# Improving Air Quality for Congested Urban Corridors using Microscopic Simulation Models

**Metwally Gouda(1), Mohamed Nasr(2), Mohamed Shalaby(1) and Mohamed Abd-Elghany(1)**

(1) Staff members, Highway and Airport Engineering Department, Faculty of Engineering, Zagazig University, Zagazig, Egypt.

(2) Civil engineering, M.Sc. researcher

**Corresponding Author:** Mohamed Nasr, Email: Mnasrmhegazy@gmail.com

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## Abstract

Air quality in congested urban cities has been deteriorating as result of vehicles emissions. Air pollution caused by vehicles emissions has harmful effect on people who are exposed to the polluted air, as well as causing damages to the surrounding environment. Increase in vehicles emissions is caused by a continuous growth in population and car ownership. This study has many objectives. The first is building traffic models using PTV VISSIM and emissions models using COPERT for different corridors as an example to build like these models for Zagazig streets network. These models were built to determine how traffic-related emissions affect the levels and concentrations of CO, $NO_X$, and $CO_2$. In order to reduce traffic congestion and concentrations of the emitted pollutants, several traffic scenarios were simulated and tested. Analyzing modeling results showed that the average traffic speeds were improved for enhancement modifications of traffic compared to current condition. Despite this improvement in the average speed, the total emissions of CO and $NO_X$ fluctuated between a decrease for some links and an increase for others. In addition, concentrations of CO decreased to be lower than or nearby World Health Organization (WHO) permitted values. The total amount of $CO_2$ decreased with increasing average speed for these corridors. The average reduction in $CO_2$ emissions with each 1 km/h increase was 94 kg. In this paper, the annual emission costs were also evaluated for all corridors in order to identify the benefits gained from emission decrease and the damage cost from emission rise.

**Key words:** Corridors, Modeling, Vehicles Emissions, Air Quality.

## 1-INTRODUCTION

In the last 50 years, the population of urban areas has rapidly increased in both developed and developing nations. As a result of the ongoing growth of urban areas and income, there has been an increase in car ownership [1]. Since 2010, more than 77 million automobiles have been produced annually worldwide as a result of rapid urbanization [2]. In unplanned urban areas, where the number of vehicles on the road is growing, severe traffic congestion is evident by very low average vehicle speeds and high percentages of driving time, which was followed by high rates of motor vehicle pollution emissions [3].

Nitrogen oxides ($NO_X$), carbon monoxide (CO), sulfur dioxide ($SO_2$), particulate matter (PM), and carbon dioxide ($CO_2$) are the pollutants released from cars and linked to human diseases according to World Health Organization (WHO) [4]. Motor vehicles emissions are a complicated combination of air pollution caused by friction and combustion, two processes established to be harmful to human health[5]. The majority of analyses conducted in the WHO European Region show that the air pollution carried on by transportation is to blame for tens of thousands of deaths annually from homicidal diseases[6]. Egypt's poor air quality has been detrimentally affecting people's health, placing it at the top of the list of nations with high disability adjusted life years (DALYs) caused by disease, which impacted more than 1.2 million people in 2012 [7]. Those who live in areas with high air pollution levels experience higher incidences of heart attacks, respiratory illnesses, and lung cancer than those who lead relatively healthier lives [8, 9].

Congestion in the road causes a drop in operating speed relative to post speed conditions, which approximately raises emissions in the air. Variables that affect traffic flow, such as density, flow, volume-to-capacity ratio, number of stops per mile, and signal coordination, are impacted by traffic congestion in numerous ways [10, 11]. Potential sources of emitted gaseous and particle pollution include the cars that are forced to stop before accelerating, which results in extreme urban traffic congestion and extremely poor air quality [12]. The interruptions of traffic flow at junctions or crossroads that occur between cars or between cars and pedestrians result in a number of conflict areas and produce variable rates of pollution emission within the junctions [13, 14]. Due to notable illegal parking, the section of road's effective width has been reduced significantly, which contributes to an increase in traffic density and vehicle emissions. Age and poor maintenance of a vehicle have an impact on the emissions produced from all vehicles classes. Additionally, the quality of the fuel directly affects the emissions from motor vehicles [15].

The macro simulation technique and the micro simulation approach are the two main methods used to estimate the emissions produced by vehicles on the road [16-19]. A microscopic simulation model known as VISSIM, which depends on the time-step and the behavior, could simulate the operations of mixed traffic in highway lanes and networks of urban roads. The two main categories of data collected from the field to build a network on VISSIM are static and dynamic data. The number of lanes, link start and end, width, length, and grade are all examples of static data. Traffic volumes for various movements, routes, and times, as well as signal timing plans and priority rules, are all examples of dynamic data [20]. COPERT is employed as the analysis tool to estimate automotive emissions in metropolitan areas. The European Environment Protection Agency (EEPA) created it as one of its standard emission frameworks for vehicles [21]. The primary variables for the COPERT are the type of vehicle, the emission standards, the average vehicle speed, the annual vehicle kilometers (VKT), the fuel quality, and the temperature [22]. The fundamental equation utilized to create the COPERT model is given in Equation (1). Quantity of pollutant m for vehicle n:

$$Q_{m,n} = \sum_i \sum_j (P_{i,j} \times VKT_{m,i} \times EF_{i,j,n}) \quad (1)$$

where i is the vehicle type; j is the local emission standard; Pi,j is the number of vehicles in category i with emission standard j; VKTi is the annual average vehicle kilometers travelled (km) for vehicles category i; and EFi,j,n is the emission factor in g/km for pollutant n emitted from vehicle category i with emission standard j.

This study aims to evaluate traffic characteristics and emission results for different corridors in Zagazig city, as well as suggestion several scenarios for each studied corridor to improve traffic and emission results. The study methodology was created and used to achieve the study objectives.

## 2-STUDY METHODOLOGY

To achieve the study objectives, a comprehensive study methodology was designed and carried out. Flowchart (shown in Figure.1) describes the study methodology. The study methodology started off with a thorough explanation of the simulation area and how data was gathered for the simulation in order to develop a realistic traffic model. VISSIM software was utilized in this study to create a traffic model simulation and obtain traffic results for the study area. The development of the traffic model in VISSIM was continuously detailed along with its adjustments to various parameters. To improve traffic statistics using the traffic model, two scenarios were suggested. The COPERT software was used to estimate emissions under various scenarios in order to produce a representative emission computation that complies with Environment Protection Agency (EPA) guidelines.

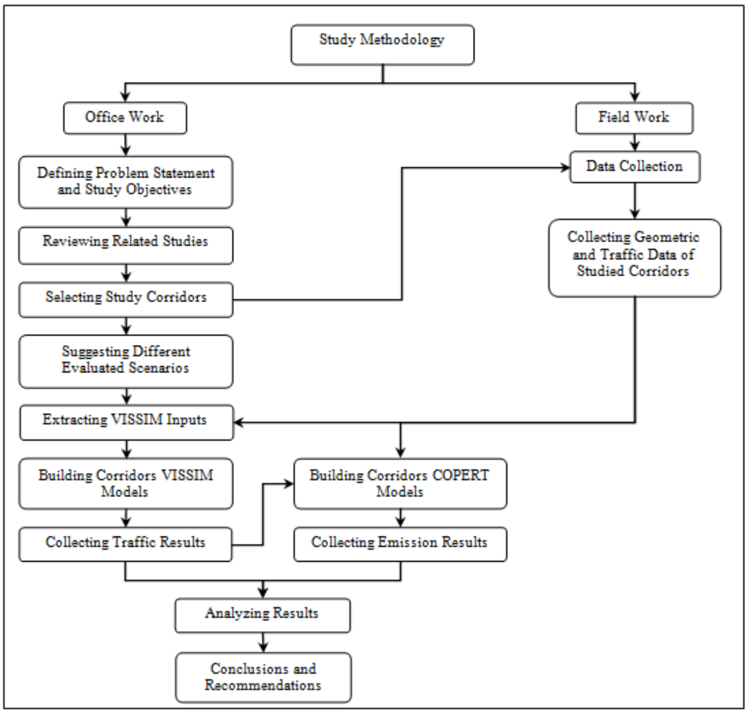
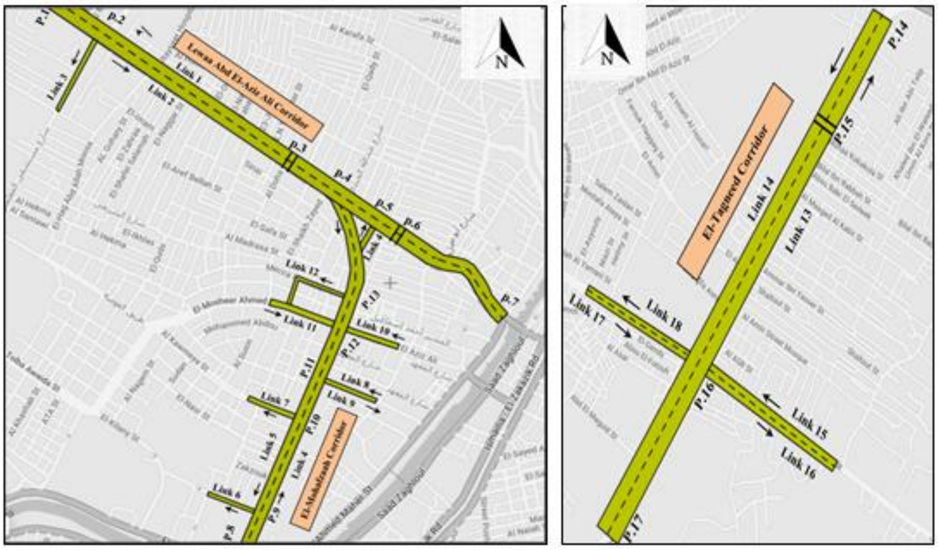


**Figure (1) Study Methodology Flowchart**

## 2.1 STUDY AREA

Three different corridors in Zagazig city (study area) were selected including El-Lewaa Abd-Elaziz Ali Street (corridor 1), El-Mohafzah Street (corridor 2), and El-Tagneed Street (corridor 3), to be evaluated. Figure.2 presents map of Zagazig city as study area including evaluated corridors. Zagazig City is the capital of Alsharkia's governorate, and it is located 86 kilometres northeast of greatest Cairo. Zagazig city as study area is bounded by Harayah from the north, Al-Shobak from the east, Al-Zanklun from the south, and El-Qanayat from the west. Details of the studied corridors are shown in Figure.3 (a and b). El-Lewaa Abd-Elaziz Ali corridor is of length about1.5 km and consists of three links (Links 1, 2, and 3). Link 1 starts from El-Obour bridge and ends at Mansoura station. In addition, Link 2 starts from Mansoura station and ends at El-Obour bridge. Link 3 is an exist route from main street (Link 2) to El-Moaalmeen hospital. El-Mohafzah corridor is of length about 1 km and consists of 9 links (Links 4 to 12). Link 4 starts at the governorate building and ends at El-Lewaa Abd-Elaziz Ali Street (Link 2) at point 5. Link 5 starts from El-Lewaa Abd-Elaziz Ali Street (Link 2) at point 4 and ends at governorate building. Links 6 and 7 are exit routes from Link 5 to El-Gamaah street and Al-Kawmeya street, respectively. Links 8 and 10 are entrance routes to main street (Link 4) for vehicles coming from Ahmed Maher street, as well as link 9 is an exit route from Link 4 to Ahmed Maher Street. Links 11 and 12 are entrance and exist routes, respectively, between Link 5 and El-Mosheer Ahmed Ismail street. El-Tagneed corridor is of length about 1.4 km and consists of Links 13, 14, 15, 16, 17, and 18. Link 13 starts from El-Tagneed area and ends at El-Zeraah area. In addition, Link 14 starts from El-Zeraah area and ends at El-Tagneed area. Links 15 and 17 are entrance routes from El-Ghar region to Link 13 and from Farouk Street to Link 14, respectively. Links 16 and 18 are exist routes from Link 13 to El-Ghar region and from Link 14 to Farouk Street, respectively.


**Figure (2) Map of Zagazig City Including Studied Corridors**




**(a)** **(b)**

**Figure (3) Details of El-Lewaa Ali Abd-Elaziz Street, El-Mohafzah Street, and El-Tagneed Street as Study Corridors**

## 2.2 SCENARIOS SELECTION

Three different scenarios were suggested to be evaluated for the studied corridors, including basic scenario. Basic scenario reflected current conditions of study corridors, which suffer from limited usable width because of on-street parking in addition to congested traffic flow at junctions. In suggested additional two scenarios (1 and 2); restricting on-street parking which increases usable road width, intersection management using signal design, and changing road geometry like shifting the location of U-turns were estimated. All changes were suggested as trials to enhance traffic movements and reduce vehicle emissions. Details of different scenarios for the studied corridors are illustrated in Table.1.

**Table (1) Details of Different Scenarios of the Studied Corridors**

| Corridor name | Scenarios | | |
|---|---|---|---|
| | **Basic Scenario** | **Scenario 1** | **Scenario 2** |
| El-Lewa Abd-Elaziz Ali street | | Restricting on-street parking for both direction at main street (link 1, link 2) | shifting the location of U-turn (point 3) from section 850 m to section 600 m (from Mansoura station) |
| El-Mohafzah street | -Limited usable width<br>- on-street parking<br>- congested traffic flow at junctions | Restricting on-street parking for both direction at main street (link 4, link 5) | Signal design with cycle time 64 second at point 12 between (link 4 and link 10) |
| | | | Signal design with cycle 45 second at point 12 between (link 5 and link 11) |
| El-Tagneed street | | Restricting on-street parking for both direction at main street (link 13, link 14) | Signal design with cycle time 45 second at U-turn (point 15) between (link 13 and link 14) |

## 2.3 TRAFFIC MODELLING

The next step (as shown in Figure 1) was building traffic simulation models of the studied corridors. This activity needed to collect complete geometric and traffic data of the studied corridors. The geometric data of studied links included link length, lane width, and number of lanes. Link length of each link was determined from Google Maps. Link width and number of lanes were manually measured during field work. After that, an accurate traffic count was conducted on eighteen investigated links of studied corridors to create the VISSIM models. Different vehicle traffic volumes of the studied corridors were changed to passenger car (PC) according to Passenger Car Equivalent (PCE) factors mentioned in Table.2

[23, 24]. Table.3 shows geometric data and traffic volumes of study corridors links.

**Table (2) Passenger Car Equivalent Factors [23, 24]**

| Type | Passenger Car | Taxi | Motorcycle | Three Wheels | Microbus | Bus | Signal unit truck |
|---|---|---|---|---|---|---|---|
| PCE | 1 | 1 | 0.25 | 0.5 | 1.5 | 2.5 | 2 |

**Table (3) Geometric and Traffic Volumes in PCU/hr of Study Corridors Links**

| Corridor Name | Link Name | From | To | link length(m) | Number of lanes | lane width(m) | Volume PCU/hr |
|---|---|---|---|---|---|---|---|
| El-Lewaa Abd-Elaziz Ali street | Link 1 | El-Mansoura Station | El-Obour Bridge | 1550 | 2 | 3.5 | 2240 |
| | Link 2 | El-Obour Bridge | El-Mansoura Station | 1550 | 2 | 3.5 | 1890 |
| | Link 3 | Link 2 | El-Moalmeen Hospital | 100 | 1 | 3.5 | 285 |
| El-Mohafzah street | Link 4 | El-Lewa Abd-Elaziz Ali street | El-Mohafzah building | 1070 | 1 | 3.5 | 780 |
| | Link 5 | El-Mohafzah building | El-Lewa Abd-Elaziz Ali street | 1065 | 1 | 3.5 | 705 |
| | Link 6 | Link 5 | Governmental Interests Street | 130 | 1 | 4 | 90 |
| | Link 7 | Link 5 | Al-kawmaya Street | 160 | 1 | 4.5 | 275 |
| | Link 8 | QNB Street | Link 4 | 145 | 1 | 3.5 | 460 |
| | Link 9 | Link 4 | QNB Street | 145 | 1 | 3.5 | 110 |
| | Link 10 | Abd El-Aziz Ali Street | Link 4 | 175 | 1 | 4 | 305 |
| | Link 11 | El-Mosheer Ahmed Ismail Street | Link 5 | 300 | 1 | 3.5 | 380 |
| | Link 12 | Link 5 | El-Mosheer Ahmed Ismail Street | 335 | 1 | 3.5 | 305 |
| El-Tagneed street | Link 13 | El-Tagneed area | El-Zeraah area | 1425 | 2 | 2.75 | 2375 |
| | Link 14 | El-Zeraah area | El-Tagneed area | 1425 | 2 | 2.75 | 2140 |
| | Link 15 | El-Ghar area | Link 1 | 115 | 1 | 3.5 | 270 |
| | Link 16 | Link 1 | El-Ghar area | 115 | 1 | 3.5 | 410 |
| | Link 17 | Farouk street | Link 2 | 115 | 1 | 3.5 | 665 |
| | Link 18 | Link 2 | Farouk street | 115 | 1 | 3.5 | 775 |

Building traffic simulation models of the studied corridors was established using VISSIM software-version 8.00-15. At first, the position of each link of the evaluated corridor was marked in Google maps image placed in VISSIM screen. All links of studied corridor were drawn at its position in Google maps image. Link length was automatically determined after its drawing on Google Maps image. In addition, link name, link width, and number of lanes were entered in VISSIM. After that, traffic volume in PCU/hr was entered in VISSIM model on each link of the evaluated corridor. After that, a number of VISSIM model variables, such as limit speeds for each link at turns, and reduced speed area at intersections, were adjusted to develop simulations that accurately represent traffic conditions. Then, simulation process was started and vehicles moved at links to represent actually traffic conditions. Figure.4 displays an example of PTV VISSIM model screen during simulation process for El-Tagneed corridor.

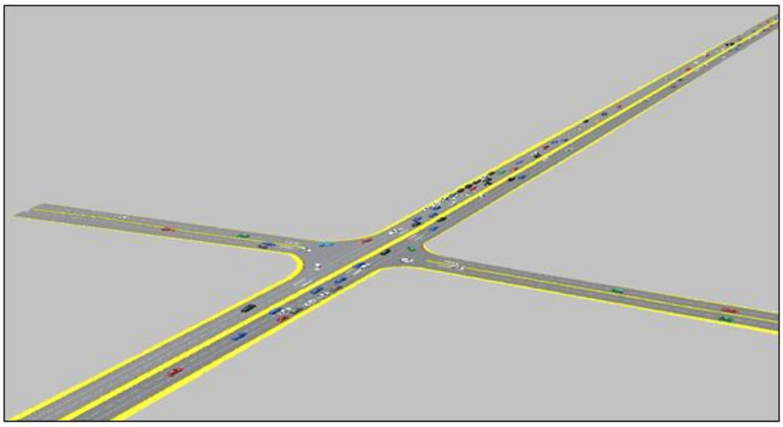


**Figure (4) An Example of VISSIM Simulation Model Screen of El-Tagneed Corridor**

## 2.4 EMISSION MODELLING

The COPERT software's emission models were produced for all investigated corridors. COPERT, computer software created by the European Commission (EC), which calculates emissions from road transportation, is an average speed model. Firstly, the VISSIM model output was utilized to represent the indicated cars in COPERT using the average traffic volume with passenger car classification (PC). A medium-sized passenger car that runs on gasoline was used in the COPERT model to estimate air pollutants. Additionally, urban highways option was chosen to reflect study area conditions. CO, $NO_X$, and $CO_2$ emissions from COPERT were measured as a vehicle's emission rate in grams per kilometer (g/km). The total emissions amount for each link was estimated using the emission rate, average traffic volume, and length of each link in accordance with Equation 2. Each pollutant's quantity was determined for each link and added together to determine the overall amount for each corridor.

$$\text{Total hourly emission amount (grams)} = \text{emission rate (g/km)} \times \text{number of vehicles (veh/hr)} \times \text{link length (km)} \quad (2)$$

## 2.5 EMISSION DAMAGE COST

The damage cost of air emissions were expressed as damages in dollars per kilogram for effects on health and the environment [25]. Air emission cost included Internal and external costs of harmful effects of air pollution. Internal cost associated with air pollution intake and external costs associated with the health harm caused by released pollutants on other people [26]. As a result of the lack of previous studies on determining the cost of damage caused by air emission in Egypt, this cost was estimated based on unit cost of pollutants from other sources. The unit cost of CO pollutant was estimated by K. A. Small and C. Kazimi [27] based on harmful effects on human health. The Environmental Protection Agency's data on New Jersey's pollutant emission levels was used to calculate unit costs including $NO_X$ and $CO_2$ [28]. The unit costs for each pollutant (CO, $NO_X$, and $CO_2$) are shown in Table.4 in dollars per ton.

The total hourly cost of emitted emission from the studied corridors was calculated by multiplying the unit cost in dollars per ton (shown in Table.4) of each pollutant by the total amount of emission (in tons). Then, the annual damage costs for these urban corridors were determined using k-value for the average daily cost and 365 days for one year as shown in Equation 3. The k-value was used at 10%, as specified in the Egyptian Code of Practice for Rural and Urban Road Works [29].

$$\text{Total annually emission cost (dollar)} = \text{emission unit cost (dollar/ton)} \times \text{emission amount (ton)} \times \text{K-Value} \times 365 \quad (3)$$

**Table (4) Damage Unit Cost of Each Pollutant Type (dollars/ton)**

| Pollutant Type | CO | $NO_X$ | $CO_2$ |
|---|---|---|---|
| Unit cost Dollars/ton | 15.21 | 15,600 | 52 |
| For CO (source): K. A. Small and C. Kazimi [27].<br>For $NO_X$, and $CO_2$ (source): [30] | | | |

## 3- RESULTS AND DISCUSSION

### 3.1 TRAFFIC CHARACTERISTICS RESULTS

Traffic characteristics results produced using VISSIM simulation models are average speed and percent of average delay. The estimated average speed and percent of average delay of all vehicles for all studied corridors are shown in Table.5. Scenario 1 causes increasing the average speed at all studied corridors. This increase ranges between 20.08% for the El-Mohafzah corridor and 39.95% for the El-Lewaa Abd-Elaziz Ali corridor compared to the basic scenario. This increase may be due to the increasing in road width after restricting of street parking. Applying Scenario 1 also causes decreasing the percent of delay for all studied corridors. This decrease may be due to the increasing in road width after restricting on-street parking. This decrease ranges between 59.56 % for El-Tagneed corridor and 73.15 % for El-Lewaa Abd-Elaziz Ali corridor compared to basic scenario. The difference between little and larger increase in average speed may be due to the difference in the geometric characteristics of studied corridors.

Evaluating the average speed and percent of delay time resulted from applying Scenario 2 on studied corridors shows lower improvements than that achieved applying Scenario 1. This improving in average speed ranges between 7.75 % for El-Mohafzah corridor and 29.22 % for El-Tagneed corridor compared to basic scenario. The decreasing in percent of delay ranges between 31.80 % for El-Tagneed corridor and 48.04 % for El-Lewaa Abd-Elaziz Ali corridor compared to basic scenario. This improvement may be due to improving traffic flow movements at intersections which may be due to signal design, as well as shifting the locations of U-Turns. The difference between little and larger improvements in average speed and percent of delay compared to basic scenario may be due to the difference in the geometric characteristics of studied corridors. Applying Scenario 1 always achieves better improvements on studied corridors than Scenario 2.

**Table (5)** Average Vehicles Speed and Delay Percent of Studied Corridors

| Corridor ID | Corridor name | scenarios | Average vehicles speed (Km/hr) | Average vehicles delay (%) |
|---|---|---|---|---|
| 1 | El-Lewaa Abd-Elaziz Ali | basic scenario | 33.54 | 35.2 |
| | | scenario 1 | 46.94 | 9.45 |
| | | scenario 2 | 42.26 | 18.29 |
| | | Sc.1/Basic Sc. (%) | 139.95 % | 26.85 % |
| | | Sc.2/Basic Sc. (%) | 126 % | 51.96 % |
| 2 | El-Mohafzah | basic scenario | 32.02 | 22.58 |
| | | scenario 1 | 38.45 | 7.09 |
| | | scenario 2 | 34.5 | 15.4 |
| | | Sc.1/Basic Sc. (%) | 120.08 % | 31.40 % |
| | | Sc.2/Basic Sc. (%) | 107.75 % | 68.20 % |
| 3 | El-Tagneed | basic scenario | 30.94 | 37.93 |
| | | scenario 1 | 42.37 | 15.34 |
| | | scenario 2 | 39.98 | 20.18 |
| | | Sc.1/Basic Sc. (%) | 136.94 % | 40.44 % |
| | | Sc.2/Basic Sc. (%) | 129.22 % | 53.20 % |

## 3.2 VEHICLES EMISSIONS EVALUATION

Different air emissions resulted from daily traffic movements on studied corridors are discussed in this paragraph. Table.6 shows total quantity and average concentration per $m^3$ of CO, $CO_2$, and $NO_X$ for studied corridors for basic scenario (current situation) and two improvements scenarios.

The table shows that average concentration of CO for basic scenario is about 190 %, 105%, and 199% compared to the allowed by the World Health Organization (30 $mg/m^3$) for El-Lewaa Abd-Elaziz Ali corridor, El-Mohafzah corridor, and El-Tagneed corridor, respectively. So, numerous cases of headache, nausea, dizziness, breathlessness, fatigue, visual disturbance, and confusion for the people living on Zagazig are anticipated. Average concentration of CO on current condition records its minimum values at El-Mohafzah corridor. The lowest affecting traffic volume compared to the other corridors may be the reason. Increasing road width by restricting street parking (scenario 1) on studied corridors enhances this situation and decreasing CO average concentration to 33.31mg/m3, 37.81 mg/m3, and 24.1 mg/m3 for El-Lewaa Abd-Elaziz Ali corridor, El-Mohafzah corridor, and El-Tagneed corridor, respectively. Applying Scenario 1, the maximum decrease in CO concentration is found at El-Tagneed corridor, which decreases from 89.91 $mg/m^3$ to 24.10 $mg/m^3$ to be lower than limit value allowed by the World Health Organization (30 $mg/m^3$). The largest street width, the highest increasing of average speed, and the lowest nearby tall buildings may be the causes. Applying Scenario 2 on studied corridors decreases CO concentrations to 70.33mg/m3, 62.95 mg/m3, and 70.21 mg/m3 for El-Lewaa Abd-Elaziz Ali corridor, El-Mohafzah corridor, and El-Tagneed corridor, respectively. Valuable notice can be deduced comparing the results of CO concentrations in Scenario 1 and Scenario 2. This may be due to the minor improvements in Scenario 2 which not increased by shifting U-turns locations as well as using traffic signals to rearrange traffic movements.

Applying both scenarios (scenario 1 and 2) simultaneously increase traffic flow for all studied corridors. So, CO concentrations achieve the lowest values compared to Scenario 1 or Scenario 2, where CO concentrations values are 29.62 mg/m3, 35.34 mg/m3, and 23.38 mg/m3 for El-Lewaa Abd-Elaziz Ali corridor, El-Mohafzah corridor, and El-Tagneed corridor, respectively. Applying more traffic improvements in Zagazig corridors is recommended to destroy and decrease the CO concentration to be lower than 30 mg/m3. Hence, respiratory illness for Zagazig people must be decreased.

Regarding to the other types of air pollutions, Table 7 shows noticeable decreasing of $CO_2$, and $NO_X$ resulting from applying different scenarios. There are not minimum limit announced by WHO for these emissions. In spite of this, the reduction of $CO_2$, and $NO_X$ due applying different improvement scenarios must enhance Zagazig human health. Adding suitable types of green plants to Zagazig streets is highly recommended to decrease the amounts of $CO_2$, and $NO_X$ pollutions, and enhance the physical visions for city streets.

**Table (6) Quantities and Average Concentration of Emission Pollutants of Studied Corridors**

| Corridor Name | Scenario | Emission Quantities and Concentrations | | | | | |
|---|---|---|---|---|---|---|---|
| | | CO | | $CO_2$ | | $NO_X$ | |
| | | Quantity | Avg. Conc. | Quantity | Avg. Conc. | Quantity | Avg. Conc. |
| | | Kg/hour | $mg/m^3$ | Kg/hour | $g/m^3$ | Kg/hour | $mg/m^3$ |
| El-Lewaa Abd-Elaziz Ali street | basic scenario | 7.188 | 87.22 | 1737.15 | 21.00 | 0.343 | 304.41 |
| | scenario 1 | 1.679 | 33.31 | 1254.16 | 12.31 | 0.161 | 197.33 |
| | scenario 2 | 5.272 | 70.33 | 1357.69 | 17.97 | 0.266 | 258.91 |
| | Sc.1 + Sc. 2 | 1.523 | 29.62 | 1171.37 | 11.86 | 0.153 | 188.17 |
| | Sc.1/Basic Sc. | 23.35% | 38.19% | 72.20% | 58.62% | 46.94% | 64.82% |
| | Sc.2/Basic Sc. | 73.34% | 80.64% | 78.16% | 85.57% | 77.55% | 85.05% |
| | (Sc.1 + Sc. 2)/ Basic sc. | 21.19% | 33.96% | 67.43% | 56.48% | 44.61% | 61.81% |
| El-Mohafzah street | basic scenario | 2.579 | 61.59 | 608.56 | 12.75 | 0.115 | 153.22 |
| | scenario 1 | 2.89 | 37.81 | 456.02 | 6.20 | 0.117 | 152.72 |
| | scenario 2 | 2.667 | 62.95 | 507.4 | 11.66 | 0.116 | 153.54 |
| | Sc.1 + Sc. 2 | 2.617 | 35.34 | 447.27 | 5.98 | 0.115 | 151.93 |
| | Sc.1/Basic Sc. | 112.05% | 61.39% | 74.93% | 48.63% | 101.74% | 99.67% |
| | Sc.2/Basic Sc. | 103.40% | 102.21% | 83.38% | 91.45% | 100.87% | 100.21% |
| | (Sc.1 + Sc. 2)/ Basic sc. | 101.47% | 57.38% | 73.50% | 46.90% | 100.00% | 99.16% |
| El-Tagneed street | basic scenario | 7.544 | 89.91 | 1585.97 | 23.67 | 0.343 | 266.45 |
| | scenario 1 | 1.747 | 24.1 | 1314.68 | 12.48 | 0.168 | 175.92 |
| | scenario 2 | 5.025 | 70.21 | 1347.41 | 21.44 | 0.258 | 223.24 |
| | Sc.1 + Sc. 2 | 1.623 | 23.38 | 1251.94 | 11.73 | 0.153 | 161.23 |
| | Sc.1/Basic Sc. | 23.15% | 26.80% | 82.89% | 52.72% | 48.97% | 66.02% |
| | Sc.2/Basic Sc. | 66.61% | 78.09% | 84.96% | 90.58% | 75.22% | 83.78% |
| | (Sc.1 + Sc. 2)/ Basic sc. | 21.51% | 26.00% | 78.94% | 49.56% | 44.61% | 60.51% |

### 3.3 EMISSION COST RESULTS

The annual emission costs in dollar are calculated for all studied corridors based on unit cost of air emission pollutants. Table.7 shows annual emission damage costs for all scenarios applied on studied corridors. For basic scenario (current situation), the table shows largest values of emission damage costs for all studied corridors. Applying Scenario 1 decreases emission cost by 18.33%, 7.33, and 11.01% for El-Lewaa Abd-Elaziz Ali corridor, El-Mohafzah corridor, and El-Tagneed corridor, respectively. This may be due to huge decrease in quantities of emission pollutants after restricting of street parking. Applying Scenario 2 achieves high emission cost values compared to that achieved applying Scenario 1. This may be due to that Scenario 2 achieves less improvement and largest air emission quantities compared to Scenario 1 results. These cost values are 11.51%, 6.64%, and 8.18% for El-Lewaa Abd-Elaziz Ali corridor, El-Mohafzah corridor, and El-Tagneed corridor, respectively compared to basic scenario.

Applying both Scenario 1 and Scenario 2 simultaneously achieves better results of traffic flow and emission quantities compared to Scenario 1 or Scenario 2. So, the table shows the lowest values of emission cost in this case for all studied corridors. Applying both Scenario 1 and Scenario 2 decrease emission cost compared to basic scenario by 20.96%, 8.99%, and 12.79% for El-Lewaa Abd-Elaziz Ali corridor, El-Mohafzah corridor, and El-Tagneed corridor, respectively.

**Table (7) Total Annual Emission Costs for all Corridors in Dollars**

| Corridors | Unit Cost $/ton | Total Annual Emission Cost ($) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Basic scenario | Scenario 1 | Scenario 2 | Sc1 +Sc2 | Sc.1 /Basic Sc. | Sc.2 /Basic Sc. | Sc.1 + Sc.2 /Basic Sc. |
| El-Lewaa Abd-Elaziz Ali | CO =15.21<br>$NO_X$=15,600<br>$CO_2$=52<br><br>Total =15,667.21 | 736,753 | 601,702 | 651,963 | 582,327 | 81.67% | 88.49% | 79.04% |
| El-Mohafzah | | 251,339 | 232,906 | 234,658 | 228,753 | 92.67% | 93.36% | 91.01% |
| El-Tagneed | | 707,772 | 629,844 | 649,882 | 617,271 | 88.99% | 91.82% | 87.21% |

## 4- CONCLUSIONS

In order to improve the air quality in the study area, PTV VISSIM and COPERT have been used to model a number of traffic improvement scenarios (scenarios 1 and 2). The results of the analysis of improvements indicate that:

1. Restricting street parking on studied corridors (Scenario 1) increases average speed by ranges between 20.08 % and 39.95 %, as well as decreases percent of delay by ranges between 59.56 % and 73.15 %,
2. Using signal design at intersections or shifting the locations of U-Turns (Scenario 2) increases average speed by ranges between 7.75 % and 29.22 %, as well as decreases percent of delay by ranges between 31.80 % and 48.04 %,
3. Evaluating the average speed and percent of delay time resulted from applying Scenario 2 on studied corridors shows lower improvements than that achieved applying Scenario 1,
4. Average concentration of CO on current condition records its minimum values at El-Mohafzah corridor,
5. Applying Scenario 1, the maximum decrease in CO concentration is found at El-Tagneed corridor, which decreases from 89.91 $mg/m^3$ to 24.10 $mg/m^3$, as result of the highest increasing of average speed,
6. Applying Scenario 2 by shifting U-turns locations as well as using traffic signals to rearrange traffic movements achieves little improvements compared to Scenario 1.
7. Applying both scenarios (scenario 1 and 2) simultaneously increase traffic flow for all studied corridors, as well as CO concentrations achieve the lowest values compared to Scenario 1 or Scenario 2,
8. The noticeable reduction of $CO_2$, and $NO_X$ due applying different improvement scenarios must enhance Zagazig human health.
9. Applying Scenario 2 achieves high emission cost values compared to that achieved applying Scenario 1.
10. Applying both Scenario 1 and Scenario 2 simultaneously achieves better results of traffic flow and emission quantities compared to Scenario 1 or Scenario 2.

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