Blantika: Multidisciplinary Jornal
Volume 2 Number 10, Agustus, 2024
p- ISSN 2987-758X e-ISSN 2985-4199

THE EFFECT OF PM2.5 DUST EXPOSURE ON MDA AND 8-OHDG URINE AS AN OXIDATIVE STRESS INDICATION OF BRICK WORKERS IN MOJOKERTO DISTRICT, 2024

Atikah, Soedjajadi Keman, Yudied A. Mirasa
Airlangga University, Indonesia
E-mail: 211202006725@mhs.dinus.ac.id

ABSTRACT
Exposure to PM2.5 dust could enter the human body through inhalation and have a negative impact on health through the mechanism of the formation of reactive oxygen species (ROS) in the respiratory tract, where the remaining ROS could burn cell nuclei and produce a byproduct in the form of malondialdehyde (MDA). In addition, oxygen radicals that could enter cells could burn DNA and produce 8-hydroxy-2'-deoxyguanosine (8-OHdG). High levels of MDA and 8-OHdG in the body reflect high levels of oxidative stress. Analyze sis influence on pap a ran PM 2.5 was an indication of oxidative stress through examination of urine MDA and 8-OHdG levels in brick-making workers in Mojokerto. Regency This type of research was observational and analytical, with a cross-sectional approach. There was an influence of exposure to PM 2.5 dust particles on MDA and 8-OHdG levels. MDA and 8-OHdG levels in the urine of workers at exposed locations were higher compared to workers at unexposed locations. The oxidative stress of workers in exposed locations was higher than that of workers in unexposed locations.

Keywords: *brick workers; PM 2.5 dust; MDA levels; 8-OHdG levels; oxidative stress*

INTRODUCTION

Globally, around 2.4 billion people are exposed to dangerous levels of household air pollution when using polluting open fires or simple stoves for cooking using kerosene, biomass (wood, animal waste, and crop waste), and coal (Lee & Greenstone, 2021). The combined effects of ambient air pollution and household air pollution are linked to 7 million premature deaths annually (WHO, 2023). In Indonesia, air pollution is becoming a concern along with the rapid growth of the industrial sector (Avenbuan & Zelikoff, 2020). This activity makes a significant contribution to the air pollution problem. Decreased air quality has become an increasingly real problem in recent years, especially in large cities and in centers of industrial growth such as Mojokerto Regency, East Java Province. The industrial profile in Mojokerto Regency until 2015 was still dominated by small industries. Several types of small industries (people's crafts) that contributed quite a lot to the industry in Mojokerto Regency were bricks, which were the leading industry in Mojotamping Village, Bangsal District, Mojokerto Regency (Amalia & Novianus, 2022).

Workers in the brick-making industry are often exposed to PM2.5 $_{dust}$ generated during the production process (Burleson, 2003). PM $_{2.5}$ dust It has a very small size, less than 2.5 micrometers, so it can penetrate deep into the respiratory tract and reach the deepest parts of the lungs (Cáceres et al., 2020). According to Sembiring, 2020, dust smaller than 2.5 microns (PM $_{2.5}$) is one of the pollutants from emissions that can enter and penetrate the human respiratory system and bind to the blood through gas exchange in the lung alveoli so that it can cause deposits in the alveoli and result in cell damage. PM $_{2.5\ dust}$ can enter an individual's body through the respiratory tract, reaching the upper and lower airways, including the alveoli within the lungs, where gas exchange occurs. PM $_{2.5\ dust}$ can come into direct contact with lung epithelial cells. This can trigger inflammation and induce the production of reactive oxygen species (ROS) (Xuan, Y., *et al.*, 2022).

A relevant grand theory that could be applied is Ecosocial Theory, which explores how social, economic, and environmental factors interact and impact human health. This theory emphasizes that air pollution, including PM $_{2.5}$, is not only an environmental issue but also shaped by broader social and industrial factors, particularly in developing regions. It highlights the importance of addressing these issues through a holistic approach, integrating environmental health with social determinants of health to mitigate negative impacts on populations exposed to pollution, such as brick-making workers

Oxidative stress is a condition where there is an imbalance between the production of free radicals in the body and the body's antioxidant capacity to fight these free radicals. Exposure to PM $_{2.5}$ dust and other factors mentioned previously can increase the production of free radicals, which can then cause oxidative stress (Nirmala, 2015).

Oxidative reactions occur because exposure to PM $_{2.5}$ causes the formation of free radicals, such as ROS. These free radicals can damage cellular components, including lipids, proteins, and DNA. However, ROS formation is influenced by the activity of the enzymes GPX (glutathione *peroxidase*), SOD (superoxide *dismutase*), and catalase (Ayu, 2021). These enzymes play an important role in regulating ROS levels in the body and help reduce the potential for cellular damage caused by ROS. Not all ROS can be neutralized by the body. Residual ROS such as peroxide can burn cell walls, producing a byproduct in the form of *malondialdehyde* (MDA). High MDA levels reflect high levels of lipid peroxidation in cells. Meanwhile, ROS, in the form of oxygen radicals, can enter cells and damage DNA. Oxygen radicals that enter the cell will burn DNA (oxidative DNA), causing modifications to the *deoxyguanosine nucleotide*. One of the end products of this damage is *8-hydroxy-2'-deoxyguanosine* (8-OHdG), which can detect oxidative damage (Feng et al., 2021). Damage products such as MDA and 8-OHdG can be excreted through the kidneys and are found in urine. This increase in levels may reflect exposure to PM $_{2.5\ dust}$ and the damage that occurs in the body (Liu K. *et al.*, 2022).

Examination of *malondialdehyde* (MDA) and *8-hydroxydeoxyguanosine* (8-OHdG) levels in workers' urine as indicators of oxidative stress (Gangwar et al., 2020). *Malondialdehyde* is a byproduct of lipid oxidation that is a common biomarker for oxidative stress, while *8-hydroxydeoxyguanosine* is a biomarker for oxidative DNA damage (Azizah, 2019).

RESEARCH METHOD

The researched would held this used typed researched and analysis observasional (Fussell & Kelly, 2020). The research design was used cross sectional, conducted in Sumber Pandan Hamlet, Mojotamping Village, Bangsal District, and Mojokerto Regency as exposed locations and in Kuripan Hamlet, Jumeneng Village, Mojoanyar District, and Mojokerto Regency as non-exposed locations. The population in this study was 20 brick-making workers in Sumber Pandan Hamlet, Mojotamping Village, Bangsal District, and Mojokerto Regency as the exposed group and 20 workers in Kuripan Hamlet, Jumeneng Village, Mojoanyar District, and Mojokerto

Regency as the unexposed group (Dhingra et al., 2020). This sample used total population (Wyer et al., 2022).

RESULTS AND DISCUSSION

Table 1. Differences in PM $_{2.5}$ Dust Levels between Brick Making Workers in Exposed Locations and Workers in Unexposed Locations

Variable	Group	N	Mean (mg/ ^{m3})	elementary school	*p-value*
PM $_{2.5\ dust}$	Exposed	20	2,945	5,184	0.029
	Not Exposed	20	0.310	0.265	

Respirable dust standard: 3 mg/m3 (RI Minister of Manpower Regulation number 5 of 2018 concerning K3 Work Environment)

From Table 1, the group of workers in exposed locations had an average PM 2.5 dust level of 2. 945 mg/m3, and the group of workers in unexposed locations had an average PM 2.5 dust level. amounting to 0.310 mg/m3. The average PM 2.5 dust level in the exposed group was higher than that in the non-exposed group. The group of workers at the exposed location had a standard deviation (SD), meaning the average distribution of PM 2.5 dust levels in the group of workers at exposed locations was 5,184, while the group of workers at unexposed locations had an average distribution of PM 2.5 dust levels of 0.265. It shows that the variability of the group of workers in exposed locations was higher than that of the group of workers in unexposed locations (Gao et al., 2020).

Based on the independent sample t-test (a t-test of two independent samples), a p-value of 0.029 was obtained, meaning it was much smaller than the significance level α . = 0.05, so there was strong evidence that there was a statistically significant difference between the averages. the average group of workers at exposed locations and the group of workers at unexposed locations. In other words, exposure conditions had a significant impact on the measured results, corresponding to a higher mean and a very small p-value =0.029 (Giakoumi et al., 2009).

Table 2. Differences in MDA Levels between Brick Making Workers in Exposed Locations and Workers in Unexposed Locations

Group	N	Mean (nmol/ml creatinine)	elementary school	*p-value*
Exposed	20	2,187	1,315	0.001
Not Exposed	20	1,106	0.455	

From table 2, the group of workers at exposed locations had an average MDA level of 2,187 nmol/ml creatinine, and the group of workers at unexposed locations had an average MDA level of 1,106 nmol/ml creatinine. The average MDA level of the exposed group was higher compared to the unexposed group. The group of workers in exposed locations had a standard deviation (SD), meaning that the average distribution of MDA levels in the group of workers in exposed locations was 1. 315, while the group of workers in unexposed locations had an average distribution of MDA levels of 0. 455. It shows that the variability of the group of workers in exposed locations was higher than that of the group of workers in unexposed locations.

Based on the independent t-test, a p-value of 0.001 was obtained, meaning it was much smaller than the significance level α. = 0.05, so there was strong evidence that there was a statistically significant difference between the average group of workers at the exposed location and the group of workers in unexposed locations. In other words, exposure conditions had a significant impact on the measured results, corresponding to a higher mean and a very small p-value =0.001 (Creswell & Creswell, 2009).

Table 3. Differences in 8-OHdG Levels between Brick-Making Workers in Exposed Locations and Workers in Unexposed Locations

Group	N	Mean (ng/mg creatinine)	elementary school	*p-value*
Exposed	20	29,492	36,741	0.039
Not Exposed	20	11,405	8,812	

From table 3, the group of workers at exposed locations had an average 8-OHdG level of 29,492 ng/mg creatinine, and the group of workers at unexposed locations had an average 8-OHdG level of 11,405 ng/mg creatinine. The average 8-OHdG level in the exposed group was higher compared to the unexposed group. The group of workers in exposed locations had a standard deviation (SD), meaning that the average distribution of 8-OHdG levels in the group of workers in exposed locations was 36.741, while the group of workers in unexposed locations had an average distribution of 8-OHdG levels of 8.812. It shows that the variability of the group of workers in exposed locations was higher than that of the group of workers in unexposed locations. Based on the independent samples t-test (a t-test of two independent samples), a p-value of 0.039 was obtained, meaning it was much smaller than the significance level α = 0.05, so there was strong evidence that there was a statistically significant difference between the averages. the average group of workers at exposed locations and the group of workers at unexposed locations. In other words, exposure conditions had a significant impact on the measured results, corresponding to a higher mean and a very small p-value =0.039 (Putri & Andriansyah, 2022)..

Effect Pm2.5 Dust Exposure on Mda And 8-Ohdg Levels

Table 4. Effect of PM $_{2.5}$ dust levels on MDA levels and 8-OHdG levels in urine between brick-making workers at exposed locations and workers at non-exposed locations

	p-value	MDA levels	Rate 8-OHdG	PM $_{2.5}$ dust
Pearson	MDA levels	-	0,000	0.606
	Rate 8-OHdG	0,000	-	0.662
	PM $_{2.5}$ dust	0.606	0.662	-

Based on Table 4, it was known that the Pearson correlation coefficient (r) valued between PM 2.5 dust levels and MDA levels was 0.606, meaning it shows the strength and direction of the linear relationship between the two variables, which was positive, and the significance value (p-value) was 0.000, meaning it was much higher. Small than the significance level α = 0.05, indicating the correlation was statistically significant. Meanwhile, the Pearson correlation coefficient (r) valued between PM 2.5 dust levels and 8-OHdG levels was 0.662, meaning it shows the strength and direction of the linear relationship between two positive variables and p-value a significance of 0. 000, meaning it was much smaller than significance level α= 0.05, indicating the correlation was statistically significant (Alrashed et al., 2021).

Discussion

PM2.5 dust Exposure levels have a significant influence on increasing MDA and 8-OHdG levels. The considerable contribution of exposure to PM2.5 dust was 3.37% towards increasing MDA levels and 87.41% towards increasing 8-OHdG levels. The microscopic size of PM2.5 increases its potential to penetrate deep into the respiratory tract. With a size of 2.5 microns, PM2.5 can enter the circulatory system and even the brain. Short-term symptoms of exposure to high levels of particulate matter include irritation of the throat and airways, coughing, and difficulty breathing (Albano et al., 2022).

The MDA level in the group of workers at the exposed location was 2.1866 ± 1.31478, while the MDA level in the group of workers at the unexposed location was 1.1065 ± 0.45548. Meanwhile, the 8-OHdG level in the group of workers at exposed locations was 29.4923 ± 36.74095, while the 8-OHdG level in the group of workers at unexposed locations was 11.4050 ± 8.81246. Based on this data, categories of oxidative stress levels can be created for workers at locations exposed to PM2.5 dust as follows MDA level Average = 2.1866 and 8-OHdG level Average = 29.4923.

So the categories of oxidative stress levels:

1. Low
   a. MDA level < 1.5
   b. 8-OHdG levels <15
2. Currently
   a. MDA levels 1.5 – 2.5
   b. 8-OHdG levels 15 – 30
3. Tall
   a. MDA level > 2.5
   b. 8-OHdG levels > 30

In workers at exposed locations, an average MDA level of 2.1866 indicates oxidative stress at a moderate level, and an average 8-OHdG level of 29.4923 also indicates oxidative stress at a moderate level. Meanwhile, at unexposed locations, the average MDA level was 1.1065, indicating low-level oxidative stress, and the average 8-OHdG level was 11.4050, also indicating low-level oxidative stress. The combination of markers for MDA and 8-OHdG levels shows that the group of workers at exposed locations experienced higher levels of oxidative stress, namely at a medium level with indications towards high, than the group of workers at unexposed locations who only experienced oxidative stress at low levels (Rovira et al., 2020).

Malondialdehyde (MDA) is the product of lipid peroxidation and is often used as a marker of oxidative stress. Higher MDA levels indicate greater lipid damage, which is caused by exposure to pollutants and hazardous substances in the work environment. This is following research results that show that workers who are exposed to air pollution in their workplace, such as dust and chemicals, tend to experience increased oxidative stress 8-hydroxy-2'-deoxyguanosine (8-OHdG) is a marker of DNA damage due to oxidation. Higher 8-OHdG levels indicate more significant DNA damage, which can be caused by exposure to the same pollutant. This DNA damage has the potential to lead to a variety of health problems, including chronic disease and cancer (Abduh et al., 2023).

CONCLUSION

MDA and 8-OHdG levels in the urine of workers at exposed locations were higher compared to workers at unexposed locations. The average MDA leveled in workers at exposed locations was in the medium category, while the MDA leveled in workers at unexposed locations was in the low category. The average 8-OHdG levels in workers at exposed locations were in the medium category, while those in workers at unexposed locations were in the low category.

REFERENCES

Abduh, M., Alawiyah, T., Apriansyah, G., Sirodj, R. A., & Afgani, M. W. (2023). Survey Design: Cross Sectional dalam Penelitian Kualitatif. *Jurnal Pendidikan Sains Dan Komputer*, *3*(01), 31–39.

Albano, G. D., Gagliardo, R. P., Montalbano, A. M., & Profita, M. (2022). Overview of the mechanisms of oxidative stress: impact in inflammation of the airway diseases. *Antioxidants*, *11*(11), 2237.

Alrashed, M., Tabassum, H., Almuhareb, N., Almutlaq, N., Alamro, W., Alanazi, S. T., Alenazi, F. K., Alahmed, L. B., Al Abudahash, M. M., & Alenzi, N. D. (2021). Assessment of DNA damage in relation to heavy metal induced oxidative stress in females with recurrent pregnancy loss (RPL). *Saudi Journal of Biological Sciences*, *28*(9), 5403–5407.

Amalia, N., & Novianus, C. (2022). Faktor-faktor yang mempengaruhi keluhan saluran pernapasan pada pekerja di PT. X Plant Parung Bogor. *Jurnal Fisioterapi Dan Kesehatan Indonesia*, *2*(1), 32–42.

Avenbuan, O. N., & Zelikoff, J. T. (2020). Woodsmoke and emerging issues. *Current Opinion in Toxicology*, *22*, 12–18.

Ayu, V. A. R. (2021). *Ekspresi 8-OHdG urin pada post tuberkulosis dewasa awal*. Universitas Hasanuddin.

Azizah, I. T. N. (2019). Analysis The Level Of PM2, 5 And Lung Function Of Organic Fertilizer Industry Workers In Nganjuk. *Jurnal Kesehatan Lingkungan*, *11*(2), 141–149.

Burleson, M. (2003). *The ceramic glaze handbook: Materials, techniques, formulas*. Lark Books.

Cáceres, L., Paz, M. L., Garcés, M., Calabró, V., Magnani, N. D., Martinefski, M., Adami, P. V. M., Caltana, L., Tasat, D., & Morelli, L. (2020). NADPH oxidase and mitochondria are relevant sources of superoxide anion in the oxinflammatory response of macrophages exposed to airborne particulate matter. *Ecotoxicology and Environmental Safety*, *205*, 111186.

Creswell, J. W., & Creswell, J. D. (2009). Research Design Qualitative, Quantitative, and Mixed Methods Approaches, 3rd Ed. In *SAGE Publications, Inc*.

Dhingra, S., Gupta, S., & Bhatt, R. (2020). A study of relationship among service quality of E-commerce websites, customer satisfaction, and purchase intention. *International Journal of E-Business Research (IJEBR)*, *16*(3), 42–59.

Feng, R., Xu, H., He, K., Wang, Z., Han, B., Lei, R., Ho, K. F., Niu, X., Sun, J., & Zhang, B. (2021). Effects of domestic solid fuel combustion emissions on the biomarkers of homemakers in rural areas of the Fenwei Plain, China. *Ecotoxicology and Environmental Safety*, *214*, 112104.

Fussell, J. C., & Kelly, F. J. (2020). Oxidative contribution of air pollution to extrinsic skin ageing. *Free Radical Biology and Medicine*, *151*, 111–122.

Gangwar, R. S., Bevan, G. H., Palanivel, R., Das, L., & Rajagopalan, S. (2020). Oxidative stress pathways of air pollution mediated toxicity: Recent insights. *Redox Biology*, *34*, 101545.

Gao, J., Yuan, J., Lei, T., Shen, X., Cui, B., Zhang, F., Ding, W., & Lu, Z. (2020). Metformin protects against PM2. 5-induced lung injury and cardiac dysfunction independent of AMP-activated protein kinase α2. *Redox Biology*, *28*, 101345.

Giakoumi, A., Maggos, T. H., Michopoulos, J., Helmis, C., & Vasilakos, C. H. (2009). PM 2.5 and volatile organic compounds (VOCs) in ambient air: a focus on the effect of meteorology. *Environmental Monitoring and Assessment*, *152*, 83–95.

Lee, K., & Greenstone, M. (2021). Annual update. *Air Quality Life Index*.

Putri, T. E., & Andriansyah, A. (2022). Pengaruh Struktur Modal, Ukuran Perusahaan dan Pertumbuhan Penjualan Terhadap Pertumbuhan Laba. *JASS (Journal of Accounting for Sustainable Society)*, *4*(01), 16–28. https://doi.org/https://doi.org/10.35310/jass.v4i01.969

Rovira, J., Domingo, J. L., & Schuhmacher, M. (2020). Air quality, health impacts and burden of disease due to air pollution (PM10, PM2. 5, NO2 and O3): Application of AirQ+ model to the Camp de Tarragona County (Catalonia, Spain). *Science of the Total Environment*, *703*, 135538.

Wyer, K. E., Kelleghan, D. B., Blanes-Vidal, V., Schauberger, G., & Curran, T. P. (2022). Ammonia emissions from agriculture and their contribution to fine particulate matter: A review of implications for human health. *Journal of Environmental Management*, *323*, 116285.