ASSESSMENT OF INDOOR AIR POLLUTION LEVELS WITH GASES IN THE LIBYAN IRON AND STEEL COMPANY

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ABSTRACT

The study aims to analyze and evaluate the levels of indoor air pollution with gases in Libyan iron and steel company. The study used the descriptive analytical method to analyze the data and record the results. The study found that the average concentrations of nitrogen oxides reached about 24 micrograms/m^3 over the various areas inside the factories, which is a rate considered good and falls within the framework of international values and regulations for globally accepted and healthy air quality issued by the World Health Organization (WHO), which indicates It concluded that the level of emissions of nitrogen oxides into the environment does not exceed 40 micrograms/m^3, and it also concluded that carbon monoxide (CO) was one of the most common types of gases emitted within the factories of the Libyan Iron and Steel Company in Misrata, where emissions from the various factories amounted to about 118,213.7 mg/ m^3, The results also concluded that the air quality index in the city of Misrata, Libya, on July 23, 2023, reached 74 degrees, which is an average score for air quality according to the US Environmental Protection Agency (2009) classification, and therefore falls into the second category, which ranges from 51 to 100.
Keywords : Air pollution, sustainable development, air quality index, gases, and air pollution costs, Libyan Iron and Steel Company, Misrata.

INTRODUCTION

Air pollution is one of the most serious problems facing living organisms and the ecosystem in general and humans in particular, it needs to demonstrate all efforts to address and reduce it, and despite that, man is working to increase air pollution rates as a result of his activities. Air pollution threatens human life and causes a change in the natural balance of the environment and its various components, living and non-living. Air pollution is defined as "a defect in the air ecosystem as a result of the release of large quantities of gaseous and solid elements, which leads to a significant change in the properties and size of

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air elements", many of which turn from useful and life-making elements to harmful elements (pollutants) that cause a lot of damage and risks (Abdel Sahib, 2018)

The levels of indoor air pollution vary with gases and particles sent by the chimneys of iron and steel companies and many other sources, and these emissions of gases are toxic and harmful, which cause diseases to humans in the long term, including tracheal and lung diseases, chronic pneumonia, respiratory deficit, poisonings, cancer, and others, and affects badly and seriously in the heart and blood, The more the composition or composition of the components of the air is disturbed, the more harmful and polluted and, in the case of the spread of suspended particles and gases, whenever it negatively affects the environment and human health (Amirkhani et al., 2020; Kazem, 2022).

Iron and steel factories in Misrata, Libya, are one of the most important reasons for the increase in environmental pollution in the country. The Libyan Iron and Steel Company in Misrata has implemented several projects towards environmental sustainability, including an asbestos treatment project and a project to replace halon gas used in firefighting with environmentally friendly gases. The company is also currently working on establishing an environmental monitoring center and providing it with all its equipment and devices, in addition to renewing pollution control systems in factories and facilities (Al-Darwish and Al-Jamal, 2021).

According to an estimate by the Industrial Development Organization, the added value of the most environmentally polluting industries in developing countries has increased, at least by double the rate of its increase in developed countries. The iron and steel industry, for which local and global demand is increasing, is considered one of the industries that pollute the environment and air the most after the cement industry. Most developed countries want to resettle this environmentally polluting industry in developing countries (Abdel-Gawad, 2019).

Monitoring local air quality by governmental and non-governmental agencies is a way to overcome the lack of information and awareness of air quality. As a result of technological development, it has allowed for the easy deployment of low-cost air quality

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monitoring devices that can be converted into public reports at stations. The more stations are connected to the Internet, more air quality data is available, helping researchers, policy makers, and communities create knowledge, awareness, and work toward cleaner air and healthier communities (IQAir, 2021).

The study sought to achieve its main objective by assessing the levels of indoor air pollution with gases and particles in Libyan iron and steel company in their various factories, and identifying the pollutants that were most concentrated and harmful to the health of workers. Carbon monoxide (CO) is one of the most emitted types of gases within the factories of the Libyan Iron and Steel Company in Misrata. The study adopted other goals that it will achieve, the most important of which are reducing emissions, whether suspended particles or gases emerging from the company's chimneys, preserving the health of workers, reducing their infection rates, and providing a healthy work environment.

Emissions of sulfur dioxide and nitrogen oxides have been determined, according to the US Environmental Protection Agency, at approximately 30 and 53 µg/m^3 for both compounds, respectively, while the European Commission for the Environment (ECE) has approved sulfur dioxide as 350/1 hour or 150/24 hour, and approximately 20 / year µg/m^3, and for nitrogen oxides it was 200/1 hour, or 40 / year µg/m^3, while for the World Health Organization (WHO), sulfur dioxide was 20/24 hours or 500/10 minutes µg/m^3, while private emissions were With nitrogen oxides, it was 200/1 hour or 40 / year µg/m^3, while Egypt and Libya had the same international legal rates for gas emissions of sulfur dioxide and nitrogen oxides, where the rates of sulfur dioxide reached 350/1 hour or 150/24 hour or 60 / year µg/m^3, while the rates of nitrogen oxides were 150/24 hour or 400/1 hour µg/m^3, at the level of the two countries.

MATERIALS AND METHODS

Sampling Site: The company's various factories are located in Qasr Ahmed area to the east of the city of Misrata. The company's location is about 12 km from the city center, and the company's area is estimated at about 1,200 hectares. The number of factories affiliated with

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the company is estimated at 12 factories with chimneys for different purposes and outputs. Figure (1) shows the geographic map of the company's emissions monitoring points and their clear points in the industrial area, through Google Maps.

Figure (1): A map of the study site showing the monitoring points that were approved to measure the company's emissions and the points surrounding it in the industrial area.

Sample Collection: The study was carried out in the area surrounding the headquarters of the Libyan Iron and Steel Company in the Qasr Ahmed area in the city of Misrata.

The 15 monitoring points were distributed inside the company and on the perimeter of its wall from the inside and in all directions, and monitoring points next to, above and inside the company's radioactive sources warehouse, and near scrap yards and solid waste collection places. Measurements were taken for (5) replicates at each point, Measurements were taken in all seasons of the year, starting from spring to winter, repeatedly at a rate of 4 to 6 rounds in each season from all the points mentioned previously, noting that the measurements are made below the direction of the wind at the time of measurement so as to ensure that the wind passes over the company's site on its way to the points. Monitoring: Due to the security conditions the country witnessed, samples were taken during daylight hours from eight in the morning until five in the evening (Okasha et al., 2021).

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Methods

Indoor air pollution measurements included some important pollutants and some specialized devices were used for each pollutant separately, as follows:

Measuring emissions of carbon monoxide and dioxide (CO, CO_2), sulfur dioxide SO_2,and hydrogen sulfide H_2S:

A multi-functional gas measuring device of the GX6000 type was used, which can measure 6 gases at the same time because it contains a variety of sensors. The device contains an electrochemical-type sensor to measure concentrations of different gases. Japan is considered its country of origin.

RESULTS AND DISCUSSION

1- Nitrogen oxide rates in the Libyan Iron and Steel Company according to different areas:

Nitrogen oxides are among the most common types of oxides emitted from the Iron and Steel Company's factories, and their results vary from one factory to another according to the type of manufacturing, the production method, and the measured internal area, The 15 observation points were distributed over an area ranging from 100 to 2000 meters, 95% indicates the confidence coefficient for the parameters, and indicates the level of certainty of the accuracy of the estimate or prediction. It is usually expressed as a percentage, with the most common confidence level being 95%. Confidence intervals are used to quantify uncertainty about a sample statistic, such as the mean or median. and can be clarified through the following table:

Table (1) shows the emissions of nitrogen oxides in the Libyan Iron and Steel Company according to different areas 2021:

LEVEL OF FACTOR	N	NOX	KNOX	NOX	KNOX	KNOX
		Mean	Std.Dev.	Std.Err	-95.00%	+95.00%
100	24	24	26	5	12	35
500	24	23	15	3	17	29
1000	24	19	14	3	13	25
2000	24	16	16	3	9	23

It is clear from the previous table that the average concentrations of nitrogen oxides reached about 24 micrograms/m^3 over the different areas inside the factory, which is a rate that is considered good and falls within the framework of international values and regulations for globally accepted and healthy air quality issued by the World Health Organization (WHO), which indicates The level of nitrogen oxide emissions in the environment does not exceed 40 micrograms/m^3 on an annual average (WHO, 2010), and it is also clear that the results of the statistical analysis of the measurements were highly significant ($p<0.05$).

At some monitoring points, concentrations exceeded the permissible annual rate of exposure to it according to the World Health Organization bulletin, as high concentrations were at the RO2 and RSE monitoring points located within the company's site in the center and on the southeastern side.

2- Measurements of gases polluting indoor air within the Libyan Iron and Steel Company :

Measurements carried out within the company reached several results for each element of greenhouse gases and air pollutants, which are:

Many international organizations have been interested in setting standards for air pollution with gases, particles, and other pollutants, in order to preserve the environment, global health, and maintain the purity of the air. Given the seriousness of the matter, the United States Environmental Protection Agency (USEPA), the European Commission for the Environment (ECE), and the United States Environmental Protection Agency (ECE) have set standards. World Health Organization (WHO), in addition to some regulations in Egypt and Libya, can be clarified through the following table:

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Table (2): Limit values of gaseous pollutant concentrations for air quality in some international regulations

STANDARD / EMISSIONS	US EPA	ECE	WHO	EGYPT	LIBYA
So_2	30 µg/m^3	350/1 hour 150/24 hour 20 / year µg/m^3	20/24 hour 500/10 Minutes µg/m^3	350/1 hour 150/24 hour 60 / year µg/m^3	350/1 hour 150/24 hour 60 / year µg/m^3
Knox	53 µg/m^3	200/1 hour 40 / year µg/m^3	200/1 hour 40 / year µg/m^3	150/24 hour 400/1 hour µg/m^3	150/24 hour 400/1 hour µg/m^3

Source: Okasha et al., (2021), The Radiological Background Inside and Outside the Libyan Iron and Steel Company in Misrata City, Northwest of Libya. *ARID International Journal for Science and Technology (AIJST)* VOL. 4, and NO.8, p.158.

Emissions of sulfur dioxide and nitrogen oxides have been determined, according to the US Environmental Protection Agency, at approximately 30 and 53 µg/m3 for both compounds, respectively, while the European Commission for the Environment (ECE) has approved sulfur dioxide as 350/1 hour or 150/24 hour, and approximately 20 / year µg/m3, and for nitrogen oxides it was 200/1 hour, or 40 / year µg/m3, while for the World Health Organization (WHO), sulfur dioxide was 20/24 hours or 500/10 minutes µg/m3, while private emissions were with nitrogen oxides, it was 200/1 hour or 40 / year µg/m3, while Egypt and Libya had the same international legal rates for gas emissions of sulfur dioxide and nitrogen oxides, where the rates of sulfur dioxide reached 350/1 hour or 150/24 hour or 60 / year µg/m3, while the rates of nitrogen oxides were 150/24 hour or 400/1 hour µg/m3, at the level of the two countries.

The measurements of emissions were taken from the company's factories to analyze their percentage and compare them with the international measurements allowed above, and Presented in table (3):

Table (3): Average concentrations of pollutants emitted within the factories of the Libyan Iron and Steel Company 2021.

FACTORY	CO	CO_2	SO_2	NOX
	mg/m^3	%	mg/m^3	mg/m^3
The third unit gas plant - reduction plant	8129	11.2	Nd	43.4
lime factory	422	2.6	0.76	19.5
Steel Factory No. (1)	21.5	0.26	Nd	7.53
Steel Factory No. (2)	101.2	0.19	Nd	2.86
The first line - bars and skewers factory	Nd	2.58	Nd	30.2
The second line - bars and skewers factory	Nd	1.9	Nd	28.3
double line -Rails Factory and skewers	100	2.9	0.14	40.3
Sectors Factory	Nd	2.9	7.9	82.7
rolling mill on Direct - Chimney (1)	Nd	7.7	Nd	77
rolling mill on Direct - Chimney (2)	Nd	7.7	Nd	77
Boiler No. (2) electricity station	Nd	8.5	Nd	136
Boiler No. (5) electricity station	Nd	7.1	Nd	162
Boiler No. (3) desalination station	34921	10.2	Nd	49.1
Boiler No. (5) desalination station	40157	10.1	Nd	40
Boiler No. (6) desalination station	26411	10.5	Nd	60.6
Boiler No. (7) desalination station	7394	9.6	Nd	50
Boiler No. (8) desalination station	557	9.3	Nd	61
Bar Factory (2)	Nd	3.5	Nd	39.5

As indicated by the authors they measured 5 duplicates at each point and they may give the average in Table 3. Please put the standard deviation values for the measurements.

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Nitrogen oxides (NOX), their emission rates vary in all factories of the Libyan Iron and Steel Company, and the highest percentage of emission of this gas from the chimney of boiler No. 5 at the power station was about 162 mg/m^3, and came in second place as the second largest volume of nitrogen oxides gas emissions from boiler No. 2 at the power station by about 136 mg/m^3. This means that the electric power plant caused the spread and large emissions of these oxides, not to mention that the control points showed that this rise in the two factories increased significantly as a result of the presence of a scrap shearing yard through which a range of different emissions are produced, and these emissions can negatively affect the health of workers within the company, and by comparing the emissions from these two factories with international standards and regulations, we find that they are exaggeratedly higher than international rates, while it ranked last as the lowest volume of emissions of NOX gases in both Steel Plants No. 1 and No. 2 by about 7.53 mg/m^3 and 2.86 mg/m^3 respectively, and these values are within very safe limits compared to international standards and regulations.

Sulfur dioxide (SO_2), it is clear through measurements that the volume of emissions of this gas is not present in most factories, but it is clearly shown through the sectors factory as the highest volume of emissions by about 7.9 mg / m^3, while emissions from the lime plant came as the second largest emissions of 0.76 mg / m^3, and in last place were emissions from the double line of the rods and skewers factory by about 0.14 mg / m^3. Comparing these rates with international rates, we find that their percentage is very small, as international standards and regulations stipulate the acceptance of 30 mg/m^3 of emissions of this gas according to the US Environmental Protection Agency or 20 mg/m^3 per year according to the European Commission's environmental standards, and the reason for this low rate is due to the company's use of environmentally clean technologies and the use of fuels containing low sulfur.

Carbon dioxide gas (CO_2), the most volume of emissions from factories was in the third unit gas plant (reduction plant), at a rate of 11.2% of the total emissions, and the boiler plant No. (6) At the desalination plant came as the second largest factory in carbon dioxide (CO_2)

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emissions by about 10.5%. It ranked last as the lowest volume of emissions of CO_2 gases in both steel plants No. 1 and No. 2 by about 0.26% and 0.19% respectively, and these values are within very safe limits compared to international standards and regulations, and this indicates the use of production methods of clean fuels.

Carbon monoxide (CO), it is clear through measurements that the volume of emissions of this gas is not present in most factories, but it is clearly shown by boiler plant No. 5 in the desalination plant at about 40157 mg/m^3. While carbon monoxide emissions from boiler plant No. 3 at the desalination plant came in second place with about 34,921 mg/m^3, and by comparing these rates with international standards, we find that they have risen significantly, while the lowest measurements came in the steel plant No. 1 at about 21.5 mg/m^3.

From the above, we conclude that: the emissions resulting from carbon monoxide (CO) gas were very high, and the most types of gases emitted from various factories had a total volume of emissions estimated at 118213.7 mg/m^3, and nitrogen oxides (NOX) emissions came in second place by about 1006.99 mg/m^3, and in third and last place came sulfur dioxide gas (SO_2) with a total volume of emissions estimated at 8.8 mg/m^3.

The most factories responsible for these different emissions were both boiler factories No. 5, and No. 2 at the power station, which are responsible for the production of nitrogen oxides, then the sectors and lime manufacturers responsible for the production of sulfur dioxide gas, followed by the third unit gas plants (reduction plant), and the boiler plant No. (6) in the desalination plant, then both boiler factories No. 5 in the desalination plant, and the boiler plant No. 3 in the desalination plant, while we find that the lowest emissions of various gases were in the steel plants No. 1 and No. 2, rods and skewers factory.

3- Discussing the results of previous studies:

By comparing the results of the current study with previous studies that dealt with assessing levels of air pollution with gases, it turns out that the results presented in the study (Ben Orabi, 2023) revealed the behavior of the monthly carbon dioxide concentration, as maximum values were recorded in their entirety. This increase in the CO_2 concentration is due to the weather conditions in this region including high temperature and lack of wind

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blowing, which in turn reduces the strength of atmospheric emissions. This is explained by the high CO_2 values within the production units. In general, and based on the statistical study, the carbon dioxide concentration content exceeds the permissible values given the standard. NBN EN 13779 which suggests a maximum of 1000 ppm (Ben Orabi, 2023)

It turns out that a study prepared by the annual report for the year 2020 according to the Hashemite Region has shown that monitoring of gaseous pollutants in the region has shown high levels of carbon monoxide and carbon dioxide, and their percentages have increased in the two monitoring sites in the governorate, and as for nitrogen oxides, they have shown a slight decrease, and the study has monitored a decrease. A slight increase in hydrogen sulfide gas. The study also witnessed an increase in SO_2 gas in the two study sites, but it remained within the annual limit stipulated in Jordanian Technical Regulation No. 1140/2006 (Ministry of Environment of Jordan, 2020)

While the study by (Al-Shammari, 2020), which this study aimed to evaluate air pollution in urban centers in Wasit Governorate, showed (40) sites were identified to measure concentrations of air pollutants, and the measurement results showed high concentrations of particulate pollutants and heavy metals, exceeding environmental determinants in most measurement sites, especially in During the summer season, as the concentrations of some TSP were above the standard limits in all locations, the study revealed high concentrations of pollutant gases within the permissible environmental parameters. The study revealed that the highest concentrations of pollutants were recorded to detect (AQI) in industrial and traffic sites, and the Air Quality Index was used. (Al-Shammari, 2020)

It was found through a study (Al-Zboon and Forton, 2019) that carbon dioxide emissions at all measurement points in the vicinity of the outside air were the most polluting type of emissions, as they ranged from 356 parts per million in the slag casting area to 410 parts per million in the area. casting, while its percentage in the indoor air in the fusion zone increased by about 398 parts per million, while the concentration of carbon monoxide gas was zero because this gas turns into carbon dioxide as a result of refining and smelting

operations, while nitrogen dioxide emissions came as the second most common type. Gases emitted by the company, The NO2 concentration ranged from 0.07 in the scrap yard to 0.49 ppm in the scrap yard. The furnace space compared to 0.05 in the ambient air. The lowest level was detected in the loading, casting and slag areas, while the lowest level was in the cooling area. In the furnace zone, nitrogen dioxide is generated through two processes, the initiation of the smelting process, and through the after-combustion of carbon and hydrogen oxides inside and outside the furnace. About half of the sulfur dioxide produced in the steel industry results from the oxidation of sulfur during the sintering and pelletizing process. The concentration of sulfur dioxide ranged from 0.02 in the cooling zone to 0.27 ppm in the furnace (melting) zone, and the loading and casting areas also had a high concentration (0.22 and 0.18 ppm respectively) which indicates a high increase compared to the ambient level of 0.02 ppm. (Al-Zboon and Forton, 2019)

The results of the study (Argunhan and Avci 2018) also confirmed that Average indoor carbon dioxide (CO_2) value is higher than the ASHRAE standards. This is caused due to closed doors and windows in winters. The decrease in CO_2 level in spring shows that there is air ventilation in classrooms, even it is not sufficient. An air ventilation system must be constructed to prevent the exceeding indoor CO_2 levels convenient to standards. (Abdullah *et al*., 2019: Argunhan and Avci 2018; Peng et al., 2017).

Al-Dahidhawi's study (2015) also aimed to spatially analyze air pollution in the Najaf Governorate by detecting the concentrations of air pollutants and their spatial and temporal variation and comparing the results with environmental determinants. The study revealed a clear spatial and temporal variation in the concentrations of pollutants, and that some of them exceeded the permissible limits, such as (NO_2, SO_2, CO, O_3,TSP, Pb, Cd) and the association of these concentrations with natural and human sources. The study also revealed that most of the studied sites are contaminated with the dangerous elements Cd and Pb, as specialists who study environmental pollution consider them to be among the big three, along with mercury. The study concluded that More than 83.7% of the studied sites were polluted with SO_2 gas, as the concentrations and recorded sites exceeded the permissible

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limits nationally and internationally. There is also a strong relationship between SO_2 concentrations that witness heavy traffic (crowded intersections) and the locations of generators and laboratories, especially brick laboratories (Al-Dahidhawi, 2015)

CONCLUSION

Measurements showed that the average concentrations of nitrogen oxides reached about 24 micrograms/m^3 over the various areas inside the factory, which was a good rate and falls within the framework of international values and regulations for globally recognized and healthy air quality issued by the World Health Organization. The World Health Organization indicates that the level of emissions of nitrogen oxides into the environment does not exceed 40 µg/m^3 on average. Carbon monoxide (CO) is one of the most common types of gases emitted by various factories, with a total volume of emissions estimated at 118,213.7 mg/m^3, and nitrogen oxide emissions (NOX) came in second place at about 1006.99 mg/m^3, and came in third place. The last is sulfur dioxide gas (SO_2), and the total volume of emissions is estimated at 8.8 mg/m^3.The most responsible factories for nitrogen oxides emissions are boiler No. 5 and No. 2 at the power station, then the sectors and lime factories responsible for producing sulfur dioxide gas, followed by the third unit gas plants (reduction plant), and the boiler plant No. (6) at the desalination plant, then both boiler factories No. 5 at the desalination plant, and boiler plant No. 3 at the desalination plant. While we find that the lowest emissions of various gases were in the steel factories No. 1 and No. 2, and the rods and bars factory.

RECOMMENDATIONS

Strengthening international cooperation to confront air pollution, so that knowledge and experiences are exchanged, and technical and financial support is provided to mitigate the effects of air pollution. Pay attention to conducting environmental measurements periodically and adjusting the deviations, if any. Periodic maintenance must be performed on boilers, forklifts, and any equipment or machines that may emit emissions that may pollute

the air. Establishing and installing a fixed system of devices to measure air pollutant concentrations equipped with remote sensing technologies to determine the concentrations of air pollutants and monitor the concentrations of air pollutants on an ongoing basis. Raising the level of environmental awareness and promoting environmental practices regarding the dangers of air pollution and its harmful effects on human health and the environment through media campaigns.

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تقييم مستويات تلوث الهواء الداخلي بالغازات بالشركة الليبية للحديد والصلب

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1) قسم العلوم الأساسية البيئية، كلية الدراسات العليا والبحوث البيئية، جامعة عين شمس 2) المعهد العالي للعلوم والتقنية بمصراتة، ليبيا 3) كلية علوم البيئة والموارد الطبيعية بجامعة مصراتة، ليبيا.

المستخلص

تهدف الدراسة إلى تحليل وتقييم مستويات تلوث الهواء الداخلي بالغازات في شركات الحديد والصلب الليبية،وقد استخدمت الدراسة المنهج الوصفي التحليلي لتحليل البيانات وتسجيل النتائج، توصلت الدراسة إلى أن متوسط تركيزات أكاسيد النيتروجين قد بلغ حوالي 24 ميكروجرام/م3 على المساحات المختلفة داخل المصنع ،وهو معدل يعتبر جيد ويقع في إطار القيم واللوائح الدولية لجودة الهواء المقبولة عالميا وصحيا الصادرة عن منظمة الصحة العالمية(who)،والتي تشير إلى أن مستوى انبعاثات أكاسيد النيتروجين في البيئة لا يتجاوز 40 ميكروجرام/م3 ، كما خلصت إلى أن غاز أول أكسيد الكربون (CO) كان من أكثر أنواع الغازات المنبعثة داخل مصانع الشركة الليبية للحديد والصلب في مصراتة، حيث بلغت الانبعاثات من مختلف المصانع حوالي 118213.7 ملغم / م 3 ، كما خلصت النتائج إلى أن مؤشر جودة الهواء في مدينة مصراتة بليبيا في 23 يوليو 2023 وصل إلى 74 درجة وهي درجة متوسطة لجودة الهواء وفقًا لتصنيف وكالة حماية البيئة الأمريكية (2009) ، وبالتالي تندرج في الفئة الثانية والتي تتراوح من 51 إلى 100.

الكلمات المفتاحية: (تلوث الهواء، التنمية المستدامة، مؤشر جودة الهواء، الغازات، تكاليف تلوث الهواء، الشركة الليبية للحديد والصلب، مصراتة)