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Evaluation of Urban Vehicle Emissions Using Traffic and Emission Models - An Overview

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ABSTRACT

Due to the country's rapidly growing population and economy, transportation has become an essential part of Egyptian life. Air quality has decreased as a direct result of the rapid increase in urban areas' vehicle use due to human activities. In Egypt, almost 48.1% of all trips are taken by private automobiles, whereas public transportation is utilized only sometimes. Heavy congestion is the direct result of people's reliance on personal automobiles. More than 98% of the world's population in 2019 was located in regions where air quality did not meet World Health Organization (WHO) criteria. About 32% of Egypt's 2019 emissions came from the transportation sector. Different aspects that define the causes and possible alternatives to the air pollution problem at intersections are addressed in this research. Three intersections in Zagazig are the focus of this project, which looks into ways to reduce emissions from moving cars. PTV VISSIM generates a realistic peak-hour traffic simulation of the current traffic situation. Emissions are calculated using the data collected from the vehicles in the traffic simulation as input to the emission modelling software COPERT.

1. Introduction

Due to the tremendous growth of Egypt's population and economy, transportation has become an essential component of daily life. This has led to traffic and air pollution on the highways. When vehicles are halted in a bottleneck on congested highways, they slow down and almost come to a complete stop, resulting in higher air pollution emissions. Elements that are dangerous to human and environmental health may be emitted by these substantial vehicle emissions. Due to the rapid development of car ownership, vehicle exhaust emissions are one of the primary sources of air pollution in cities [1]. Egypt's planners and policymakers are extremely concerned with the amount of fuel the transportation sector uses and the pollution it produces. Approximately 27% of total U.S. greenhouse gas emissions [2] are related to fuel consumption related to transportation. Due to the congestion and numerous stop-and-go actions they involve; urban arterial intersections account for around 30% of extra gasoline usage. In addition, the increase in FC has negative impacts on the environment since it increases carbon dioxide (CO2) emissions into the atmosphere and harms human

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health by increasing particulate matter (PM) and other dangerous pollutants [3]. Vehicle emissions have been shown to put drivers, commuters, and the community at risk for morbidity and mortality [4]. In 2019, approximately 32% of Egypt's overall emissions were produced by the transportation sector [5], [6]. As the nation with the fastest greenhouse gas emissions, Egypt is rated at number 10 [7], [8]. According to the World Health Organization (WHO), air pollution in developing countries causes approximately 4 million deaths each year as well as numerous cases of respiratory illness [9], [10]. Pollutants in the air can come from a wide range of activities, both natural and man-made, like the consumption of fossil fuels in transportation, industries, homes, and electricity generation. The urban transport sector is the primary source of air pollution, especially in urban areas. According to studies, 70–80% of air pollution in developing nations is caused by vehicle emissions, particularly those from a significant number of older vehicles with poor vehicle maintenance, poor fuel quality, and inadequate road infrastructure [11], [12]. Increased air pollution has been associated with an increase in the incidence and severity of diseases such as chronic obstructive pulmonary disease (COPD), respiratory infections, lung cancer, and asthma [13], [14].

2. Traffic congestion

Congestion on the roads is a major issue in many cities throughout the world, both in developed and developing countries, and is only expected to get worse [15], [16]. It results in delay, wasted energy, and environmental contamination. Congestion is the degradation of traffic flow due to increased travel demand and/or decreased traffic movement capacity [17]. Traffic congestion and delays in travel time are crucial challenges for the global sustainability of urban transportation systems [18], [19]. Rapid urbanization has caused an increase in travel demand, resulting in the production of almost 77 million vehicles annually worldwide since 2010 [20]. This growth in vehicle manufacturing not only causes road congestion and an increase in fuel consumption, but also affects the environment by increasing the amount of pollution they produce. As a result, turning to public transportation to reduce traffic has positive effects on the environment, land usage, and economic system [21]. The effects of traffic congestion can be classified into four primary categories: ecological, economic, health-related, and social [22], [23]. Air and noise pollution, as well as visual intrusion, are the general environmental effects of traffic congestion. Air pollution causes a rise in greenhouse gases (GHG) in the atmosphere, thereby contributing to global warming. The economic effects include a rise in fuel consumption, which results in greater transportation expenses, the loss of working time, and a delay in the delivery of services. Headaches, mental tension, and fatigue are some of the negative health effects that can be brought on by prolonged exposure to filthy air and needlessly long amounts of time spent travelling on roadways. The social impacts include a lower quality of life, which is reflected in decreased personal incomes as a result of increasing costs associated with transportation, as well as a loss of time that would have otherwise been spent participating in social activities. It has been said that traffic congestion in urban areas cannot be totally removed, but instead can only be reduced to an acceptable level, and that there is not one solution to the problem [24]. In Egypt, examples of bad traffic management include insufficient parking capacity, random car stops, the absence of a pedestrian crossing, and U-turns. This is likely the most significant cause of traffic congestion [25]. The World Bank [25] mentioned in its research on Egypt's traffic congestion "that traffic congestion is a terrible issue in Egypt" and that it has detrimental and large effects on the quality of life (the environment and human health) and the economy. It is also a key factor in wasting time stopped in traffic. This time could have been utilized for other purposes. Numerous people suffer because of traffic congestion, not only the drivers but also the residents, pedestrians, and commercial activities, because stopping vehicles for a long period raises the emission rates of many dangerous pollutants such as SO2, CO, and NO2.

3. Source of emission

Air pollution can be caused by both natural and human activities. Carbon monoxide and nitrous oxide from vehicle exhausts, as well as smoke and Sulphur dioxide from power plants, are examples of man-made pollutants. Smoke from forest fires and ash from volcanoes are two examples of natural causes. Natural air pollution is extremely important in influencing atmospheric change, although its effects are temporary. Air pollution can be emitted directly into the atmosphere by stationary or mobile sources, such as carbon monoxide or hydrocarbons, or formed in the atmosphere by physical and chemical processes such as hydrolysis, oxidation, or photochemistry, producing

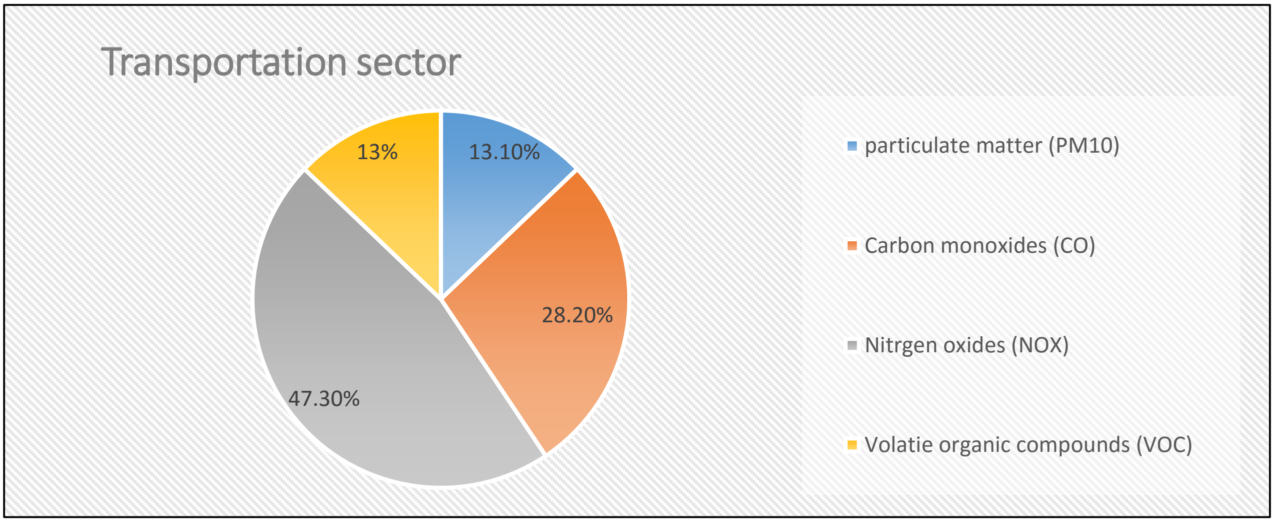


Fig. 1. contribution of the transportation sector to each air pollution source's emissions.
Source: EEA data was gathered by the Author (2021) [28].

ozone, carbon dioxide, and acid rain [26], [27]. Oxides of nitrogen (NOx), sulphur dioxide (SO2), carbon monoxide (CO), particulate matter (PM), volatile organic compounds (VOCs), and ozone (O3) are the main air pollutants responsible for deteriorating air quality and impacting human health. Fig. 1 illustrates the percentage of pollution caused by transport sector [28]. Fig. 1 shows the percentage of nitrogen oxides, carbon dioxide, suspended particulate matter, and volatile organic compounds emitted by the transportation sector.

4. The impact of emissions on human health

Numerous studies have provided conclusive evidence that there is a connection between the quality of the air and the status of human health. According to newly released data from the WHO, nine out of ten people throughout the world breathe air that is of lower quality than the guidelines set by the WHO. Air pollution is one of the predominant killer factors worldwide, causing 7 million deaths annually, including 600,000 children [29]. Increased air pollution has been associated with an increase in the incidence and severity of diseases such as chronic obstructive pulmonary disease (COPD), respiratory infections, lung cancer, and asthma [13], [14]. Air pollution can have a direct effect on human health depending on a variety of factors, including the time that we are exposed to it, the level of pollution we are exposed to, the type of pollutants we are exposed to, and the overall health of the population [30]. People who breathe polluted air have much higher rates of heart attacks, respiratory illnesses, and lung cancer [31], [32] when compared to people who live in surroundings that are generally cleaner. This is because contaminated air has a higher concentration of harmful substances. Directly affecting the respiratory system are gaseous contaminants. Short-term exposure to SO2 can irritate the eyes, nose, and throat, whereas long-term exposure can lead to bronchitis, emphysema, asthma, and lung disease [13], [33]. Furthermore, high NO2 levels can increase the risk of asthma and other respiratory diseases. Epidemiological studies [34], [35] indicate that 5-7% of lung cancer in smokers and non-smokers is caused by NO2 in the environment. Direct exposure to CO is dangerous for anybody, but those with heart problems are extremely sensitive because it reduces the quantity of oxygen delivered throughout the body [36]. Also, there is an agreement among researchers that PM is the pollutant with the most severe effects on human health. PM2.5 reaches the lungs deeply and may cause chronic obstructive pulmonary disease (COPD) and even cancer. The chance of developing cardiovascular illness, respiratory disease, and lung cancer is increased as a result of it. Globally, PM2.5 is known to be the sole cause of roughly 3.3 million deaths yearly, and long-term exposure of 10 g/m3 or more to PM2.5 might cause an increase of up to 11% in cardiovascular mortality [27], [37]. Different contaminants can cause different sorts of harm and have distinct effects on cardiovascular health. Numerous studies have shown that a pollutant can directly cause inflammation in the respiratory tract, which can lead to systemic inflammation and increase the risk of cardiovascular morbidity and mortality [38], [39]. 60–80% of all deaths caused by air pollution are related to cardiovascular disease [40].

5. Emissions-influencing factors

Emissions-influencing factors. Vehicle emissions are caused by a variety of factors interacting with one another. A number of studies have examined various aspects of vehicle emissions, but depending on their objectives, the literature presents very different interpretations of the factors that affect actual emissions from operating vehicles. There is a plethora of information regarding the fuel type, fuel consumption, distance travelled, speed, road grade, road elevation, operating acceleration, and restraint. Emissions from vehicles can be affected by a number of different factors.

5.1. Vehicle characteristic and other factors

The primary aspects that have an effect on the amount of fuel used are the characteristics of the vehicle. These aspects include the type of fuel used, the amount of fuel consumed, the distance travelled, and the type of engine. From the perspective of a vehicle that is actively being run, the different kinds of engines, fuels, and the amount of gasoline that is consumed during operation each have a direct influence on emissions. In theory, the type of engine in a vehicle determines the amount of emissions it produces; a larger engine will consume more gasoline and produce more pollutants than a smaller engine[41]. The type of engine has an impact on fuel consumption as well. The kind of fuel used is also a crucial factor in determining emissions [42]. When modelling emissions, it is essential to take into account the age of the vehicle as well as the type of vehicle being modelled because older vehicles are responsible for a greater amount of emissions.

Emission rates from motor vehicles are connected with a variety of vehicle and engine variables (including mass, engine size, transmission type, emission control systems), and driving modes (idle, cruise, acceleration, and deceleration). There are four driving modes: idle, acceleration, deceleration, and cruising. Several recent studies have examined emissions data for various driving scenarios. In reality, vehicle exhaust pollutants are primarily the result of incomplete fuel combustion. During acceleration, the engine needs more fuel to accelerate, which increases pollution. Hence, acceleration mode is the most polluting and fuel-hungry of the four normal driving modes. However, in cruising mode, gasoline is used to maintain engine speed, resulting in lower fuel consumption and emissions than in acceleration mode. During deceleration, vehicles are essentially moved by the inertial forces obtained during the previous acceleration and cruising modes, so little fuel is required. However, the fuel flow cannot be stopped immediately if the acceleration or cruising mode is suddenly changed to deceleration mode. In the initial few seconds of the deceleration modes, excess fuel continues to flow. Especially for rapid acceleration and deceleration variations, the induced fuel consumption and emissions are more significant [43]. For idling, fuel is used to maintain the engine's operation. Consequently, fuel consumption and emissions are substantially lower compared to other driving modes. [44] demonstrated that emissions from acceleration conditions were greater than emissions from constant speed movement, whereas emissions from deceleration conditions were less. Poor vehicle maintenance and age have both had an impact on the emissions released by all kinds of vehicles. Furthermore, fuel quality has a direct impact on vehicle emissions [45]. Vehicle speed, ambient temperature, ambient pressure, ambient relative humidity, horizontal alignment bearing angle, and profile road grade all have a beneficial impact on CO2 emissions in gasoline vehicles. The number of rotations per minute for vehicle engines has a detrimental impact on vehicle CO2 emissions [46]. Light-duty vehicles (LDV) account for 97 percent of CO2 pollution generated from the transport sector in Egypt, while heavy-duty vehicles (HDV) account for 3 percent [47]. There are significant differences between these emissions of the bus and the diesel van, which are primarily attributable to their respective engine sizes. The bus, which is the largest and heaviest, has the largest engine capacity, consumes more energy, and has, without question, relatively high emission factors. The bus has the highest levels of HC, NO%, and particulate emissions among all test vehicles. For gasoline vehicles, the emissions from the gasoline van are significantly greater than those from the private automobile. It is due to the effects of both the catalytic converter and engine capacity. Due to the larger engine capacity of the gasoline van, its emission factors and fuel consumption are higher than those of the private automobile [43].

5.2. Traffic volume

The most important factor in determining the amount of gaseous pollutants emitted by vehicles is traffic volume. Emissions increase in direct proportion to the amount of traffic that is present. A further significant finding is that along road segments where traffic volumes do not significantly differ, emissions depend on the composition of the traffic, with heavy vehicles (trucks and buses) having a noticeable impact on the emission of gaseous pollutants; a high proportion of heavy vehicles in the composition of the traffic has a significant negative impact on emissions, while light vehicles barely affect the total traffic emissions [41].

5.3. Road environmental factor

Some researchers have come to realize that it is important to consider environmental conditions when operating a vehicle. According to [48], a major influence on the emission results was caused by the real road conditions that the vehicles were driving on at the time of the operation. Other researchers observed that the actual road conditions would impact the vehicle's engine power and braking system, affecting the vehicle's energy consumption and pollution emissions. Thus, the estimated number was lower than the actual result since the laboratory test neglected how driving circumstances affected the car Some researchers have come to realize that it is important to consider environmental conditions when operating a vehicle. According to [48], a major influence on the emission results was caused by the real road conditions that the vehicles were driving on at the time of the operation. Other researchers observed that the actual road conditions would impact the vehicle's engine power and braking system, affecting the vehicle's energy consumption and pollution emissions. Thus, the estimated number was lower than the actual result since the laboratory test neglected how driving circumstances affected the car [49]–[51]. According to [52], if road conditions were ignored, the results of the pollution emission evaluation would be 16%–22% unclear. In order to create a vehicle pollution emission model, it is crucial to take into account the variables influencing the road conditions when a vehicle is operating. In both intersections and segments, the road environmental factors reflect the external environment as a result of car emissions.

5.3.1 Speed

Design speed is a significant factor that affects other design features in the geometry of highways. It should be noted that the stability of vehicle speed has a significant impact on the production of traffic emissions. In many models, the basic indicator of emissions is the vehicle's running speed, which primarily includes both the average speed and the instantaneous speed. More particularly, emissions are reduced when traffic flows smoothly and increased when vehicle speed is unstable due to vehicle decelerations and accelerations (stop and go) [41]. There is a direct correlation between vehicle speed, acceleration, and emissions. CO and HC levels increase as the speed increases from 15 to 32 km/h. However, CO and HC concentrations decrease slightly as speed increases from 32 to 53 km/h. In contrast, NO2 emissions obviously increase over the same vehicle speed range [53]. Fuel consumption and emissions vary with speed rate: idling accounts for 50% of total emissions, accelerating accounts for 35–40% of total emissions, and decelerating accounts for 10% of total emissions [54].

5.3.2 Signalized intersection

Vehicle acceleration, idling, and deceleration regularly near intersections on the urban road network cause traffic delays, increase energy consumption, and increase emissions. The intersection parameters have a substantial impact on the emissions produced by vehicles moving at intersections. These variables are classified as signal timing for isolated intersections, average delay, and signal coordination for signalized arterials. Many studies have demonstrated that optimizing traffic signals is one of the most efficient methods for increasing the capacity of current urban networks [55], [56]. The prevalent strategy for optimizing traffic signals (in order to achieve effective traffic flow on urban arterials) involves minimizing delay and the number of stops. Considering that the majority of excess fuel is burned during the deceleration-acceleration phases of a stopping event, past surveys have also shown that decreasing the number of stops reduces fuel consumption (FC) [57], [58].

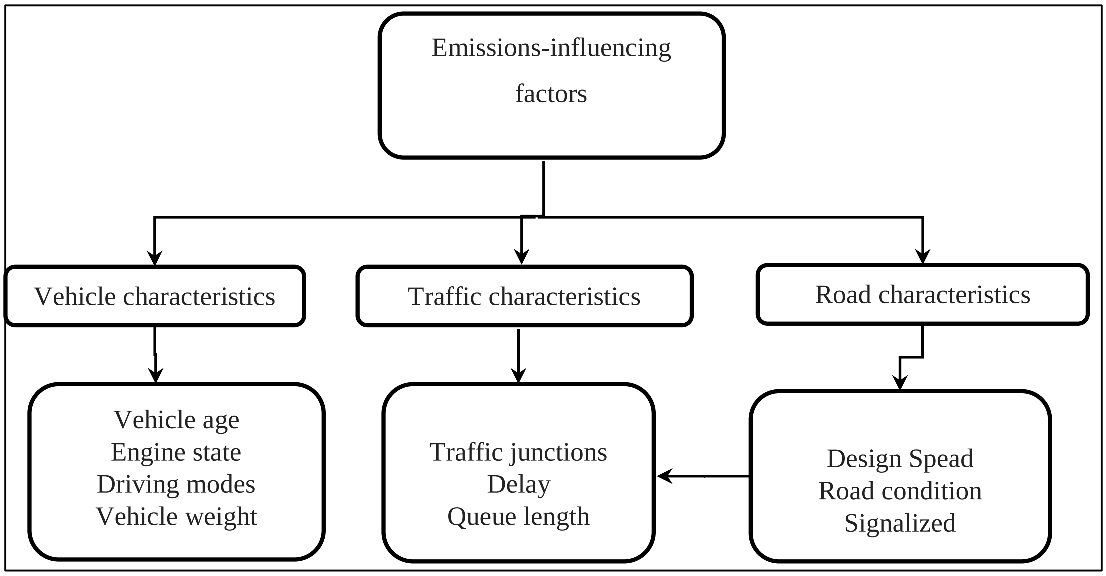


Fig. 2.Flowchart showing variables that contribute to vehicle emissions

6. Modeling

The concept of building a system model is a scientific technique for analysing a complicated phenomenon. By simulating a real-world scenario, a model is developed to fully comprehend how a system functions. There are various approaches to system modelling, and each depends on the model's goal. For this study, the types of models that will be used are microscopic traffic flow, calibration, and emission modelling.

6.1. Traffic modeling

As a non-direct dynamic analysis method for the Early in the 20th century, traffic flow models were developed to make it possible to comprehend the dynamics of traffic flow [59]. Furthermore, it is essential to recognize the distinction between traffic flow and transportation. Aspects like "efficient, safe, and sustainable movement of people and products" are often taken into account in transportation, according to [60]. As opposed to traffic flow, which is a method for analysing "the capacity and traffic operating quality of transportation facilities." Thus, operational quality (speed, delay, or journey time) analysis within a traffic stream forms the basis of traffic flow theories. However, traffic flow models can be modelled at three different scales: macroscopically, mesoscopically, and microscopically. Macroscopic models are built from an all-encompassing perspective and focus on elements like traffic volume and density. Microscopic models are built on a more in-depth level and concentrate on modelling the movement of individual cars, which together make up a traffic stream. Finally, mesoscopic models are a cross between microscopic and macroscopic models. Traffic simulation models are implemented in various traffic and transport planning software to display traffic behavior via a graphical user interface, where the user can define input parameters and observe outputs [61]. SUMO, MAT Sim, AIMSUN, CORSIM, Paramics, VISSIM, and TRANSIMS are the seven most well-known traffic simulation tools, according to Ejercito et al. [62]. We can consider traffic simulators to be dynamic visualization models that employ statistical methods to analyze traffic behavior and provide statistical reports for the simulated scenario. "Simulation of Urban Mobility" (SUMO) is an open-source, highly portable, microscopic road traffic simulation application designed to manage large road networks [63]. Aimsun is a simulation package that combines three kinds of transport models: tools for static traffic assignment, a mesoscopic simulator, and a micro simulator [62]. CORSIM TRAFVU is a viewer for traffic simulation and is included in the TSIS CORSIM software suite. Using the CORSIM input and output files created by a licensed user of TSIS CORSIM, it provides animation and static visualizations of traffic networks [62]. The simulation programme used in this study is called VISSIM, and it uses time steps and behavior-based models to simulate traffic flow. According to[64], VISSIM is a microscopic traffic simulation model, which means it concentrates on each individual vehicle and how it interacts with other vehicles. The model provides an overview of the movements along the entire road network and can simulate traffic flows within an area in detail. Both private and public transportation operations, as well as pedestrian flow, can be studied in VISSIM [65].

6.2. Emission modeling

When conducting an EIA of a traffic network, it is necessary to take into account the many components that make up the network. For instance, a roundabout in a traffic network shows that drivers on the outside of the roundabout must wait due of priority regulations for vehicles on the inside of the roundabout. A car's fuel consumption and emissions go up because of the multiple processes involved in coming to a stop, including braking and idling. The vehicle and engine characteristics determine the exhaust and non-exhaust emissions. This is why it is essential to take into account the vehicle and engine characteristics in the emission modelling in addition to the network components [66]. In recent years, researchers have built and improved models that represent a system that generates emissions from mobile sources. The authors classify these emission models into three categories [66]: macroscopic, medium, and microscopic. The key difference between the major models is how scalable they are and what model parameter they are based on. While "macroscopic emission models" are based on an average speed, "medium emission models" take into account things like acceleration, speed, and the ratio of capacity to speed. All of these things can be measured using the traffic infrastructure that is already there. The most important thing that goes into "microscopic emission models" is data on how many seconds it takes for a vehicle to complete one complete cycle of operation.

The name of the simulation programme that was utilized in this research is COPERT. The COPERT model is one of the most comprehensive ways to model transportation emissions that is used in Europe [67]. Because COPERT is an "average speed" model, the computations rely on speed-dependent equations that are specific to a certain vehicle type [68]. Since COPERT is an "average speed" model, this means that this model makes significant use of trustworthy experimental data that is consistent with statistical calibrations and parameter variables from a wide variety of countries. The COPERT model examines a wide variety of pollution types and categorizes different kinds of vehicles in detail. Furthermore, the model's user is superior to the MOBILE model, making it easier for people to understand and use [69]. Furthermore, the model's user is superior to the MOBILE model, making it easier for people to understand and use [69]. The COPERT's fundamental parameters include vehicle type, emission standards, annual vehicle kilometers travelled (VKT), fuel quality and annual fuel consumption, Reid vapor pressure, vehicle population, and meteorological conditions such as temperature and humidity [70]. The fundamental equation used to create the COPERT model is shown in Eq. 1

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

where $Q_{m,n}$= Quantity of pollutant m for vehicle n and $\boldsymbol{i}$: is the vehicle type, j: is the local emission standard $P_{i,j}$: is the number of vehicles in category i with emission standard j,$\mathrm{VKT}_{m,i}$: Is the annual average vehicle kilometers travelled (km) for vehicles category i while $\mathrm{EF}_{i,j,n}$: is the emission factor in g/km for pollutant n emitted from vehicle category i with emission standard j.

7. Emission measurements

The equipment and techniques used to measure car emissions in the field differ significantly. Exhaust emissions from real-world data are analysed during on-road measurements utilising instantaneous real-time emission collection or remote-sensing devices (RSDs) from huge fleets of individual vehicles at particular sites traversed by the vehicles along the road's network. This data can show how emissions affect real-world vehicle behavior [71]. However, on-road measurement has not been widely accepted as a

Fig. 4. portable emissions measurement system[80]

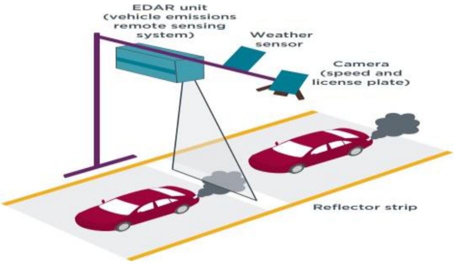


Fig. 3. Remote sensing [81]

means of estimating emissions for various vehicles or various types of emissions, particularly for heavy traffic over several lanes, as it restricts the operating condition range and controls the size and weight of the system. Another constraint is the relative cost of the measurement. A portable, affordable, and non-invasive system for monitoring vehicle activity and pollutants was developed by [72]. For instance, the EPA developed ROVER on-road pollution monitoring to examine the emission rate and distribution of vehicles. CATI created the portable emission measuring system (PEMS) to measure mass emissions second by second. Fig. 4 illustrates how the PEMS is mounted in the vehicle during operation.

remote sensing equipment, it is able to measure the emissions of thousands of vehicles every day as they pass by, making it a significant method for measuring vehicle emissions. Remote sensing devices measure pollution concentrations in the tested vehicle's exhaust plume using a snapshot of the exhaust plume. Fig. 3 illustrates one remote sensing installation method. For tunnel study measurements that are used to quantify the emissions of a large vehicle sample under relatively restricted settings, such as high-speed driving that is unsuitable for urban driving and signalized arterials. Pollutant levels were measured both inside and outside the tunnel during certain studies, and an average fleet-wide emission factor was calculated using data on traffic volumes. Many experimental tunnel studies have been conducted in China [73], [74]. Table 1 includes a brief overview of each strategy as well as its benefits and drawbacks.

Another approach for assessing car emissions on various roads is the chassis dynamometer test, which is performed by driving the vehicle through a defined pattern of speed and time (driving cycle) while it is placed on a dynamometer. Fig. 5 illustrates the chassis dynamometer emission measurement test (process and component)[75].

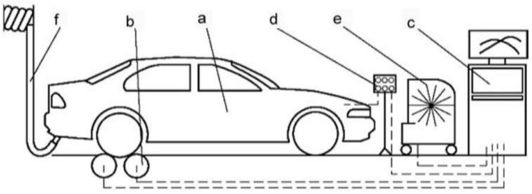


Fig. 5. Chassis dynamometer test stand[75].

Where a. tested vehicle; b. twin-roller type chassis dynamometer with eddy-current brake; c. dynamometer control system; d. vehicle signals connector box; e. fan; f. exhaust gas extractor.

Table 1. Comparison of vehicle emission measurement.

Model	Category	Main characteristics
MOBILE	Average speed model, developed by US EPA	Calculate the average vehicle emissions using the FTP and in-use vehicle testing as the inputs.
EMFAC	Average speed model, developed by US CARB	Predict regional HC, CO, NOx, CO2, PM, SOx, and fuel usage inventories and projections.
COPERT *4*	Average speed model, financed by EEA	Estimates can be made for all major air pollutants and greenhouse gas emissions from vehicles, including CO, NOx, VOC, PM, NH3, SO2, CO2, N2O, and CH4; vehicle categories include passenger cars, light commercial vehicles, HDV, buses, motorcycles, and mopeds.
CMEM	Instantaneous speed model, developed by NCHRP	Evaluate CO, CO2, HC, NOx, and PM emissions, in addition to fuel usage.
VT-Micro	Instantaneous speed model, proposed by [76]	Compute fuel usage and emissions of HC, CO, NOx, and CO2.
PHEM	Instantaneous speed model, originated from the Artemis Project	Determine the dynamics of the driving cycle based on the instantaneous engine power demand and engine speed, and estimate fuel consumption and emissions for various driving patterns.
EMPA	Instantaneous speed model, originated from the Artemis Project	Consider the size of the car's exhaust system and quickly estimate the emissions of a certain vehicle.
MODEM	Instantaneous speed model, originated from the Drive Project	Evaluate Euro I's fuel consumption and emissions of CO, HC, NOx, and CO2.
MOVES	Multi-scale model, developed by US EPA	Evaluate many contaminants for the US LDV and HDV vehicle fleet.
IVE	Multi-scale model, developed by UCR	Calculate the amount of local air pollutants (criteria pollutants), greenhouse gas emissions, and hazardous pollutants.

8. Air quality index

Air quality index (AQI) is used globally to inform people about air pollution levels (deterioration or improvement) and the health impacts associated with these levels. Different kinds of human activity, especially transportation, have a huge effect on the quality of the air in many ways. Air that is free from pollution is essential to the health and well-being of humans and should never be neglected. Today, air pollution is recognised as a serious environmental issue that is linked to urban areas all over the world [77]. The major contributor to the regional burden of disease is urban air pollution. There is a strong correlation between human health and well-being on the one hand and air pollution levels on the other. Not only is awareness of pollution levels important for people who suffer from illnesses that are made worse by air pollution, but it is also important for the general public, who, if conscious of daily variations in air pollution levels, may choose to change their activities according to those variations. Both the scientific community and the appropriate authorities have concentrated on monitoring and analysing the atmospheric pollutants' concentrations in order to combat air pollution issues and establish abatement solutions. AQI values are separated into ranges, with a description and color code given to each range. Table 2 includes each range as well as the impact of that range on health. The AQI measures the health risks associated with inhaling polluted air "within a few hours or days" [78]. The AQI is calculated with the following formula Eq. 2

$$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}}(C - C_{low}) + I_{low} \qquad (2)$$

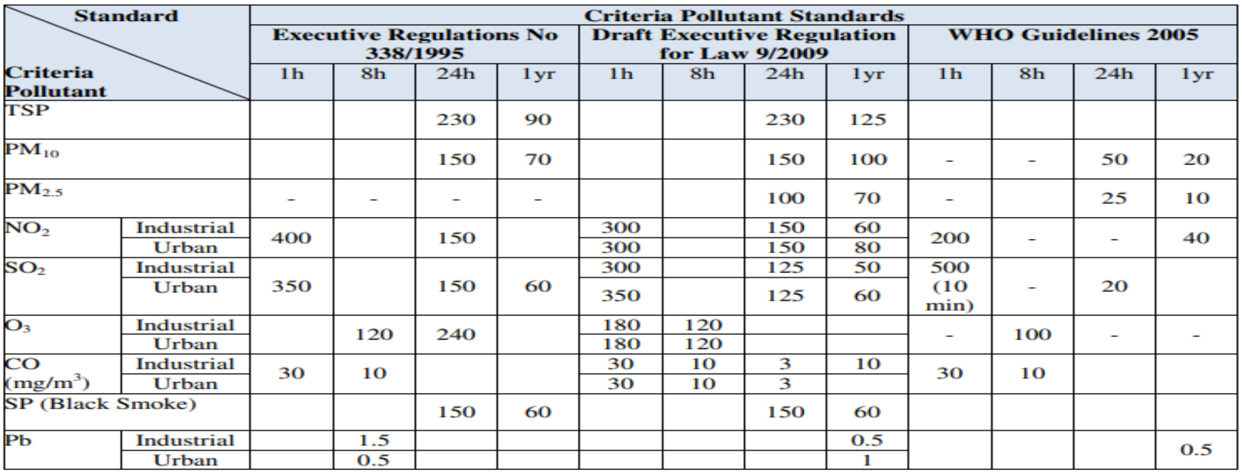
Where I = The (Air Quality) index, C = The pollutant concentration, Clow = The concentration breakpoint that is ≤C, Chigh = The concentration breakpoint that is ≥C, Ilow = The index breakpoint corresponding to Clow while Ihigh = The index breakpoint corresponding to Chigh.

Table 3 shows a comparison between the air quality guidelines set by the World Health Organization (WHO) and the criteria set by the Egyptian government for the different types of pollution in the area. In this area, the air quality is acceptable and pollution levels are low.

Table 2. AQI Ranges, Colors and Descriptors in US/EPA [79]

Levels of concerns	Numerical Value	Meaning	Color
Good	0-50	In this area, the air quality is acceptable and pollution levels are low.	Grean
Moderate	51-100	Air quality is satisfactory: nevertheless, for a very small number of people who are extremely sensitive to air pollution. Some contaminates may cause health risks.	Yellow
Unhealthy Sensitive groups	101-150	Sensitive groups may face adverse health impacts. It is unlikely that the general population will be harmed.	Orange
Unhealthy	151-200	Everyone may suffer health impacts: however, member of sensitive groups may suffer more severe health effects.	Red
Very Unhealthy	201-300	Health warnings for emergency situations it is more likely that the enter population will be affected.	Purple
Hazardous	301-500	Everyone could have health problems that get worse.	Maroon

Table 3. Ambient air quality standards in Egypt and according to WHO



Standard / Criteria Pollutant		Criteria Pollutant Standards											
		Executive Regulations No 338/1995				Draft Executive Regulation for Law 9/2009				WHO Guidelines 2005			
		1h	8h	24h	1yr	1h	8h	24h	1yr	1h	8h	24h	1yr
TSP				230	90			230	125				
PM_{10}				150	70			150	100	-	-	50	20
$PM_{2.5}$		-	-	-	-			100	70	-		25	10
NO_2	Industrial	400		150		300		150	60	200	-	-	40
	Urban					300		150	80				
SO_2	Industrial	350		150	60	300		125	50	500 (10 min)	-	20	
	Urban					350		125	60				
O_3	Industrial		120	240		180	120			-	100	-	-
	Urban					180	120						
CO (mg/m^3)	Industrial	30	10			30	10	3	10	30	10		
	Urban					30	10	3					
SP (Black Smoke)				150	60			150	60				
Pb	Industrial		1.5						0.5				0.5
	Urban		0.5						1				

9. Conclusion

One of the health-harming risk factors is air pollution. In the majority of low- and middle-income nations, air quality does not reach WHO standards. Since 1990, more than 100 deaths per 100,000 Egyptians have been attributed to outdoor air pollution. Consequently, the lack of data makes it difficult for decision-makers to take remedial measures to enhance the air quality in urban areas with high pollution levels. A high number of vehicles moving through urban areas is correlated with a high pollution index. Studies have shown that congestion and the time vehicles spend at intersections both contribute to air pollution. Several scales of modeling can be utilized to simulate various traffic flow characteristics and evaluate emissions. In this study, we used VISSIM for traffic simulation; it uses time steps and behavior-based models to simulate traffic flow. For emission modeling, we used COPERT, which is one of the most comprehensive ways to model transportation emissions that is used in Europe.

Emission reductions can be achieved by incorporating various methods of traffic mitigation into the models. A few examples of these methods are: (1) optimizing signal timing to minimize delays and the number of stops; (2) restricting illegal parking; (3) reducing the number of heavy vehicles using the urban network; and (4) studying the effects of various driving behaviors.

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