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A Study of CO Emission Sources and Their Impacts on the Respiratory Systems of Patients in Al-Muthanna Governorate

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***Abstract*— This study examines carbon monoxide (CO) emissions and their health effects on individuals with respiratory conditions such as asthma, COPD, and bronchitis. CO sources include biomass burning, industrial processes, and vehicle exhaust, with CO's high hemoglobin affinity impairing oxygen transport. The current study aimed to assess CO emissions' impact on respiratory health in Al-Muthanna Governorate. From November 2023 to July 2024, CO levels were measured in high-emission areas, including a cement factory, oil refineries, and seven fuel stations, using Drager X am 5000 devices. Two control areas, Hay Al Hussein and Al Doha Residential Compound, were used for comparison.**

The study involved 120 participants: 60 fuel station workers, 20 refinery residents, and 40 controls. The highest CO concentration was from the cement plant (48.98 ppm), with the lowest 100 meters from station S5 (1.67 ppm). Control areas had no detectable CO (0.00 ppm). Health assessments included blood (WBC, Lym, Neu, Eos), lung function (FVC, FEV, PEF), and immunological markers (IgE). Findings showed high CO levels near sources, exceeding global limits. Affected individuals aged 30–50 had increased eosinophils (7.60–9.90%), reduced lung function (FVC 54–81%, FEV 27.33–49.75%, PEF 16–26.75%), and elevated IgE (170.5–518.3 U/mL), with bronchial allergies more common than asthma.

***Keywords*— Air pollutants, Carbon monoxide (CO), Bronchial allergy, Al-Muthanna.**

I. Introduction

Air pollution is the direct or indirect release of harmful substances into the atmosphere or confined space by humans that have negative effects and are likely to endanger human health, damage living things, damage property, disturb ecosystems, or produce an overpowering odor [1].

There are two types of air pollutants: primary and secondary pollutants. Primary pollutants, such as NO_2, SO_2, CO, and VOCs, directly released into the atmosphere when fossil and biomass fuels are burned. Secondary pollutants, such as gaseous ozone (O_3), are release in to the atmosphere by primary pollutants [2].

The release of harmful gases into the atmosphere is referred to as "air pollution caused by gaseous emissions" and has a significant effect on air quality and public health [3]. Carbon monoxide is a flammable, colorless, odorless, and toxic gas, remains at the atmosphere for 0.1 to 5 years and reacts slowly with other chemical compounds. CO is an artificially produced primary pollutant and a component of ground-level ozone [4]. Incomplete combustion produces carbon monoxide. Vehicle exhaust from burning fuel and the burning of biomass are the two main sources of CO in the world. Burning carbon-containing fuels like coal, kerosene, natural gas, and wood are additional sources. CO also released during solid waste burning, industrial processes, and tobacco use [5].

When CO enters the bloodstream, it causes significant tissue damage by replacing oxygen in red blood cells and lowering the amount of oxygen delivered to vital organs like heart, lungs, and brain. The only significant pathway for environmental exposures is the lungs. When CO and hemoglobin combine, carboxyhemoglobin (COHb) is created. As CO enters the lungs, it quickly diffuses through the capillary and alveolar membranes. Reversibly, CO binds to a hemoglobin protein [6]. Blood's ability to carry oxygen is reduces 80 and 90% of absorbed CO binds to hemoglobin. Hemoglobin has a 200–250 times greater affinity for CO than that oxygen; however, its relative affinities for other hemoglobin proteins, such as cytochrome oxidase and cytochrome P–450, are significantly lower [7]. Decreasing the blood's ability to carry oxygen causes hypoxia, which impacts the cardiovascular and respiratory systems [8].

According to [9], exposing human to CO can have long-term health effects and cause mild to severe symptoms. CO affects on respiratory function, especially on mucociliary clearance (MCC) and acute exposure. According to previous research, CO decreases oxygen delivery, which impairs respiratory function. It also disrupts MCC by altering the properties of mucus and ciliated cells, which lowers the effectiveness of removing particles and pathogens from the respiratory tract [10].

We did not obtain local studies in the city of Muthanna Governorate on determining the concentration and impact of this gas on human health and the environment, and most previous studies addressed the issue of water pollution [11-13].

So, the current study addressed this problem.

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II. METHODS

A. Collection of Samples

In the field (at cement factories, oil refineries, and fuel stations; figure1-1), air samples were gathered and measured. CO was one of the gases whose percentages were measured and reported as a unit PPM. Using the Drager X am 5000 devices, the concentration was measured directly at the emission sites, which include the vicinity of the cement factory, the oil refinery, and seven fuel filling stations. For comparison, the study included two areas (Al Doha Residential Compound and Hay Al Hussein area) with standard emissions and no pollution. All measurements were taken at a height of 150 cm and in the direction of the winds.

Regarding blood samples, there are 120 clinical samples in total, 60 of them have worked in petroleum fuel stations for 1–5 years and are continuously exposed to petroleum products and vehicle vapors, and 20 of them live close to cement plants and oil refineries. The control group is made up of 40 healthy individuals who do not have respiratory conditions such as bronchial allergy, emphysema, or chronic bronchitis, and they have any clinical or anatomical issues that could affect respiratory function. The subjects of both groups are between the ages of 20 and 60. Tests to support diagnostics include lung tests, immunoglobulin (IgE), and Complete Blood Count (CBC).

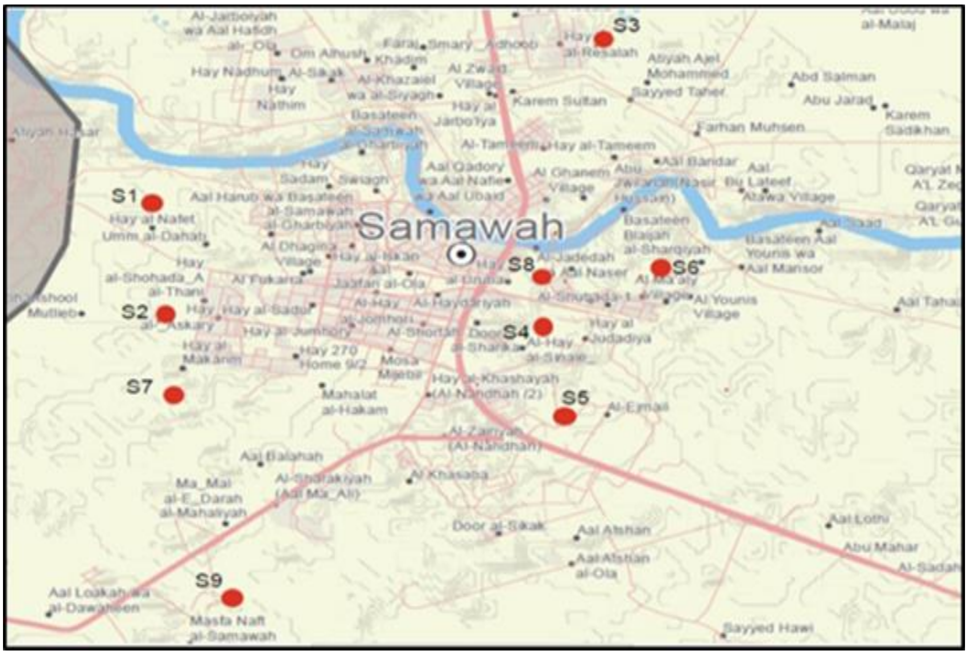

Fig. 1-1: Map show the study sites in Samawa city.

B. Physiological tests

1) Pulmanary function test (PFT)

Using a portable Spirometry SP 80 B device, this examination was conducted concurrently for patients present at the study and work locations. The lung examination calculates the FVC, FEV, and PEF—the maximum volume of air that a person's lungs can absorb after taking a deep breath and the amount of air that the lungs can exhale in a single puff. Within a minute, the outcome is visible [14].

2) Measurements in the lab

a) Complete blood count test (CBC)

The Erba H560 5-part automatic complete blood count analyzer was used to perform complete blood counts, and results are available in one minute. The most useful measurement for the study was chosen from the range of measurements the device offered. The WBC differential count, the total white blood cell count (WBC^3/uL), the lymphocyte percentage, the neutrophil percentage, and the eosinophil percentage [14].

b) Immunological Parameters (Immunoglobulin E Test)

The allergen-specific IgE test measures immunoglobulin E (IgE) antibodies. Using an automated pipette, a 10 µm aliquot of serum is added to the Cobas e 411 apparatus. Within eighteen minutes, the results are available [14].

C. Statistical analysis

The SPSS program was used to find relationships between the various variables and determine the significant differences at the 0.05 and 0.01 levels. Through the t.test. The correlation coefficient has been determined using Pearson correlation.

III. RESULTS AND DISCUSSION

A. Distribution of the study groups according to their age

The age distribution in the current study was from lowest to highest (20–60). Group1 (21–30) with n=30 (37.5%), the number of healthy samples was 16 (40%). Group2 (31–40) comprised n=31 (38.75%), samples were healthy12 (30%). Group3 (41–50) comprised n=14 (17.75%), samples were healthy 12 (30%). showed that within the specified age groups, there is no statistically significant difference (P>0.05) between the control group and station workers. Group 4 (51–60), comprising n=5 (6.25%). In this age group, no healthy samples were found. Additionally, the statistical analysis showed that there were significant differences (P<0.05) between the control group and station workers in this age group (Figure1-2).

This study reported s a high prevalence of asthma and bronchial allergies among those aged 21–40, with rates of 37.5% and 38.50% for the 21–30 and 31–40 age groups, respectively. Adults in these groups face frequent exposure to environmental triggers like allergens, air pollution, and occupational irritants, which can exacerbate respiratory issues. Lower sample sizes may explain the reduced rates in older groups. Similar studies indicate the highest asthma incidence among those aged 30–49, with a decline after age 46. Age-related tissue changes and immune function decline may contribute to lower rates in older adults.

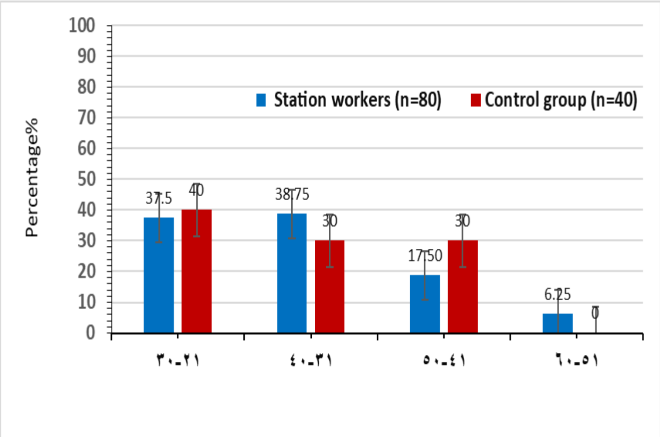

Fig. 1-2: Age groups distribution in the study.

B. *Distribution of groups depending on the disease condition*

According to the study's findings, the percentages of participants were split up into three groups. There were 70 patients (58.33%) with bronchial allergy in the group1, 10 patients (8.33%) with asthma in the group2, and 40 healthy individuals (33.33) in the group3. According to the statistical findings, patients with respiratory conditions (such as asthma and bronchial allergies) and healthy individuals differed significantly (P<0.05; figure1-3).

The findings indicated that a greater proportion of individuals had bronchial allergies than asthma. According to [15], gas pollutants like CO primarily irritate the respiratory system, which can intensify allergic reactions in susceptible people and result in more obvious bronchial allergies. The findings of [16] were comparable. They clarified that although asthma may also be more common in contaminated areas, it may not receive as much attention as bronchial allergies because asthma is often treated as a chronic condition that necessitates a more complex set of diagnostic standards. This aligns with the findings of the study [17].

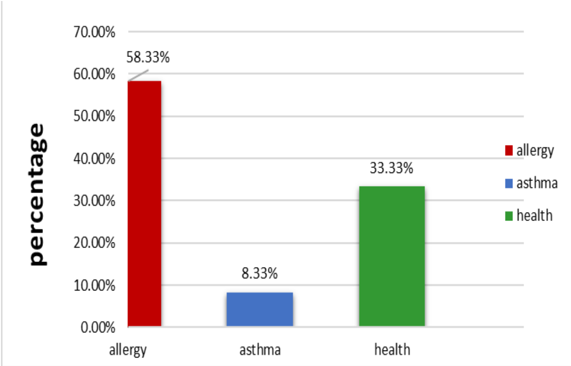

Fig. 1-3: Percentage of patient's number infected with respiratory disease during the study period.

C. *Gaseous air pollutants*

1) *Carbon monoxide*

The results of our study showed a significant increase in CO gas levels, with concentrations at the sites under investigation surpasses the internationally recognized thresholds for safe exposure of 4.6 ppm for a 24-hour period [18].

The cement factory had the highest concentration of CO gas, according to the results, with a level of 49.48 ppm. In contrast to the control results, which showed a gas concentration of 0.00 ppm, the gas concentration was at its lowest, 1.67 ppm, 100 meters from the S5 pump (table 1-1).Statistical results showed significant differences (P<0.05) between concentration of CO gas at station pump and at a distance of 100 meters from pump, significant differences(P<0.05) between CO measured at the stations (both at the pump and 100 meters after the pump) and concentration of CO gas at control areas (table1-1).

This gas was highly concentrated in the vicinity of the cement factory. This is a result of the factory's outdated and antiquated technology, its location in a crowded residential area, the use of black oil as fuel in all phases of cement production, and the fact that burning it releases a lot of CO gas in addition to other gases [19]. Furthermore, the absence of filters at the factory is a contributing factor to the enormous emissions of gaseous and mineral waste [20]. These substances can lead to major health issues in urban areas where they accumulate in the atmosphere and eventually fall to the ground. The results of this study were in agreements with those of [20] assessment of the effects of industrial projects, like cement factories, on the governorate's environment.

According to [21], modern cement plants, with their sophisticated technologies and enhanced control systems, typically have lower CO emissions than older or less modern cement factories. These results are in agree with those of [22], who pointed out that high CO levels can deteriorate the quality of the air near cement factories. Because CO interferes with the body's ability to carry oxygen in the blood, it can affect respiratory function and general health.

TABLE (1-1) SHOWS THE MEAN OF THE CO CONCENTRATIONS MEASURED IN THE STUDY STATIONS.

location	Measurement distance	CO ppm	t.test (p-value)
Station1	after 100m	2.29^{a}	P<0.05
	at pump	2.2^{b}	
	Control	0.00^{c}	
Station2	after 100m	2.25^{a}	P<0.05
	at pump	3.67^{b}	
	Control	0.00^{c}	
Station 3	after 100m	2.67^{a}	P<0.05
	at pump	3^{b}	
	Control	0.00^{c}	
Station 4	after100m	2.8^{a}	P<0.05
	at pump	4.5^{b}	
	Control	0.00^{c}	
Station 5	after 100m	1.67^{a}	P<0.05
	at pump	4.6^{a}	
	Control	0.00^{c}	
Station6	after 100m	2.33^{a}	P<0.05
	at pump	3.75^{b}	
	Control	0.00^{c}	
Station7	after 100m	2.33^{a}	P<0.05
	at pump	2^{b}	
	Control	0.00^{c}	
Station 8	oil refinery	47.62^{a}	P<0.05
	Control	0.00^{b}	
Station 9	Cement plant	48.98^{a}	P<0.05
	Control	0.00^{b}	

2) *Hematological parameters*

According to the study's findings, the highest percentage of eosinophils (7.60–9.90%) in the S4 and S7 study areas was followed by neutrophils (62.8–88.33%) in the S3 and S5 study areas, white blood cells (10.85–7.22–10.58^3/uL) in the Cement Plant, (S6), and lymphocytes (5.00–17.85%) in the Cement Plant and (S3; Tables 1-2).

These findings were supported by local research conducted in Iraq, which demonstrated that air pollution increases eosinophil counts, indicating inflammatory and allergic reactions. For instance, [24] they discovered comparable correlations between pollutant exposure and elevated eosinophil counts, while [25] reported elevated eosinophil levels among Baghdad residents exposed to high pollutant concentrations. According to these studies, allergies and inflammation are exacerbated by air pollution. Also, environmental stressors that impact the immune system frequently led to elevated white blood cell (WBC) levels in contaminated areas [26]. The irritation of tissues by airborne pollutants can lead to inflammation and an increase in white blood cell production, which is frequently a sign of inflammation and allergic reactions [26].

An inflammatory response may be triggered when the body comes into contact with airborne pollutants, such as gases [27]. In response to inhaled pollutants that aggravate the respiratory system and cause inflammation, neutrophils are essential. In diseases like asthma and bronchial allergies, where exposure to pollutants worsens airway inflammation, this effect is especially important [28]. The body's response to oxidative stress and inflammation brought on by pollutants, as well as continuous immune activation and tissue damage, results in elevated neutrophil levels in polluted environments [28].

3) *Lung function parameters*

The results indicated that the FVC had the highest percentage, ranging from 54 to 81% in S3, S6, followed by the FEV examination, which had a percentage ranging from 27.33 to 49.75% in S3, S5. In (S2, S6), PEF had the lowest percentage, ranging from 16 to 26.75%, in comparison to the control group (104.52, 88.45, 88.08%; table 1-3). According to the study, impaired lung function is indicated by a significant decrease in FEV, FVC, and PEF in polluted areas. due to the presence of gaseous pollutants that cause inflammation and irritation of the airways, such as CO The respiratory tract is particularly vulnerable to environmental harm because CO negatively impacts respiratory function. Asthma, obstructive pulmonary disease, bronchial allergies, and mucosal damage can result from this [29].

The results of the study showed that the forced expiratory volume (FEV) in the contaminated areas had significantly decreased. These results are in agree with a large number of international studies. According to [30] Industrial workers' exposure to gaseous emissions, such as CO, was associated with a decrease in the forced expiratory volume ratio. In a similar vein, [31] found that breathing in gaseous pollutants makes respiratory diseases like asthma and chronic bronchitis worse. The lungs' capacity to effectively expel air during forced exhalation may be hampered by airway narrowing and increased mucus production.

The study's findings showed that FVC levels had decreased in almost every sample. According to [32], this decline is explained by the fact that FVC normally decreases in polluted environments. This study's results, which are consistent with those of [33], showed that extended exposure to high CO levels led to decreased lung function because spirometry tests showed a statistically significant decrease in both forced expiratory volume in one second (FEV1) and forced vital capacity (FVC) in those exposed to higher concentrations of CO.

The detrimental effects of various pollutants on the respiratory system are the primary cause of the decrease in peak expiratory flow in high-pollution areas [34]. Because of the inflammation, constriction of the airways, and general impairment of lung function caused by these pollutants, people are less able to expel air forcefully, which is reflected in a lower PEF measurement [35].

4) *Immunological parameters*

According to the study, the lowest IgE level, 170.5 ± 30 U/ml, was measured 100 meters from the S2 pump, while the highest level, 518.3 ± 177.0 U/ml (table 1-4) was recorded there. The IgE level in the control group, however, was 49.5 ± 23.2 U/ml. Additionally, the statistical analysis showed that the IgE levels measured at the pump and those taken from a distance of 100 meters significant differences (P<0.05).

TABLE (1-2) SHOWS THE MEAN OF HEMATOLOGICAL PARAMETERS RECORDED THROUGHOUT THE STUDY PERIOD.

location	Measurement distance	WBC 4.00-10.00 ^3/uL	Neu 40.0-75.0 %	Lym 20.0-50.0 %	Eos 0.4-8.0 %
Station 1	after 100m	9.99	83.89	7.77	8.81
	at pump	7.86	77.64	11.80	8.12
Station 2	after 100m	10.53	83.08	8.00	8.63
	at pump	8.79	76.80	10.93	8.73
Station 3	after 100m	10.81	88.33	5.00	9.83
	at pump	7.65	73.65	14.15	9.20
Station 4	after 100m	9.51	80.12	11.52	9.90
	at pump	9.60	72.94	10.33	9.22
Station 5	after 100m	9.75	71.23	14.07	8.97
	at pump	8.58	62.08	14.46	8.40
Station 6	after 100m	10.07	76.47	11.80	9.77
	at pump	7.22	75.00	11.93	8.90
Station 7	after 100m	8.17	76.37	10.57	7.60
	at pump	8.81	77.04	12.86	8.82
Station 8		8.29	71.94	16.66	8.96
Station 9		10.85	71.30	17.85	9.34
Control		7.09	58.38	19.41	1.14

The study's findings showed a significant increase in test rates, most likely as a result of the higher IgE levels found in contaminated environments. Inflammation and irritation of the respiratory system can be caused by pollutants, such as CO [30]. According to similar findings by [36;37:38] researchers, exposure to pollutants may alter the immune system's reaction to allergens, raising the risk of sensitization developed. According to these results, pollution may increase the permeability of the respiratory tract, which is consistent with a number of other studies, including a few local ones from Iraq [37,38].

TABLE 1-3 SHOWS MEAN OF LUNG PARAMETERS RECORDED THROUGHOUT THE STUDY PERIOD.

location	Measurement distance	FVC 80-120 %	FEV 80-120 %	PEF 80-100 %
Station 1	after 100m	72.57	40.14	21.57
	at pump	70.00	41.60	19.80
Station 2	after 100m	67.75	43.25	26.75
	at pump	75.67	35.33	22.33
Station 3	after 100m	65.33	44.00	23.33
	at pump	81.00	49.75	21.00
Station 4	after 100m	75.20	38.60	21.80
	at pump	70.50	40.33	21.00
Station 5	after 100m	57.33	27.33	20.00
	at pump	63.60	37.00	20.00
Station 6	after 100m	54.00	30.00	16.00
	at pump	65.75	42.75	24.75
Station 7	after 100m	60.67	40.67	20.33
	at pump	69.20	37.00	18.00
Station 8		57.20	31.80	21.40
Station 9		66.47	40.40	20.87
Control		104.52	88.45	84.08

TABLE 1-4 SHOWS IGE CONCENTRATION MEASURED FOR THE SAMPLES DURING THE STUDY PERIOD.

location	Measurement distance	Immunoglobulin E <100U/ml Mean ± STD	Control (Mean ± STD)	t.test (p-value)0.05
station 1	after 100m	223 ± 66.3	49.5 ± 23.2	0.000
	at pump	339.6 ± 55.5	49.5 ± 23.2	0.000
station 2	after 100m	170.5 ± 30	49.5 ± 23.2	0.003
	at pump	518.3 ± 177.0	49.5 ± 23.2	0.044
station 3	after 100m	219.3 ± 117.6	49.5 ± 23.2	0.129
	at pump	465.8 ± 160.1	49.5 ± 23.2	0.014
station 4	after 100m	279.6 ± 126.3	49.5 ± 23.2	0.015
	at pump	508.7 ± 183.1	49.5 ± 23.2	0.002
station 5	after 100m	258.3 ± 81.9	49.5 ± 23.2	0.047
	at pump	322.6 ± 96.9	49.5 ± 23.2	0.003
station 6	after 100m	288 ± 173.7	49.5 ± 23.2	0.140
	at pump	358.5 ± 51.8	49.5 ± 23.2	0.001
station 7	after 100m	263 ± 39.6	49.5 ± 23.2	0.010
	at pump	476.8 ± 179.9	49.5 ± 23.2	0.006
station 8	oil refinery	417.6 ± 177.9	49.5 ± 23.2	0.010
station 9	Cement plant	318.7 ± 114.2	49.5 ± 23.2	0.000

IV. CONCLUSION

The current study found a direct relationship between respiratory issues and CO emissions, with higher rates of bronchial allergies and asthma linked to increase the concentrations of air pollution. The highest CO levels were recorded near a cement factory, fuel stations, and crowded industrial areas, with CO levels exceeding global exposure limits more than other gases. Bronchial allergies were more prevalent than asthma among participants. Elevated CO emissions were associated with increased blood parameters (WBC, lymphocytes, neutrophils, eosinophils) and IgE levels, while lung function indicators (FVC, FVE, PEF) showed a significant decline.

CONFLICT OF INTEREST

Author declares that he has no conflict of interest.

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