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Standard Threshold Values and Their Role in Protecting Workers at Power Generation Stations Under Atmospheric Stability Conditions: A Case Study of the Khoms Power Station

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القيم الحدية المعيارية ودورها في حماية العاملين بمحطات توليد الطاقة تحت ظروف الاستقرار الجوي: دراسة حالة محطة الخمس لتوليد الطاقة الكهربائية

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Abstract

Industrial processes based on fuel combustion, such as those employed at the Al-Khoms Power Generation Station, result in the release of significant quantities of various air pollutants, including nitrogen oxides (NO_x), sulfur compounds, and suspended particulate matter. The dispersion of these pollutants in the atmosphere is generally influenced by several meteorological factors, particularly wind speed and direction. However, under certain conditions, air movement may decrease substantially, leading to the accumulation of pollutants in the vicinity of the emission source. This accumulation can significantly increase pollutant concentrations within the workplace environment, posing serious health risks to workers in industrial facilities. This study investigates the extent of pollutant accumulation resulting from emissions released through the stacks of the Al Khoms Power Generation Station under calm-air conditions. The analysis assumes that pollutant emissions remain within the maximum permissible limits established by Egyptian and U.S. environmental standards. The results indicate that compliance with international emission standards alone is insufficient to ensure a safe working environment for personnel in industrial facilities. Therefore, additional preventive and protective measures are required to safeguard workers' health, particularly during periods of atmospheric stability and limited air circulation.

Keywords: *Air pollution, Power station, Calmness, Al-Khoms, Libya.*

الملخص

تعتمد العمليات الصناعية التي تستند إلى احتراق الوقود، مثل محطة الخمس لتوليد الطاقة الكهربائية، على إطلاق كميات كبيرة من الملوثات المختلفة، بما في ذلك أكاسيد النيتروجين والمركبات الكبريتية والمواد الجسيمية العالقة. ويُخفِّف انتشار هذه الملوثات في الغلاف الجوي بفعل عوامل مناخية مختلفة، مثل الرياح. إلا أن سرعة حركة الهواء قد تنخفض بشكل كبير في بعض الحالات، مما يؤدي إلى تراكم هذه الملوثات في محيط مصدر الانبعاث. وينتج عن هذا

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التراكم ارتفاع تركيز الملوثات في بيئة العمل، الأمر الذي يسبب مخاطر صحية جسيمة للعاملين في هذه المنشآت الصناعية. تناولت هذه الدراسة، حساب مدى تراكم الملوثات الناتجة عن مداخن محطة الخمس لتوليد الطاقة الكهربائية خلال ظروف سكون الهواء، بافتراض أن انبعاثات هذه الملوثات تقع ضمن الحدود القصوى المسموح بها وفقًا للمعايير المصرية والأمريكية. وأظهرت النتائج أن الالتزام بالمعايير الدولية الخاصة بالانبعاثات وحده لا يكفي لتوفير بيئة عمل آمنة للعاملين في المنشآت الصناعية، وأنه يجب اتخاذ تدابير احترازية إضافية للحفاظ على صحة العاملين.

الكلمات الدالة: تلوث الهواء، محطة توليد الطاقة الكهربائية، سكون الهواء، الخمس، ليبيا.

1. Introduction

Industrial facilities such as power stations emitted numerous pollutants into the atmosphere. One of the most important pollutants is sulfur dioxide (SO_2), which is emitted from power plants that use fuel containing sulfur. Sulfur dioxide is a colorless gas with a pungent odor that can be detected in the surrounding air through the sense of smell when its concentrations range from 1,000 to 3,000 μg/m^3 (Okasha & Abouzgaya, 2021; Nicholas, 2002). Additionally, nitrogen oxides are also emitted by various factories, accounting for 30% of their non-natural emissions, while 70% is attributed to power generation plants (Cooper & Alley, 1986).

The effects of SO_2 on human health include decreased lung function, increased respiratory diseases, eye and nasal allergies, and throat sensitivity, in addition to premature deaths. Sulfur oxides are particularly hazardous to the elderly and children suffering from respiratory diseases such as asthma, with concentrations of up to 1,000 μg/m^3 over periods exceeding 10 minutes being attributed to these diseases (WHO, 2005). Inhaling sulfur dioxide will dissolve it in the respiratory upper tract's watery fluids and then be absorbed into the bloodstream. Nitrogen oxides also negatively affect the respiratory system's function, especially in adult and pediatric asthma patients, even at low concentrations. One report issued by the World Health Organization (WHO) indicates that the respiratory system's function in asthma patients is affected by the presence of nitrogen dioxide in inhaled air for 30 minutes at low concentrations (560 μg/m^3) (WHO, 2000; World Bank, 1998). Studies conducted on animals have shown that exposure to NO_2 at concentrations at levels around 1,880 μg/m^3, during from several weeks to several months has negative effects on lung function and induces biochemical changes. Animals exposed to concentrations of up to 990 μg/m^{3}of NO_2 for six months suffering tearing in the alveolar walls and an increase in respiratory infections caused by bacterial inflammation (USEPA, 2008; Nicholas, 2002).

The concentration of different pollutants in the work environment primarily depends on the emission quantity and the mitigation processes that occur under the influence of various climatic factors. However, it is observed that there are times when the air is stagnant or nearly stagnant, meaning its speed is less than 1 kilometer per hour. In such cases, the mitigation processes are at its lowest, leading to the accumulation of these pollutants in the work environment and causing significant health hazards to the workers in these industrial facilities (Alhewaimdei & Okasha, 2019; Ibrahim *et al*., 2011). Fine particulate matter, especially those with small particle sizes, can penetrate deeply into the lungs, causing a series of health problems, including: 1) coughing and difficulty breathing, 2) weakened lung function, 3) asthma, 4) acute inflammation of the airways, 5) impaired cardiac function, 6) heart diseases, and 7) premature death (WHO, 2005). Moreover, human health is affected by airborne dust based on the chemical

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composition of the dust, the duration of exposure, and the size of the particles. Dust particles smaller than 10 microns can reach human lungs and cause damage. Scientific studies indicate that there is a statistical relationship between exposure to different concentrations of particulate matter and the mortality rate. Some studies suggested that, low concentrations of particulate pollutants, within the range of 18 $\mu g/m^3$, with particle sizes smaller than 10 microns (PM_{10}), are associated with an increased number of deaths. This concentration is lower than the American national air quality standards (USEPA, 2010). According to Dockery *et al*. (1993), similar risks exist in cities with concentrations below 12.5 $\mu g/m^3$, while the risks of adverse health effects were higher at higher concentrations (i.e., 15 $\mu g/m^3$). WHO air quality guidelines brochures indicate that, the risk of death due to heart and lung diseases can begin to appear with long-term exposure to concentrations of 20 and 10 $\mu g/m^3$ for particles of size 10 and 2.5, respectively. Local studies in Libya were found emission higher concentrations of certain pollutants in the ambient air of some Libyan industrial facilities (Ibrahim *et al*., 2012a & b) concluded that, despite emissions from stacks of Khoms power plant being within permissible limits in several international legislations, there are high possibility of negative health effects on workers under specific climatic conditions, such as calm air movement. Furthermore, a study by Elagouz *et al*. (2014) found high concentrations of certain pollutants in the ambient air, exceeding the permissible exposure limits, in the working environment of the Mellitah Oil and Gas Complex (Elagouz *et al*., 2014). Another study by Okasha (2014) indicated a potential increase in concentrations of nitrogen oxides and sulphur in the ambient air of the city of Khoms due to gaseous emissions from the power plant and cement factories in the city (Okasha, 2014). Moreover, a study by Almakhrom and Altabeeb (2014) showed significant increases in concentrations of hydrogen sulfide gas in the air of the Nafoura oil field, which is operated by the Arabian Gulf Oil Company, exceeding the permissible limits according to international standards issued by the World Health Organization (Ibrahim *et al*., 2012b).

Computer and mathematical models represent the processes of transport, dispersion, and distribution that can occur to air pollutants under the influence of local climatic conditions and emission quantities from various sources. Pollutant dispersion simulation models are used to estimate the contribution of different sources to the pollutants present in the ambient air at any given point. These models can predict the magnitude of change that can occur in the impact of any emission source, such as treatment processes (Okasha *et al*., 2022), on air quality in the affected areas. Additionally, these can be used to estimate the expected impact of any pollution source on air quality during a specific time period or in a particular area in the absence or malfunction of air quality monitoring devices. Therefore, computer simulation is a complementary approach to actual measurements in estimating the impact of different pollution sources on the environment, public health, and the suitability of proposed mitigation measures (Okasha *et al*., 2014). Air pollution modeling is a numerical tool used to describe the causal relationship between emissions, meteorology, atmospheric concentrations, deposition, and other factors. It is known that air pollution measurements provide quantitative information about concentrations and deposition on the ambient air, however, they only describe air quality at specific locations and times, without giving guidance on identifying the causes of an air quality problem, while air pollution modeling can provide more complete description of the air

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quality problem including analysis of factors and causes (emission sources, meteorological processes, physical and chemical changes), some guidance on implementing mitigation measures, and air pollution modeling plays an important role in various scientific fields, due to, its ability to evaluate the relative importance of related processes. Air pollution models are the only method that measures the inevitable relationship between emissions and concentrations and their deposition or location, including their consequences in the past and future and their various scenarios and determining the effectiveness of mitigation strategies. This makes air pollution modeling an indispensable process in many fields such as monitoring and calibration applications, research, etc. (Doost *et al*., 2023; Okasha, 2017). Recently, some computer models specialized in simulating the spread of pollutants in the air have appeared, which are considered of great importance in developing modeling processes. These models are used by a large group of scientists around the world, and some of them are recommended by the US Environmental Protection Agency to simulate the spread and interactions of chemicals such as sulphur dioxide and nitrogen oxides, the most important of which are: These programs are AERMOD; RTDM; CALPUFF and DISPER (Doost *et al*., 2023; Kiaei *et al*., 2023; Slama *et al*., 2022; Okasha, 2014; Larkin et al., 2009; EPA, 2005; Scire *et al*., 1999; Paine & Egan, 1987).

The concentration of different pollutants in the work environment primarily depends on emission quantities and the mitigation processes that occur for these pollutants under the influence of various climatic factors. However, there are times when the air is stagnant or semi-stagnant, meaning that its velocity is less than 1 km/hr. In such cases, the mitigation processes for these pollutants are minimal, resulting in their accumulation in the work environment. This accumulation can cause significant health hazards to workers in these industrial facilities. Therefore, this study aims to assess the extent of gas and particulate pollutants' accumulation resulting from the power plant in the Al-Khoms area under the influence of stagnant air conditions and its impact on the health of the workers at this plant to create a suitable environment for carrying out all tasks safely in accordance with applicable safety standards.

2. Materials and Methods

2.1. Study Location

The study was conducted in the Al-Khoms area, located 120 km east of the city of Tripoli, on the coast of the Mediterranean Sea (Figure 1). The study area is characterized by a Mediterranean climate, with average temperatures reaching around 17°C in winter and 26°C in summer. The average rainfall concentrated in the months from September to March. The prevailing winds are north and west from October to April, while during the summer months (June to August), the wind direction shifts, and the area experiences winds blowing from the south (General Authority of Meteorology).

2.2. Air Pollution Dispersion Treatment

The DISPER V.4.0 software, developed by Canarina Environmental Software in 2007, was used in order to assess the impact of various emission sources on pollutant concentrations in the ambient air, taking into account local weather conditions. In our current study, this software

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was utilized to estimate the dispersion of nitrogen oxides, sulfur dioxide, and particulate matter in the air emitted from the power station.

Figure 1. Map illustrating the study area location (E 13.975 to 14.525 & N 32.725 to 32.475) and major industrial emission sources.

2.3. Data Used in Dispersion Treatment

2.3.1. Emission Sources:

In the dispersion simulation process, it is assumed that, the emission rates of sulfur dioxide, nitrogen oxides, and dust were reached the maximum limit values of both American and Egyptian emission standards. Additionally, the diameter, height of the power station chimneys and gases emission speed and temperature were collected from manufacturing catalogue.

2.3.2. Climatic Data for the Study Area:

Real climatic data representing five years from January 1, 2005, to December 31, 2010, were employed in this study. These data were obtained from the meteorological station located in Al-Khoms (station number 62012). The climatic data were practically utilized to simulate pollutant dispersion during calm wind conditions (wind speeds less than 1 km/h), which were found to occur approximately 13-15% of the time throughout the year based on the analysis of climatic data for the region.

3. Results and Discussion

3.1. Sulfur Dioxide

The results in Figure (2) illustrate that, the concentration of sulfur dioxide in the ambient air at the power station is a significant increases and reaches 1,066 μg/m^3 when the emission rate adhering to the maximum limit values of the American emission standards (Figure 2), while it reaches 3,156 μg/m^3 when this rate adhering to the maximum limit values of the Egyptian emission standards (Figure 3).

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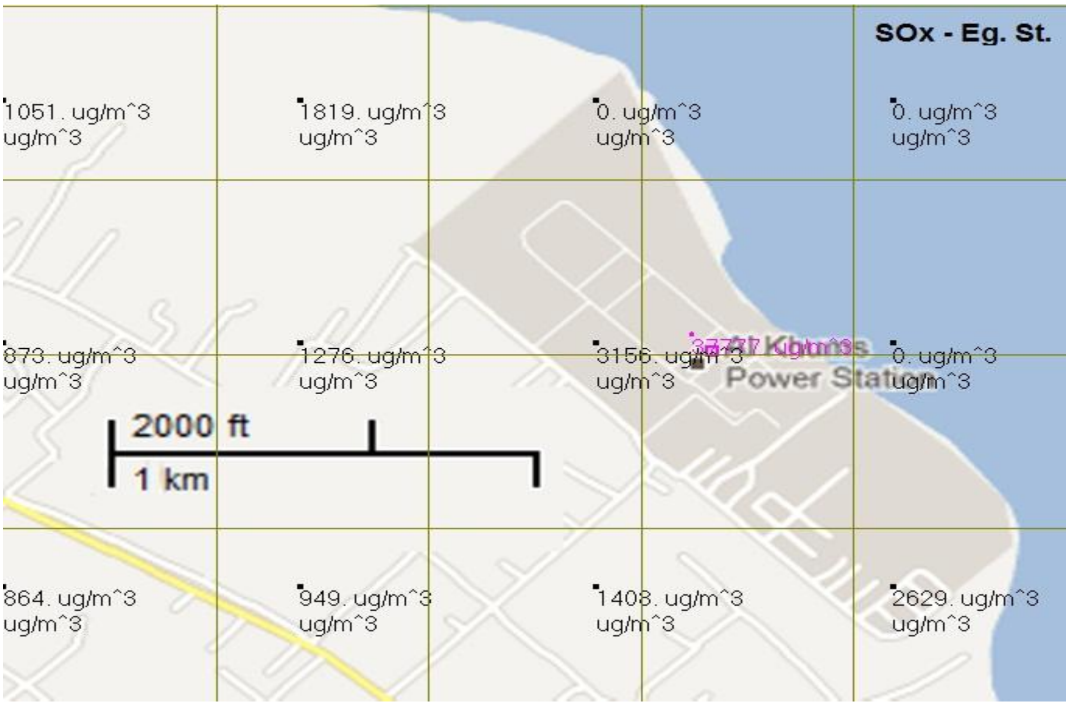

Figure 2. Illustrate the accumulation of sulfur dioxide at Al-Khoms power station under calm atmospheric conditions when emitting quantities of sulfur dioxide that are equivalent to the maximum limit value of the Egyptian standards.

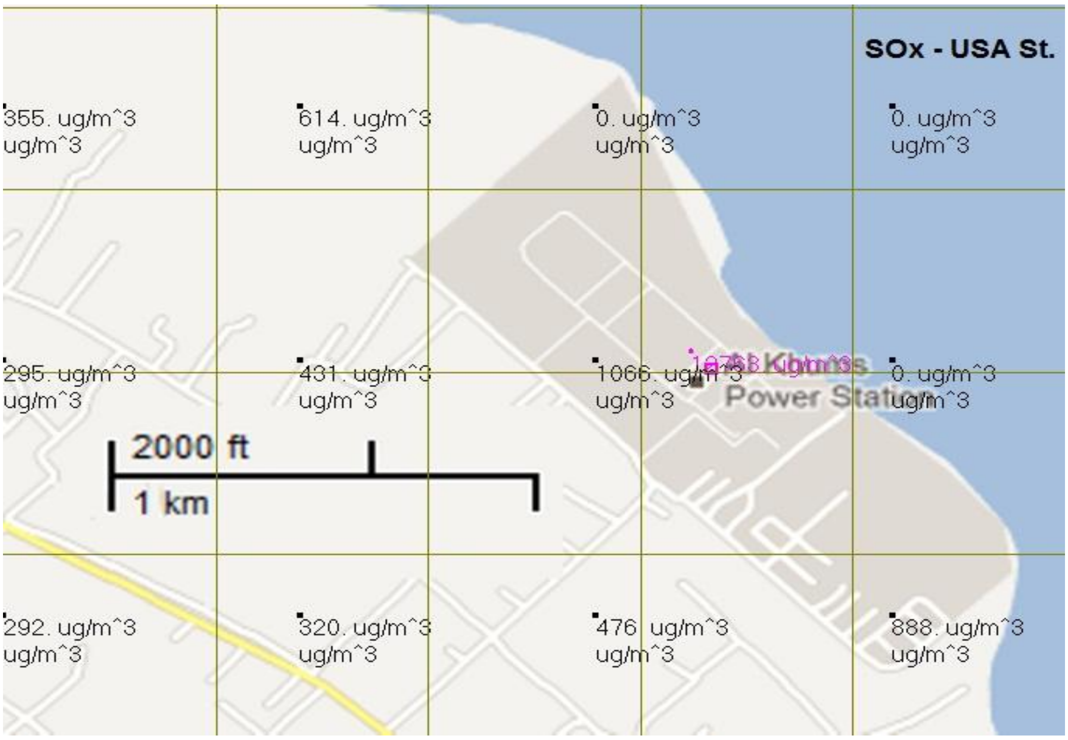

Figure 3: illustrates the accumulation of sulfur dioxide at Al-Khoms power station under calm atmospheric conditions when emitting quantities of sulfur dioxide that are equivalent to the maximum limit value of the American standards.

These results are consistent with the observations in the working environment of the power station and the surrounding areas, where a strong odor of sulfur dioxide is occasionally

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detected. Nicholas (2002) reported that the odor becomes noticeable only when the concentrations exceed 1,000 μg/m^3. The obtained concentrations are sufficient to transform the working environment in the power station into a highly hazardous area for the health of the workers. WHO (2000) and EPA (2008) reported that higher sulfur concentrations in the ambient air can lead to various diseases. Many studies conducted on asthma patients have shown changes in lung function and respiratory symptoms in some individuals after exposure to sulfur dioxide for periods not exceeding 10 minutes. Based on this data, it is recommended not to exceed a concentration of 500 μg/m^3 of sulfur dioxide for an average period of 10 minutes. Furthermore, evidence from the WHO (2010) suggests adverse health effects from exposure to sulfur dioxide for a duration of 24 hrs. at concentrations of 125 μg/m^3.

3.2. Nitrogen Oxides

Experimental studies on humans and animals indicate that the nitrogen oxides become toxic gases with serious health effects when exposed concentrations exceeding 200 μg/m^3 for short periods. Moreover, the presence of nitrogen oxides exacerbates the negative effects of other pollutants such as hydrocarbons, ozone, and sulfur dioxide. Generally, most nitrogen oxides are emitted into the atmosphere as nitrogen dioxide, which quickly oxidizes to form nitrogen dioxide. Nitrogen oxides react with water droplets in the air to form nitric acid and other harmful compounds that pose risks to human health. Inhalation of these compounds can lead to respiratory diseases such as bronchitis and asthma (WHO, 2010; EPA, 2008). Therefore, a limit of 40 μg/m^3 has been set as the annual average that should not be exceeded for nitrogen oxides to protect people from their health effects. If nitrogen oxides are detected as part of the combustion emissions mixture, it is necessary to use the lowest function value as the annual average (WHO, 2005).

From the results presented in Figures (4) and (5), a significant increase in the concentrations of these oxides can be observed in ambient air of the power station under calm atmospheric conditions. The concentrations of nitrogen oxides in the working environment in the power station ambient air reached 3769 and 1393 μg/m^3 when using the maximum allowable concentrations for nitrogen oxide emissions according to the Egyptian and American standards, respectively. These concentrations are extremely high compared to the guidelines of the WHO regarding the limits of long-term and short-term exposure to nitrogen oxides. Several studies have shown that exposure to short-term concentrations of 500 μg/m^3 of nitrogen oxides for one hour is resulting in acute health effects on respiratory functions (WHO, 2005). Furthermore, some studies have indicated that exposure of asthma patients to concentrations of 200 μg/m^3 of nitrogen oxides for short periods can lead to a significant increase in bronchial response to the disease. Therefore, the value of 200 μg/m^3 is considered a threshold value for nitrogen oxides according to the WHO guidelines (Alhewaimdei & Okasha, 2019; Ibrahim *et al*., 2012c; WHO, 2010). Studies also indicate that exposure to short periods (less than 3 hrs.) of nitrogen oxides can lead to respiratory impairment in individuals with respiratory diseases, while long-term exposure can result in permanent pathological changes in lung structure and tissue damage (Slama *et al*., 2022; USEPA, 2008).

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Figure 4. Illustrates the accumulation of nitrogen oxides at Al-Khoms power station under calm atmospheric conditions when emitting quantities equivalent to the maximum limit value of the Egyptian standards.

Figure 5. Depicts the accumulation of Nitrogen oxides at Al-Khoms power station under calm atmospheric conditions when emitting quantities equivalent to the maximum limit value of the American standards

3.3. Dust

Figures (6) and (7) illustrate the concentrations of particulate matter in the working environment of the power station ambient air when emissions are equal to the maximum allowable limit

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according to the Egyptian and American standards, respectively. These results show a significant increase in the concentrations of these particles, reaching 384 µg/m³ and 156 µg/m³ for each case, respectively. These concentrations are considered extremely hazardous to the workers at this station, as international bulletins indicate that solid particles, especially fine particles, can penetrate deep into the lungs, causing a range of health problems such as coughing, difficulty breathing, decreased lung function, asthma, acute inflammation of the airways, cardiac impairment, heart diseases, and premature death (Ibrahim *et al*., 2022; Okasha and Abouzgaya, 2021; USEPA, 2008).

Figure 6. Illustrates the accumulation of solid particles at the Five Power Station when the ambient air is calm and emissions are equal to the maximum allowable limit according to the Egyptian standards

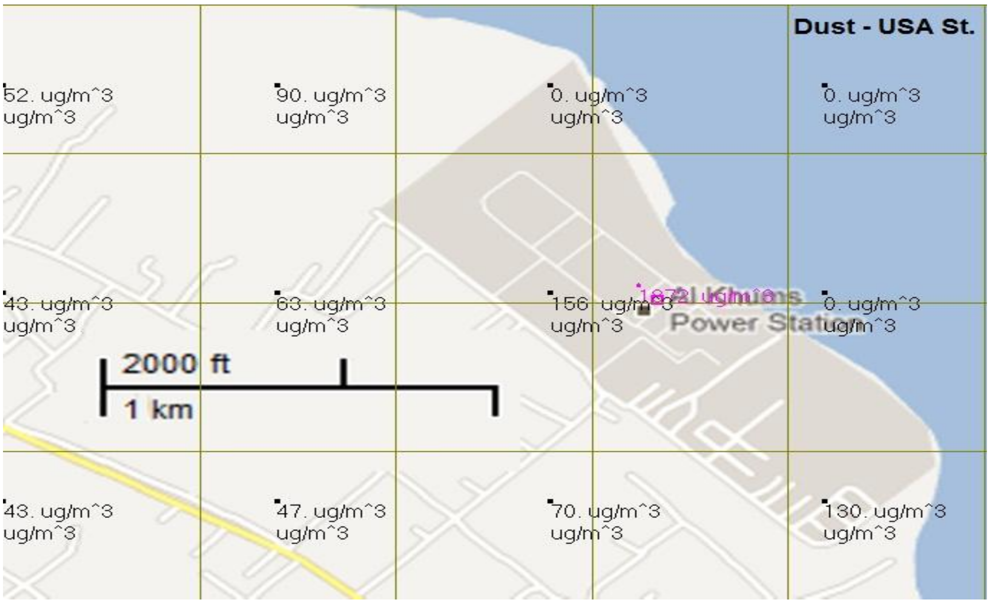

Figure 7. Illustrates the accumulation of solid particles at the Five Power Station under calm atmospheric conditions when emissions reach levels equivalent to the maximum allowable limit according to the American standards

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Therefore, an annual average concentration of 10 µg/m³ was chosen as a long-term indicator value for particulate matter 2.5. This average represents the minimum final value of a set of values that were observed to have significant effects on survival, according to a study conducted by the American Cancer Society (Pope *et al*., 2002).

Studies conducted by Pope *et al*. (2002) on six cities indicate strong associations between mortality rates and long-term exposure to particulate matter 2.5 at concentrations of 18 and 20 µg/m³, respectively, for Harvard University and the American Cancer Society. According to the results of a study by Dockery *et al*. (1993), similar risks exist in cities with concentrations below 12.5 µg/m³, while the risks of adverse health effects are higher with higher concentrations (i.e., 15 µg/m³). The fact sheets related to the WHO's air quality guidelines indicate that the risk of death from heart and lung diseases can start to appear with long-term exposure to concentrations of 20 and 10 µg/m³ for particulate matter 10 and 2.5, respectively. Scientifically, there are numerous studies linking higher exposure rates to particulate matter in the air with increased rates of respiratory system injuries and eye inflammations (ULM, 1994; World Bank, 1998). Furthermore, studies examining the effects of short-term exposure to particulate matter have shown significant negative impacts on public health. For example, studies conducted in 29 European cities and 20 American cities have found clear associations between short-term exposure to particulate matter and subsequent mortality rates, with increases of 0.62% and 0.46% per 10 µg/m³ (24-hour average), respectively (Samet *et al*., 2000; Katsouyanni *et al*., 2001). In 29 cities outside Western Europe and North America, the percentage reached 0.5% per 10 µg/m³ (Cohen *et al*., 2004). The results indicate similar health risks associated with short-term exposure to particulate matter 10 in both developed and developing countries, with an increased rate of 0.5% for every 10 µg/m³ increase in daily concentration.

4. Conclusions

Since exposure to elevated concentrations of air pollutants is strongly influenced by prevailing meteorological conditions, particularly during periods of atmospheric stability and low wind speeds that promote the accumulation of pollutants within the workplace environment, additional protective measures are necessary to safeguard workers' health. Based on the findings of this study, it is recommended that power generation stations and other industrial facilities be equipped with an integrated early-warning system linked to a meteorological monitoring network and/or a continuous air-quality monitoring system capable of detecting pollutant concentrations in real time. Furthermore, workers should be provided with appropriate personal protective equipment (PPE), including suitable respiratory protection, and its use should be mandatory whenever pollutant concentrations reach critical levels or when warning alarms are activated. These measures would contribute significantly to reducing occupational exposure risks and enhancing workplace safety under adverse atmospheric conditions.

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References

Alhuweemdi, S., & Okasha, A. Y. (2019). Effect of Sulfur Dioxide Emissions from Mellitah Oil and Gas Complex on Air Quality in Neighboring Cities. *Journal of Marine Sciences and Environmental Technologies*, 5(1), A. 44-54 [*In Arabic*].

Cohen, A. J., Anderson, H. R., Ostro, B., Pandey, K. D., Krzyzanowski, M., Kuenzli, N., Gutschmidt, K., Pope, C. A., Romieu, I., Samet, J. M., & Smith, K. R. (2004). Mortality Impacts of Urban Air Pollution. In: *Comparative Quantification of Health Risks: Global and Regional Burden of Disease Due to Selected Major Risk Factors*, (Eds.) Ezzati, M., Lopez, AD, Rodgers, A. & Murray, *CUJL*, 2, pp.,1353-1433.

Cooper, C. D., & Alley, F. C. (2010). *Air pollution control: A design approach*. Waveland press.

Dockery, D. W., Pope, C. A., Xu, X., Spengler, J. D., Ware, J. H., Fay, M. E., Ferris, B., & Speizer, F. E. (1993). An association between air pollution and mortality in six US cities. *New England Journal of Medicine*, 329(24), 1753-1759.

Eslami Doost, Z., Dehghani, S., Samaei, M. R., Arabzadeh, M., Baghapour, M. A., Hashemi, H., Oskoei, V., Mohammadpour, A., & De Marcoc, A. (2024). Dispersion of SO_2 emissions in a gas refinery by AERMOD modeling and human health risk: a case study in the Middle East. *International Journal of Environmental Health Research*, *34*(2), 1227-1240.

Ibrahim, H. G., Elatrash, M. S., & Okasha, A. Y. (2011). Steam Power Plant Design Upgrading (Case Study: Khoms Steam Power Plant). *Energy and Environment Research*, 1(1), 202-211.

Ibrahim, H. G., Okasha, A. Y., Elatrash, M. S., & Al-Meshragi, M. A. (2012a). Investigation of SO_2 and NOx Emissions from Khoms Power Stations in Libya. *2012 International Conference on Environmental, Biomedical and Biotechnology*, 41, 191-195.

Ibrahim, H. G., Okasha, A. Y., Elatrash, M. S., & Al-Meshragi, M. A. (2012b). Computer assessment of SO2 and NOx emitted from Khoms power station in north-western Libya. *International Journal of Modern Engineering Sciences*, 1(1), 45-54.

Ibrahim, H. G., Okasha, A. Y., Elatrash, M. S., & Al-Meshragi, M. A. (2012c). Emissions of SO_2, NOx and PMs from cement plant in vicinity of Khoms city in Northwestern Libya. *Journal of Environmental Science and Engineering A*, 1(5A), 620-628.

Ibrahim, H.G., Alhewaimdei, S.O., Okasha, A.O., Elshhomi, M., Maraie, A., & Aloways, A. (2022). Levels and Sources of Heavy Metals in the Dust at the Libyan Iron and Steel Company Area and the Surrounding Zone. *Libyan Journal of Ecological & Environmental Sciences and Technology*, Special issue, 151-164.

Ibrahim, H.G., Alhewaimdei, S.O., Okasha, A.O., Elshhomi, M., Maraie, A., & Aloways, A. (2022). Levels and Sources of Heavy Metals in the Dust at the Libyan Iron and Steel Company Area and the Surrounding Zone. *Libyan Journal of Ecological & Environmental Sciences and Technology*, Special issue, 151-164.

Kiaei, R., Pardakhti, A., & Zahed, M. A. (2023). Human health risk assessment for NO_2, SO_2 and CO emissions from a refinery using CALPUFF; A case study Kangan, Iran. *Research Square*. Available online at: [https://doi.org/10.21203/rs.3.rs-3166851/v1].

Nicholas, P. C., (2002). *Handbook of Air Pollution Prevention and control*. Butterworth-Heinemann, Elsevier Science, USA.

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

Okasha, A. Y. & Abouzgaya, K. (2021). Environmental situation in the area surrounding the Libyan Iron and Steel Company. *Conference on Environmental Effects of Pollution*, December 5-7, 2021, Tripoli, Libya.

Okasha, A. Y. (2014). Main Industry Stack Emissions Dispersion Over Khoms City in North-Western Libya. *International Journal of Innovative Science, Engineering & Technology*, 1(10), 635-641.

Okasha, A. Y. (2017). The effect of Vegetation Cover to Mitigation of Pollutant Emissions from Industrial Sources in the Khoms Region, Northwest Libya. *Jordan Journal of Agricultural Sciences*, 13(2), 275-285. [*In Arabic*]

Okasha, A. Y., Elatrash, M., & Elhoimdi, S. (2014). A Comparative Study of International Standards of power plant Industrial Emissions, *Proceedings of 2nd International Petroleum Environmental Conference and Exhibition*, 17-19/6/2014, Tripoli, Libya.

Okasha, A., Nasser, D., Abu-Arabia, H., & Elatrash, M. (2021). Effect of Khoms power station stack emission impact on the ancient city of Leptis Magna, Libya. *An-Najah University Journal for Research-A (Natural Sciences)*, 36(1), 109-132.

Pope, C. A., Burnett, R. T., Thun, M. J., Calle, E. E., Krewski, D., Ito, K., & Thurston, G. D. (2002). Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. *Jama*, 287(9), 1132-1141.

Samet, J. M., Zeger, S. L., Dominici, F., Curriero, F., Coursac, I., Dockery, D. W., ... & Zanobetti, A. (2000). The national morbidity, mortality, and air pollution study. *Part II: morbidity and mortality from air pollution in the United States Res Rep Health Eff Inst*, *94*(pt 2), 5-79.

Slama, F. A., Aboabboud, M. M., & Ibrahim, H. G. (2022). Simulation of the Emission and Dispersion of Gaseous Pollutants Emitted from Power Plant and the Potential Environmental Impacts: A Case Study. *Journal of Marine Sciences and Environmental Technologies*, 8(2), E. 39-56.

Ulm, K. (1994). *Epidemiology of chronic dust exposure. Toxic Carcinogenic Effects of Solid Particles in the Respiratory Tract*. International Life Sciences Institute, Washington, DC.

USEPA (2008). *National Ambient Air quality standards (NAAQS)*. U.S. Environmental Protection Agency. Available online at: [http://www.epa.gov/air/criteria.html].

USEPA (2010). *National Emission Standards for Hazardous Air Pollutants from the Portland Cement Manufacturing Industry and Standards of Performance for Portland Cement Plants*. Environmental Protection Agency, Federal Register, 75 (174) Rules and Regulations, USA.

WHO (2000). Air Quality Guidelines for Europe, 2nd ed. WHO Regional Publications, European Series 91. Regional Office for Europe, World Health Organization, Copenhagen.

WHO (2005). *Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulphur Dioxide - Global*. World Health Organization, Geneva. Available online at: [http://whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf].

WHO (2010). *Air Quality Guidelines for Europe*. World Health Organization, Geneva. Available online at: [http://www.who.dk/InformationSources/Publications/Catalogue/20010910_6].

World Bank (1998). *Pollution Prevention and Abatement Handbook*. WORLD BANK GROUP.