory 5, Factory 6 and Factory 7, in general, the lighting values are all above TLV. From this regulation, it can be seen that only around 12% of the working environment lighting levels are in accordance with the recommended TLV (Minister of Manpower Regulation, 2018).

Lighting level that is less than the Threshold Limitation Value (TLV) can have several physiological effects. One of them is the complaint in the form of sleepy eyes (Rahmayanti and Artha, 2015). Besides, lighting that does not meet the standards can cause eye fatigue (Wiyanti and Martiana, 2017). The emergence of subjective complaints related to eye fatigue also often occurs in workers (Ayu and Erwandi, 2013). This is in line with research conducted by Fitria (2018) that there is an effect of lighting intensity with eyestrain on labor. Meanwhile, excessive lighting intensity can cause glare, reflections, excessive shadows, visibility and eyestrain in the workforce (Tarwaka, 2004).

In addition to physiological effects, inappropriate lighting levels can also have psychological effects. Poor lighting below from TLV at work can also affect a worker's mental workload (Widarobi, Yadi and Mariawati, 2013). The intensity of the light that is not appropriate to the type of work will also result in discomfort disruption in work activities Wulandari (2010), and it can even increase stress on workers (Ganendra and Meiyanto, 2018).

In a work environment, it would be better if the intensity of lighting can be made as well as possible, of course in accordance with applicable standards because it can affect work performance in every workforce (Yusuf, 2015). Sanders and McCormick (1987) conclude from the results of their research on 15 companiesthat all companies studied show an increase in workplace between 4-35% after the intensity of lighting at work is increase.

A company certainly has a target product that is produced every day, and this is closely related to worker productivity. Work productivity can be disrupted if the lighting in the work environment does not match with the type of work (Ganendra and Meiyanto, 2018).

According Suma'mur (2009), it is important to divide the levels of lighting based on the types of work. For the types of work which requires medium accuracy, the level of lighting needed is 170-350 Lux. Meanwhile, for the type of work that requires high accuracy, the level of lighting needed is 700-1000 Lux. Based on this theory, the level of lightning available in each unit of the fertilizer company in this study has already been appropriate.

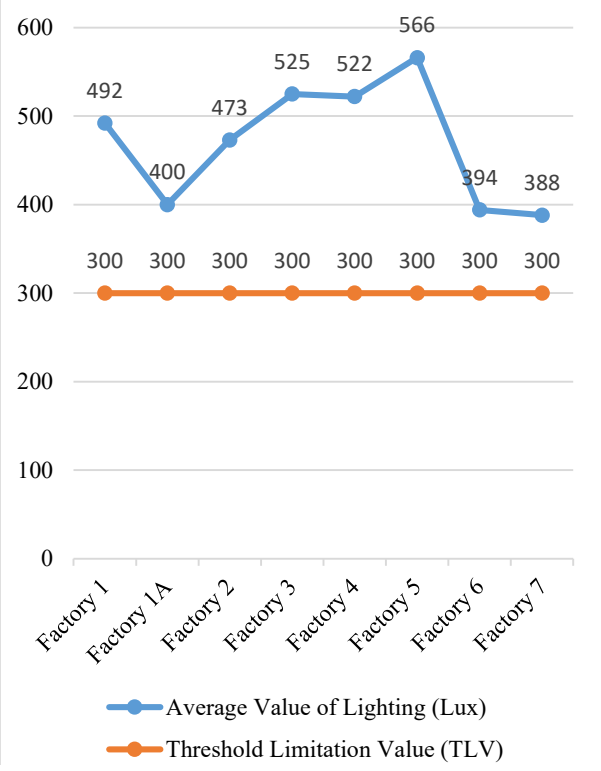

Diagram 1. Comparison of Lighting Measurement Results in Fertilizer Companies in 2017

Table 9. Recommended Maximum Exposure Dose Based on ACGIH in Fertilizer Company in 2017

Units	Noise Value (dB)	Allowable Exposure Time (Hours)
Utility K-1	86	6.35
Urea K-1	89	3.17
Utility Pabrik 1A	88	4
Urea Pabrik 1A	87	5.04
Utility K-2	89	3.17
Ammonia K-2	91	2
Urea K-2	92	1.59
Utility K-3	91	2
Ammonia K-3	99	0.31
Urea K-3	97	0.5
Utility K-4	96	0.63
Ammonia K-4	91	2
Urea K-4	93	1.26
Ammonia K-5	86	6.35
Urea K-5	87	5.04
Ammonia Storage/ASU/ AS P K-6	90	2.52

Based on the measurements made at the operations departments of Factory 1, Factory 1A, Factory 2, Factory 3, Factory t 4, Factory 5, Factory 6 and Factory 7 in general the noise values are all below the TLV according to Diagram 1. Referring to the Regulation of the Minister of Health of the Republic of Indonesia Number 70 of 2016 concerning Standards and Requirements for Industrial Occupational Health, it can be said that in each factory operations department all noise value units are above the TLV.

This fertilizer company imposes three work shifts, which means each worker will work for 8 hours. ACGIH makes rules about how long workers can be exposed to certain noise levels. Based on the results of the study, it is known that several areas have noise above the TLV, and after the calculation using the ACGIH formula the results are obtained, as listed in Table 9.

The higher the noise level in the work environment, the shorter the exposure time and vice versa (Sasmita, Elystia and Asmura, 2016). Noise levels can affect labor productivity, so it is important to consider how to reduce them so that they do not exceed the Threshold Limitation Value (Efendi, 2013). This is related to the fact that noise at work can affect work activities (Suma'mur, 2009).

Noise levels that exceed the Threshold Limitation Value (TLV) that are not in accordance with the allowed exposure time will be risks in physiological factors. According to research conducted by Masdi, Amir and Patintingan (2019) pulse difference occurs before and after exposure to noise. This is similar to research conducted by Mukhlish, Sudarmanto and Hasan (2018) at a timber factory in Jember. They suggest that in addition to the risk of increased pulse rate, there are other physiological risks. The results of research conducted by Siswati and Adriyani (2017) further confirm that confirm that diastolic blood pressure in workers experiences differences, particulary after exposure to noiseas workers exhibit symptoms of pre hypertension. Another research results also explain that there is a relationship between right ear disorders with noise intensity (Dewanti and Sudarmaji, 2015).

Moreover, exposure to noise that passes through the Threshold Limitation Value (TLV) coupled with less effective control can pose a risk of work fatigue. Research conducted by Maison, Anggraini and Falih (2020) indicates that the noise and fatigue experienced by labors are interrelated. This is strengthened by another previous study (Isnarningsih, 2009) stating that work fatigue can be caused by noise. Noise that is not in accordance with existing regulations turns out to have some detrimental effects.

The risk of psychological factors is also undeniable. According to research conducted by Budiyanto and Pratiwi (2010) the occurrence of work stress has to do with noise. This is proven by the existence of a meaningful relationship between the two. The final result that can be seen from this study is The higher the noise level, the higher the risk of work stress

Noise exposure not only impacts workers, but also the company. Research conducted by Handayani and Hati (2018) explains that noise exposure is very influential on work productivity. This is in line with research conducted by Rachmahati et al. (year) that work climate and noise affect employee productivity.

Research conducted by Akbar and Riandadari (2016) shows that there are differences in work productivity generated by workers who work in the morning and afternoon shifts, and this is related to the noise level of the machine that is in the production process of PG Kremboong PT. Perkebunan Nusantara X (Persero).

Measurements of Chemical Factors

In 2011, the Ministry of Manpower and Transmigration made a regulations about TLV in dust. In accordance with the regulation issued, the recommended TLV of dust in the industry is 10 mg /m3 (Ministry of Manpower and Transmigration Regulation, 2011).

Based on the results of the measurements of dust levels carried out in the area of NF L-1102, bagging P-2, L-2102 in Factory-7 (NPK) exceeds the Threshold Value Set because the dedusting system at NF L-1102 and L-2102 is damaged due to corrosive . In the P-2 bagging the dust content exceeds the NAV because the dust from the M-2108 crusher is broken so the dust leads to the P-2 bagging.

Moreover, there is a physiological risk due to dust exposure. Research conducted by Regia and Oginawati (2017) explain that the exposure to dust inhaled by workers can affect the health of workers, especially in the lungs. Research conducted at CV Citra Jepara Furniture also shows that the level of dust that is inhaled by workers is directly proportional to impaired lung functions experienced by workers (Putri, Darundiati and Yunita, 2017). In

addition to causing respiratory problems, exposure to fertilizer dust can cause irritation such as in the eyes and on skin that are allergic to the material from the fertilizer (Muhamid, Tambunan and Fatimahhayati, 2018).

Another research also states that in PT Arumbai Kasembadan the total dust levels have a significant relationship with lung function capacity in workers (Nafisa, Joko and Setiani, 2016). Indeed, it should be noted that dust levels can pose a risk to the health of workers in a company. This is in line with a current study that in the duration of exposure for 8 hours without using personal protective equipment, as many as 50% of respondents have abnormal lung function capacity.

CONCLUSION

Based on the analyses that have been done, it can be concluded that only a small portion of the areas of the fertilizer company which is not in accordance with the Threshold Limitation Value (TLV), in terms of both physical hazards and chemical hazards. Thus, it is necessary to take appropriate steps in accordance with the hierarcy of control in order to reduce losses that can occur in the company both in the form of materials and in terms of human resources.

ACKNOWLEDGEMENTS

The researchers express deepest gratitude and appreciation to Allah SWT and those who have contributed to the successful accomplishment of this research, especially the family and Evi Maulani Riski who have provided support in completing this journal. The researchers also say gratitude to the Faculty of Public Health Airlangga University for the maintainance of journalss sustainability.

REFERENCES

Akbar, F. and Riandadari, D. (2016) 'Analisis Pengaruh Kebisingan Terhadap Produktivitas Pada Proses Produksi di PG. Krembong PT. Perkebunan Nusantara X (Persero)', *Jurnal Teknik Mesin*, 4(2), pp. 91–98.

Ayu, R. P. and Erwandi, D. (2013) *Gambaran Intensitas Pencahayaan dan Keluhan Subyektif Kelelahan Mata pada Pekerja di Konveksi Jeans Daerah Kemayoran Jakarta Pusat pada Tahun 2013*. Undergraduate Thesis. Jakarta: Faculty of Public Health Universitas Indonesia.

Budiyanto, T. and Pratiwi, E. Y. (2010) 'Hubungan Kebisingan dan Massa Kerja Terhadap Terjadinya Stres Kerja pada Pekerja di Bagian Tenun "Agung Saputra Tex" Piyungan Bantul Yogyakarta', *Jurnal Kesehatan Masyarakat (Journal of Public Health)*, 4(2), pp. 126–135.

Central Bureau of Statistic (2016) Perkembangan Indeks Produksi Industri Manufaktur 2014-2016. Jakarta: Central Bureau of Statistic.

Dewanti, R. A. and Sudarmaji (2015) 'Impact Analysis of Noise Intensity with Hearing Loss on Laundry Worker', *Jurnal Kesehatan Lingkungan*, 8(2), pp. 229–237.

Efendi, A. N. (2013) *Pengaruh Kebisingan Terhadap Kelelahan pada Tenaga Kerja Bagian Produksi 'Candy' PT Deltomed Laboratories Wonogiri*. Undergraduate Thesis. Jakarta : Faculty of Health Science Universitas Muhammadiyah Surakarta.

Fitria, Q. (2018) *Pengaruh Intensitas Penerangan Terhadap Kelelahan Mata pada Tenaga Kerja Bagian Inspecting dan Folding di PT. Kosoema Nanda Putra Pedan Klaten*. Undergraduate Thesis. Surakarta: Faculty of Health Sciences Universitas Muhammadiyah Surakarta.

Ganendra, S. and Meiyanto, I. S. (2018) 'Pengaruh Penerangan Terhadap Stres dan Produktivitas Karyawan PT. X Purworejo', *Gadjah Mada Journal of Professional Psychology (GAMAJPP*), 4(1), pp. 73-86.

Handayani, W. N. and Hati, S. W. (2018) 'Pengaruh Lingkungan Kerja Fisik Terhadap Produktivitas Kerja Karyawan Operator Bagian Produksi Pada Perusahaan Manufaktur di PT ABC Batam', *Jurnal Aplikasi Administrasi*, 21(1), pp. 9–30.

International Labour Organization (2013) Keselamatan dan Kesehatan Kerja Sarana untuk Produktivitas. Jakarta: International Labour Office.

Isnarningsih, E. (2009) *Pengaruh Intensitas Kebisingan Terhadap Kelelahan Tenaga Kerja di Bagian Welding 2B dan Bagian P2 Shipping CBU di PT X Plant II Jakarta Utara*. Undergraduate Thesis. Surakarta : Faculty of Medicine Universitas Sebelas Maret.

Maison, Anggraini, F. J. and Falih, M. (2020) 'Analisis Tingkat Kebisingan di Area Mesin Produksi Bangsal kayu Sebrang Kota Jambi dan Hubungan dengan Kelalahan Kerja pada Karyawan', *Jurnal Engineering*, 2(1), pp. 40–49.

Masdi, Amir, R. and Patintingan, A. (2019) 'Pengaruh Intensitas Kebisingan Terhadap Frekuensi Denyut Nadi pada Pekerja Penggilingan Gabah di Desa Sanglepongan Kecamatan Curio Kabupaten

Enrekang', *Jurnal Ilmiah Manusia dan Kesehatan*, 2(2), pp. 220–229.

Minister of Manpower Regulation (2018) Number 5 Year 2018. Concering Safety and Health. Jakarta: Ministry of Manpower Republic of Indonesia.

Ministry of Health (2015) Vulnerable Mining Industry Workers Affected By Pneumoconiosise. Jakarta : Publishing Ministry of Health.

Ministry of Manpower and Transmigration Regulation (2011) Number Per. 13/MEN/X/2011 Concering Threshold Limitation Value of Physical and Chemical Factors in Workplace. Jakarta : Ministry of Manpower and Transmigration Republic of Indonesia.

Muhamid, R., Tambunan, W. and Fatimahhayati, L. D. (2018) 'Analisis Risiko Keselamatan dan Kesehatan Kerja Kegiatan Bongkar Muat Pupuk', *Jurnal INTECH Teknik Industri Universitas Serang Raya*, 4(2), pp. 45–52.

Mukhlish, W. I. N., Sudarmanto, Y. and Hasan, M. (2018) 'Pengaruh Kebisingan Terhadap Tekanan Darah dan Nadi pada Pekerja Pabrik Kayu PT. Muroco Jember', *Jurnal Kesehatan Lingkungan Indonesia*, 17(2), pp. 112–118.

Nafisa, R. S. F., Joko, T. and Setiani, O. (2016) 'Hubungan Paparan Debu Kayu di Lingkungan Kerja Terhadap Gangguan Fungsi Paru pada Pekerja di PT. Arumbai Kasembadan, Banyumas', *Jurnal Kesehatan Masyarakat (e-Journal)*, 4(5), pp. 178–186.

Putri, R. kartika, Darundiati, Y. H. and Yunita, N. A. (2017) 'Hubungan Paparan Debu Kayu Terhirup dengan Gangguan Fungsi Paru pada Pekerjaan di Industri Mebel CV. Citra Jepara Furniture Kabupaten Semarang', *Jurnal Kesehatan Masyarakat (e-Journal)*, 5(5), pp. 832–837.

Rahmayanti, D. and Artha, A. (2015) 'Analisis Bahaya Fisik : Hubungan Tingkat Pencahayaan dan Keluhan Mata Pekerja pada Area Perkantoran Health, Safety, and Environmental (HSE) PT. Pertamina RU VI Balongan', *Jurnal Optimasi Sistem Industri*, 14(1), pp. 71–98.

Regia, R. A. and Oginawati, K. (2017) 'Potensi Bahaya Debu Silika Terhadap Kesehatan Pandai Besi Desa Mekarmaju Kabupaten Bandung', *Jurnal Dampak Tehnik Lingkungan UNAND*, 14(2), pp. 73–80.

Sanders, M. . and McCormick, E. . (1987) *Human Factors in Engineering and Design* (6th ed.). New York: McGraw Hill Book Company.

Sasmita, A., Elystia, S. and Asmura, J. (2016) 'Evaluasi Tingkat Kebisingan Sebagai Upaya Pengelolaan Kesehatan dan Keselamatan Kerja (K3) di Unit PLTD/G Teluk Lembu PT PLN Pekanbaru dengan Metode NIOSH', *Jurnal Sains dan Teknologi*, 15(2), pp. 34–42.

Siswati and Adriyani, R. (2017) 'Hubungan Pajanan Kebisingan dengan Tekanan Darah dan Denyut Nadi pada Pekerja Industri Kemasan Semen', *Jurnal Kesehatan Lingkungan Indonesia*, 16(1), pp. 29–36.

Suma'mur (2009) *Hiegine Perusahaan dan Keselamatan Kerja*. Jakarta: CV. Jagung Seto.

Sumardiyono, S. et al. (2020) 'Pengaruh Kebisingan terhadap Tekanan Darah, dengan Stres Kerja sebagai Variabel Mediator', *Jurnal Kesehatan Vokasional*, 5(2), pp. 124–131.

Tarwaka (2004) K*onsep Dasar Ergonomi*. Jakarta: CV. Haji Masagung.

Widarobi, R., Yadi, Y. H. and Mariawati, A. S. (2013) 'Pengaruh Pencahayaan Terhadap Beban Kerja Mental di Area Kerja Scroll Cut', *Jurnal Tehnik Industri*, 1(3), pp. 193–199.

Wiyanti, N. and Martiana, T. (2017) 'Hubungan Intensitas Penerangan dengan Kelelahan Mata pada Pengrajin Batik Tulis', *The Indonesian Journal of Occupational Safety and Health,* 4(2), pp. 144–153.

Wulandari, A. P. (2010) *Pengaruh Intensitas Cahaya Terhadap Aktivitas Kerja Bagian Produksi di PT. Indofood CBP Sukses Makmur Divisi Noodle Cabang Semarang*. Undergraduate Thesis. Surakarta : Faculty of Medicine Universitas Sebelas Maret.

Yusuf, M. (2015) 'Efek Pencahayaan Terhadap Prestasi dan Kelelahan Kerja Operator', *Industrial Engineering National Conference (IENACO)*, pp. 24–29.