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The Relationship between Standard Air Pollutants and Air Quality in the Urban Complex of Mansoura City Using Path Analysis Modeling

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ABSTRACT

Air quality is considered one of the vital topics because it has a direct relationship to the health of the individual, which affects the sustainable development and public health of individuals within the country. Therefore, the study identified the relationship between the standard air pollutants represented in the pollutants(suspended particles, carbon monoxide, nitrogen dioxide gas and ozone gas, sulfur dioxide gas during the period from 1/1/2023 to 31/12/2024 , and built a model capable of explaining and interpreting these causal relationships and determining the direct and indirect effects on air quality in the study area and arranging them according to the degree of impact. This is what distinguishes the method of path analysis from others, considering the nature of the study area and the nature of the data used in the study. The model was built in several steps, including building a conception of the model, arranging the relationships between the dependent variables and the independent variable, drawing a diagram to clarify the path of relations between them, testing good conformance through several indicators, and analyzing and interpreting the results reached. Many programs were used to help the researcher with the effects of modeling, such as SPSS, Amos program for data analysis and extracting the proposed causal model.

Introduction

The use of structural models is the most important method used in modern studies to achieve the requirement of logic and acceptance of the results of many studies. It includes a set of variables related to causal relationships and effects and is called a causal or structural model. The path analysis model was adopted because of its ability to show direct and indirect effects between variables. It is also interesting in studying intermediate variables that play the role of dependent and independent variables at the same time (Abdul Khaliq, et al.,2021). Since there is a linear relationship between the independent

variables, it was necessary to search for a method that addresses the problem of double linearity between the variables. Therefore, path analysis modeling was used to study the most important air pollutants affecting air quality in the study area.

1. Materials and Methods

1.1 Study area

The urban complex of the city of Mansoura he area is extended from Latitude 30˚ 0 ´ 31´N to 30 ˚ 5´ 6 ´N and form longitude 20˚ 31 ´ 26 ´Eto 25 ˚ 31 ´ 43 ´E . The study area is geographically bordered to the north by the village of Orman Talkha, the village of Kafour Al-Arab, to the northeast by the village of Mit Antar, Al-Khayariya, Mit Mizah, to the east by Al-Danabiq, the village of Mit Sareem, to the southeast by the canal of Al-Mansouriya, the village of Miniyat Sandub, which extends to the south, the village of Naqita, to the southwest by the village of Mit Badr Khamis, to the west by the village of Joujar, and to the northwest by Mit Al-Karma (Figure 1).

The area of the urban complex of the city of Mansoura (140.42km^2)and it includes the city of Talkha, which has an area of about (12.2km^2) and a percentage of (930.2%) of the total area of the study area, and the city of Mansoura, which has an area of (28.2km^2) and represents a percentage of (1069.8%) of the total area of the study area and consists administratively of two parts: the eastern section of Mansoura, which has an area of (1213.39km^2) and includes seven sheikhdoms (Gulnjil – Mansouriya - Siam - Mit Haidar - Jadila - Kafr al-Badmus - Bahr al-Saghir), and the western section of Mansoura, which includes five sheikhdoms and an area of (14.83km^2), namely(Al-Hawar - Al-Najjar - Sandoub - Mit Talkha).

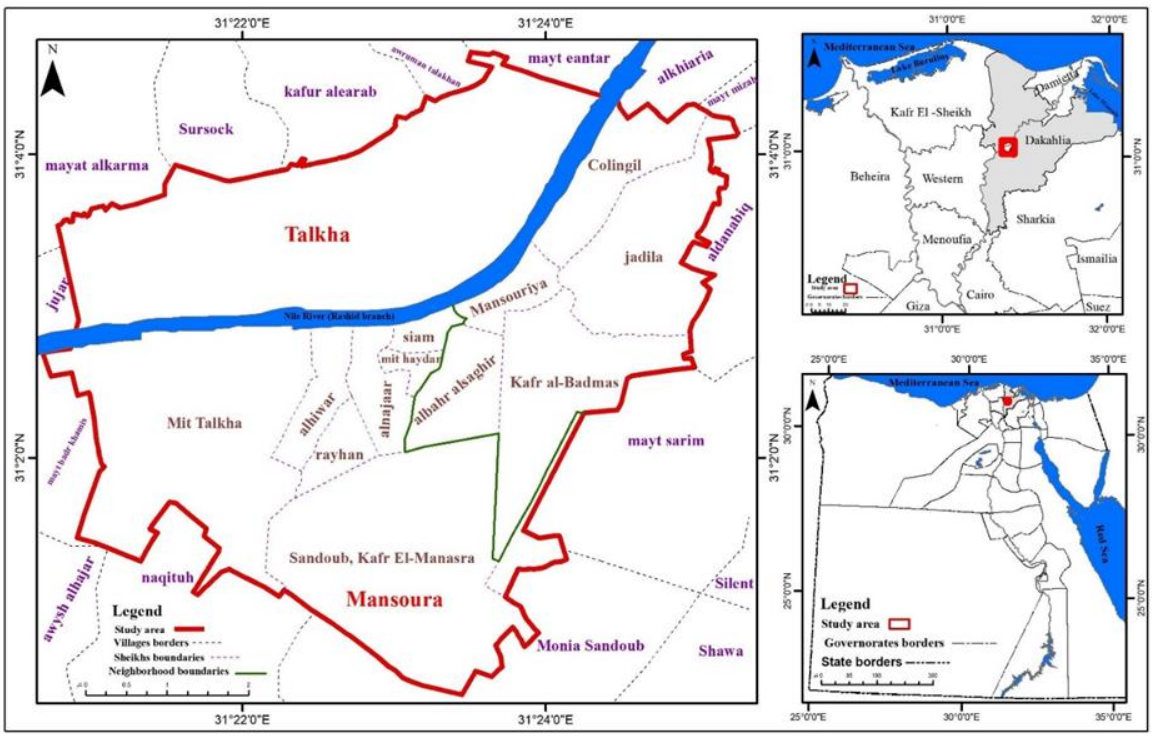


Fig. 1 Location map showing the area of study.

1.2 Previous studies

1.2.1 Path Analysis Style Studies

(Ali, 2011) study: The path analysis method was used to determine the path of relationships between independent variables, namely gender, weight, blood lipids and urea, on the dependent variable, which is human blood pressure, and to find direct and indirect effects on measuring human blood pressure.

Study of (Ahmed, 2013): The method of path analysis model was used to determine the most

important factors affecting the retention rate of insurance companies, through which it is possible to explain, identify and explain causal relationships and clarify direct, indirect and total relationships on the retention rate. These factors can also be arranged according to their importance, and this is the most important thing that distinguishes the method of path analysis from other statistical methods.

Awad et al. (2021) study: The researcher used the path analysis method in determining the factors affecting inflation in Egypt and studying the impact of independent variables such as the exchange rate, the cost of financing and others on the dependent variable, which is the rate of inflation and reaching direct, indirect and total effects on the rate of inflation in Egypt.

(Muhammad, et al. 2022) study: The multigroup path analysis model method was used to determine the most appropriate models to determine the relationships between the independent variable represented in psychological empowerment and the dependent variable, which is the psychological immunity of students during the period of the spread of Covid-19, and it was found that there are differences between psychological empowerment and psychological immunity according to the educational stage, gender, scientific specialization, and the academic team.

(Bouaisha, et al. 2024) study: The study is based on the method of path analysis in educational research, building a model and choosing theoretical models to describe the relationship between a set of variables and provide a more comprehensive and objective interpretation of educational research.

1.2.2 Air quality studies

(Adel, 2016) Study: The researcher aims to study air quality by measuring the concentrations of solid air pollutants, including suspended particulates and lead gas, in only one station within Basra Governorate, Iraq, and recording their concentration ratios during several months (April – July – December). The study managed to exceed the permissible limits of pollutants. The study attributes its results to several reasons, including drilling operations for oil wells, exhausts of electricity generators and means of transport. The study recommends reducing the concentration of solid particles through planting trees to stabilize sand dunes scattered in the region and treatment of pollutants from their sources.

The study of (Al-Sabbagh, 2021): The researcher clarifies the problem of air quality in the Kingdom of Bahrain by developing a clear vision of air quality management, determining the concentrations of particles, mitigating their risks, and determining the extent of the danger of low air quality to human health and the national economy. The study recommends the need to make data available, involve the public in the state of air quality, and raise awareness among them.

Rajab's (2023) study: The researcher evaluated the air quality situation within seven Iraqi governorates distributed from the north, center and south, namely(Kirkuk - Baghdad - Babil -Najaf - Qadisiya - Al-Muthanna - Basra), and relied on the study of air pollutant concentrations for 2019, and the study showed that most governorates are located within the ranges of (good - and very dangerous)on human health.

Study of (Al-Dughairi, 2023): The researcher tries to identify the most important sources of air pollutants within the Imam Turki Abdullah Royal Reserve inside the Kingdom of Saudi Arabia, know the spatial distribution of air quality inside it and build a digital database of air quality inside the reserve.

Study of (Issa, 2024): The study lies in understanding the extent of differences between space and time and its association with air pollution in the eastern region of the Kingdom of Saudi Arabia, identifying the sources of air pollutants, whether local and regional emissions, identifying areas prone to pollution and their health risks, and how to protect individuals from the effects of air pollutants.

1.3 Study Objectives

- Formation of causal models of the air quality situation in the urban complex of Mansoura city.

- Determine the most standard pollutants affecting air quality, whether directly or indirectly.
- Ranking of standard atmospheric pollutants according to the degree of impact.

1.4 Research Importance

There are several difficulties for researchers in knowing the nature of relationships between independent variables, especially with the existence of interrelated and overlapping relationships between variables, which cannot be dealt with through traditional models such as regression analysis. Therefore, there are scientific methods through which interrelated relationships between variables are discovered, including the use of structural equations models. Statistically, an alternative statistical method can be identified to solve the problem of linear duplication of variables, know the pollutants affecting air quality within the urban complex of Mansoura city, and know the direct and indirect impact of each variable, so that decision-makers can make sound decisions to reduce standard air pollutants and thus improve air quality in the region.

1.5 Approaches and Methods of Study

The study used the analytical approach, where it analyzed the relationships between standard air pollutants and air quality in a specific area, which is the urban complex of Mansoura city, and linked and explained the interrelationships between them and their causes so that the researcher can draw direct and indirect effects between them in order to improve air quality in the study area.

The path analysis modeling method was adopted and is considered a strong and comprehensive statistical method to understand the causal relationships between the variables and identify the main pollutants affecting air quality. Building a model for the path analysis depends on many relationships between the variables and assuming the possibility of relationships between them in the form of linear equations.

The path analysis is complementary to the regression analysis that gives a complete picture of the relationships between the variables.

The model was built through several steps:

-Building a causal model.
-Arrange relationships between variables.
-Develop a diagram of the path of relations between variables in what is known as the path diagram
-Estimate route parameters.
-Testing good conformance through several indicators commensurate with the method of path analysis, such as (Chi-square index - good conformance index (GFI) - Root mean square error convergence index (RMSER) and others).
-Analyzing and interpreting the results and making the necessary recommendations (Al-Malki,2012).

2. Statistical analysis

2.1 Variables of the study

The study relies on six independent variables, which, as Table 1 shows, are standard atmospheric pollutants and a dependent variable represented in the air quality index (Y). To know the correlation between all the study variables with each other, as shown in the correlation matrix in Table 2. The differences between the values of the correlation of the variables are due to the presence of other effects, which are indirect effects between the variables, given the importance of independent variables and their effect on the dependent variable, it was found that path analysis modeling is important to find direct and indirect effects on the dependent variable.

2.2 Hypotheses of the study

The path analysis method was used to study the correlation between standard air pollutants and air quality in the study area through the formulation of a set of hypotheses, including:

The first hypothesis: the linearity of the relationship between independent variables; the hypotheses were formulated as follows

H_0 = Zero hypothesis is the absence of a linear relationship between variables.

H_1= Alternative hypothesis is the existence of a linear relationship between variables.

Table 1. Study variables.

Code	variables
Y	AQI
X_1	PM $_{2.5}$
X_2	PM $_{10}$
X_3	CO
X_4	O_3
X_5	NO_2
X_6	SO_2
P_{Y1}	$Path_1$
P_{Y2}	$Path_2$
P_{Y3}	$Path_3$
P_{Y4}	$Path_4$
P_{Y5}	$Path_5$
P_{Y6}	$Path_6$

Source: SPSS V.23 /AMOS V.20

Table 2. Correlation matrix between study variables.

Variables	Y	X1	X2	X3	X4	X5	X6
Y	-	-	-	-	-	-	-
X1	**.917**						
	.000						
X2	**.896**	**.942**					
	.000	**.000**					
X3	**.450**	**.604**	**.460**				
	.000	**.000**	**.000**				
X4	**- .262**	**- .400**	**- .358**	**- .679**			
	.000	**.000**	**.000**	**.000**			
X5	**.425**	**.532**	**.440**	**.812**	**- .883**		
	.000	**.000**	**.000**	**.000**	**.000**		
X6	**.505**	**.572**	**.459**	**.554**	**- .508**	**.601**	
	.000	**.000**	**.000**	**.000**	**.000**	**.000**	

Source: SPSS V.23 /AMOS V.20

Table 3. Results of the linear model between variables.

The name	R^2	Value F	SIG
Model	**.936**	**107.520**	**.000**

Source: SPSS V.23 /AMOS V.20

Table 3 indicates with the formulation of assumptions that there is a linear relationship between the variables of statistical significance at a significant level (.005) Thus, the zero hypothesis (H_0) was rejected, and the alternative hypothesis (H_1) was accepted.

The second hypothesis: The Residuals follow the normal distribution; the hypotheses were formulated as follows:

H_0 = Zero residual hypothesis follows normal distribution.

H1 = The residual alternative hypothesis does not follow the normal distribution.

Table 4 shows the use of the Kolomengrove and Simmernov test and the results were that the value of (Sig)at (.001) Thus, accepting the null hypothesis that the residuals follow normal distribution.

The third hypothesis is the independence of the residuals; the hypotheses are formulated as follows:

H_0 = Zero hypothesis is the independence of the rest.

H_1 = Alternative hypothesis is that there is no independence of the residuals.

The Deren Watson test was calculated at (2.09) and close to (2), which indicates that the model does not have the problem of self-correlation of the residuals and acceptance of the zero hypothesis (H_0).

Table 4. Results of the Kolmomanrov and Smirnov test.

Model	Statistic	SIG
Kolmomanrov and Smirnov test	.155	.000

Source: SPSS V.23 /AMOS V.20.

Contrast stability test:

Through Figure 2, the model of the spread of the remnants does not take the form of a regular spread, but rather is characterized by randomness, which indicates that the model is free of the problem of the stability of the variation.

Through the correlation matrix, it was found that the proposed causal model is statistically significant at a significant level (.000) They are as follows:

$$\mathbf{Y=P_{Y1}X_1+P_{Y2}X_2+P_{Y3}X_3+P_{Y4}X_4+P_{Y5}X_5+P_{Y6}X_6}$$

$$\mathbf{Y= 1.67X_1+.36X_2+.09X_3+.27X_4+.55X_5+.31X_6}$$

2.3 Route Layout

The model diagram is used as a graphical means to display the relationships between independent variables and dependent variables, and many shapes were used within the diagram, as shown in Table 5.

The conditions of the path analysis method were investigated in the model to study the relationships between the dependent variable(Y) and the independent variables (X) Figure (3)

shows the coefficient correlation between the independent variables and each other in the two-way curve. The one-way arrows show the relationship between the independent variables and the dependent variable and are an effective way to understand the cause and effect. It means the amount of the independent variable effect on the dependent and indirect variables. It means the amount of the effects of the independent variables combined on the dependent variable. The sum of all the effects together is equal to the value of the correlation coefficient of the dependent variable with the independent variable with the direct effect, considering the value of the remaining unaccounted part of the other independent variables.

From the matrix inverse of the selected independent variables, ion coefficients are calculated for each independent characteristic in the correlation coefficient. Thus, the path analysis coefficient is as shown in the following equation:

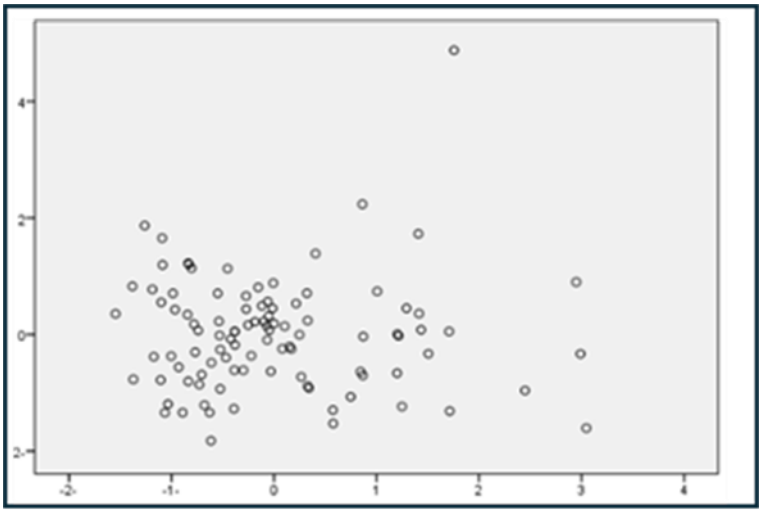
$$\mathbf{R_{Y1}=P_{Y1}+P_{Y2}R_{12}+P_{Y3}R_{13}+P_{Y4}R_{14}+P_{Y5}R_{15}+P_{Y6}R_{16}}$$

R_Y= the value of the correlation of the dependent variable with the independent variable.

P_Y = value of regression coefficients for direct effects.

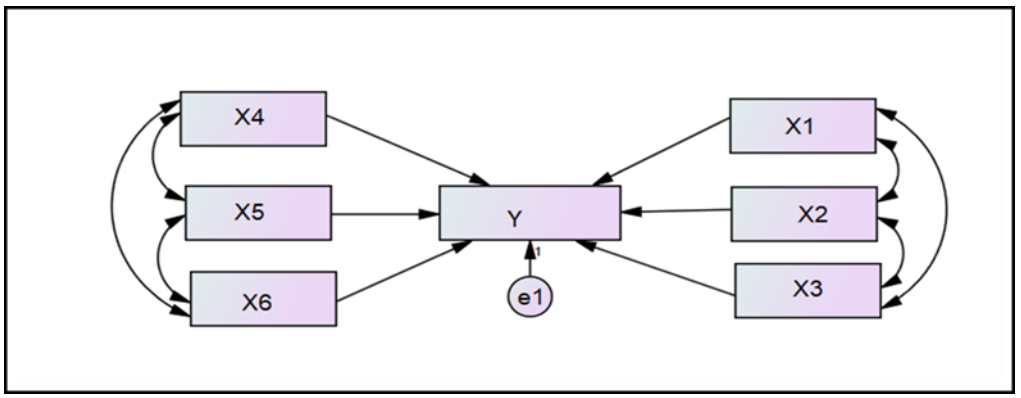
R = the value of the correlation coefficient between any two independent variables.

PYR= the indirect effect value of independent variables (Bouaisha et al.,2024)



Source: SPSS V.23 /AMOS V.20

Fig.2 Diffusion model of residuals.



Source: AMOS V.20.

Fig .3 The proposed causal model diagram between the variables under study.

Table 5 The most important shapes used within the path analysis model diagram.

The meaning	Figure
View variables	
Latent variables	
correlation	
error	

Source: Pugesek, et al,2003

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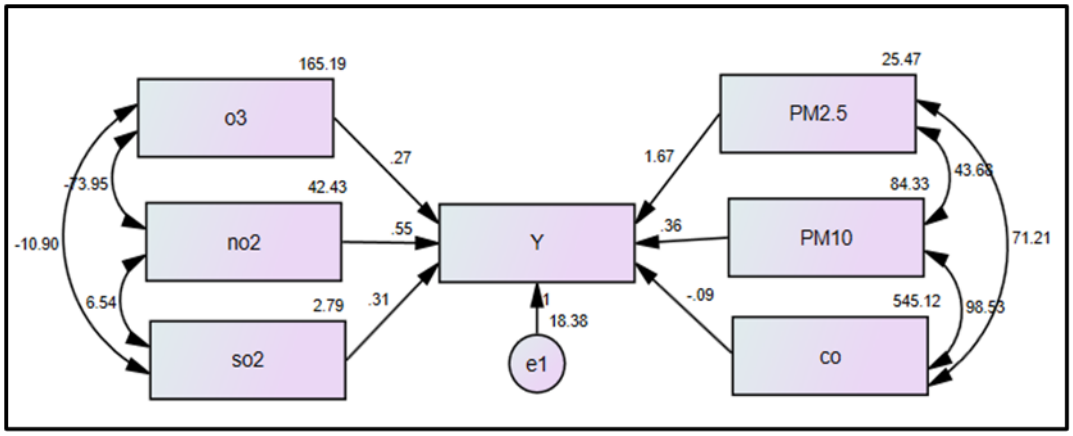
2.4 Estimating the path coefficient (direct impact) on air quality.

The assumptions of the model were verified, and the path coefficient was calculated as shown in Figure 4. The path coefficients using AOMS V.20 program. The relative weights of the independent variables were determined and calculated as indicated in Table 6 and the direct effects (D.E) were extracted on the dependent variable, which is the air quality in the study area. The value is the standard or non-standard beta regression coefficient. The standard beta values are often placed on the paths and next to them in the standard error brackets. To know the significance of the standard beta value, we divide it by the standard error, which produces a value called(Z), that is (SE/B= Z). The value is significant at a significant level (0.05) when it is equal to (1.96) or more, and at (0.01) when it is equal to (2.58) or more (Jalal,2019).



Source: AMOS V.20.

Fig.4 A diagram to illustrate the path coefficients calculated using regression analysis.

Table 6 Relative weights of independent variables.

Independent variables	Relative weight	SIG	Code
X1	**.726**	**.000**	A
X2	**.287**	**.020**	B
X3	**.171**	**.000**	C
X4	**.045**	**.344**	D
X5	**.307**	**.000**	F
X6	**.296**	**.000**	G

Source: AMOS V.20.

From Table 7, we can conclude that suspended particles (PM $_{2.5}$) directly affect air quality in the study area by a path coefficient of (1.668), i.e. the higher the concentration of suspended particles ($PM_{2.5}$) by one unit, the higher the air quality by(1.668), and also the air quality is affected by the increase in the concentration of suspended particles (PM_{10}), which leads to a decrease in air quality by a path coefficient of (.363), and carbon monoxide (CO) affects the value of the path coefficient (.85), while ozone gas(O_3) affects air quality by(.2247), and nitrogen dioxide gas (NO_2) directly affects air quality with a path coefficient value of(.547), and sulfur dioxide gas affects air quality by(SO_2) with a path coefficient value of(.309).

2.5 Evaluation of the proposed causal model

The causal model is based on a logical perception of the relationship of the study variables to each other and does not test the theory, but came to explain and confirm the

importance of some variables independent of others for the dependent variable, so the model needs evidence of its validity and there are several absolute evidence such as tests(GFI-AGFI-REMSEA) and absolute others similar to the coefficient of determination (R2) such as (IFI-NFI) (Jalal, 2019).

The validity of the model was verified using (Amos) program to obtain some of the indicators as shown in Table 8.

Table 7 Direct effects of independent variables on the dependent variable.

variables	Impact value
X1	1.668
X2	.363
X3	.85
X4	.267
X5	.547
X6	.309

Source: AMOS V.20.

Table 8 Indicators of the quality of fit of the proposed path analysis model.

Model	GFI	AGFI	RMSEA	NFI	IFI	CFI
value	.793	.856	.032	.830	.840	.837

Source: AMOS V.20.

The study was based on the cut-off scores of the matching indicators that depend on the sample size criteria of less than (500) and the number of indicators less than (30) and then (12) (Othmani, 2020).

it is clear that the Good Conformity Index (GFI)and the Adjusted Good Conformity Index (AGFI) fell within the ideal limits for each indicator, which is between zero and the correct one, which is (.793) and (856.), while the average root index of the convergent error square (RMSEA), which is located between (0> RMSEA< .08) It amounted to (.032) Below (.08) From a well-matched model, the absolute conformity indicators also came within the ideal limits of the indicators, including the (IFI) increased conformity index and the standard conformity index (NFI), which fall between zero and one, and the higher the value, the more the model matches and reaches (.840) and(.840), and the Comparative Conformity Index (CFI) reached (.837). It is close to (.9) Which indicates the extent to which the model is optimally matched.

3. Results and Discussions

The model showed the direct impact of the independent variables on the dependent variable.

The most standard atmospheric pollutants affecting air quality in the study area are suspended particles ($PM_{2.5}$), then carbon monoxide gas (CO) and nitrogen dioxide gas (NO_2), respectively. Then, suspended particles (PM_{10}) and sulfur dioxide gas (SO_2), and the least impact is ozone gas (O_3) due to the nature of the study area and the height of residential buildings in it. Therefore, the study recommends the importance of using the path analysis method in analyzing the data by building a proposed causal model to determine the direct and indirect effects of some variables.

The study also recommends working to reduce the concentration of standard air pollutants, especially suspended particles (PM2.5), nitrogen dioxide gas (No2) and carbon monoxide (Co),which lead to lower air quality levels in the study area, and raise the environmental awareness of citizens of the damages of being in sites with high concentrations of suspended particles, and avoid going out at peak times by being next to busy roads and streets to not be exposed to nitrogen dioxide and carbon monoxide, and decision-makers should create electronic panels to educate citizens, especially those with chronic diseases, to quickly leave areas of ill health Air quality, especially in crowded places.

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