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Evaluation of Vehicle Emissions on Air Quality for Urban Regions - An Overview

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ABSTRACT

The rapid growth of population in urban regions is considered a point of interest concerning car ownership. Increasing car ownership leads to traffic congestion and large amounts of emissions in urban networks. The existence of toxic pollutants and particulates in the air is one of the main reasons for diseases in humans and other living beings. The aim of this paper to identify traffic congestion and presenting it using several scales of models to explain the impact of various characteristics (road, traffic, and vehicle) on traffic flow and air pollution. Furthermore, different techniques implemented to mitigate congestion and amounts of emitted pollutants. The adopted models vary from macro-simulation, which estimates the pollutant quantity for each vehicle, to micro-simulation, which depends on several parameters affecting the vehicle and driver behaviour. The overview also includes different methods of emission measurements that are performed in the field or laboratory. Air quality evaluation is presented by a numerical index (i.e., Air Quality Index) which depends on the estimated pollutant. Air Quality Index (AQI) is categorized from good to severe effect.

1. Introduction

Urban regions in both developed and developing countries have seen quick growth in population in the last 50 years. As a result, a rise in car ownership in urban regions occurred, resulting in more congestion on the network. Furthermore, the average speed of vehicles has decreased due to the increased congestion. At high and continuous rates of congestion, the amount of emissions released from vehicles escalates [1]. Air pollutants emitted by vehicles affect human, animal, and plant health. Humans and other living beings who breathe polluted air have high rates of different diseases compared to those who have a comparatively cleaner environmental life [2]. Most studies done in various parts of the world indicate that air pollution, especially that produced by motor vehicles, is one of the main causes of severe diseases that cost the lives of tens of thousands of people annually. The quantity and type of pollutants depend on different elements such as traffic conditions, road section elements, and vehicle characteristics. Traffic and emission modeling software has eased the process of

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estimating the quantity, and types of emissions on roads. Two main modeling types are used in the process of estimating emissions from vehicles: macroscopic and microscopic models [3]. Furthermore, the estimated values of pollutants from air pollution modeling software can be compared to the actual measurements in the field or the laboratory. Then, several modifications in traffic conditions, vehicle engines, and road geometry can be proposed as possible emission reduction solutions. The quality of surrounding air has been defined using different indices, among which is the Air Quality Index (AQI). AQI depends on the concentration of several pollutants in the form of an equation [4].

2. Air Pollution Sources

Air pollution can form in the air from a variety of sources and sectors, including the energy, industrial, agricultural, and waste sectors. Emissions from the energy sector can be separated into two main parts: direct fuel combustion; and fugitive transport emissions and processing of fuels. The combustion of fossil fuels is actually the largest source of most anthropogenic air pollutants and greenhouse gases. Industrial emissions consist of industries and activities based on the manufacturing and usage of minerals, chemicals, metals, food, paper, drink, and paint. Air pollution from agriculture sector covers emissions related to the cultivation of different crops, including qualifying land, manure management, fertilizer usage, animal husbandry including enteric fermentation, field burning of residual agricultural in addition to grassland burning for crop plantation. Emissions from waste include the discarding of waste by burning or chemical treatment processes in disposal areas and sewages [5]. Fig.1 shows the sharing of each sector in pollutants (NO_X, CO, PM_{10}, and Volatile Organic Compounds (VOC))[6].

3. Traffic congestion problem

The rapid Increasing in car ownership is faced by a slight growth of infrastructure, especially roads that suffered from traffic congestion. The traffic congestion is followed by a continuous decrease in the average speed of vehicles and high rates of emission pollutants that are produced by motor vehicles [1]. The demand for transportation has increased over the last years as result of road transport growth continuously and traffic components development [7]. As a result of congestion and the combustion process of Vehicle engines, different chemical compounds have been released [8].

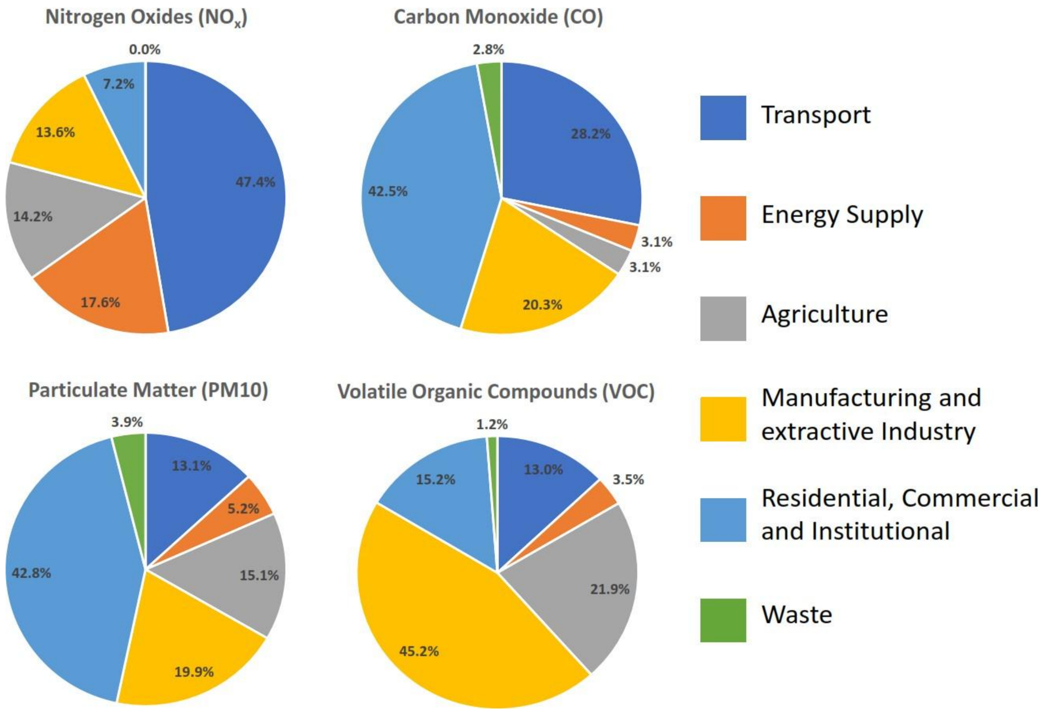

Fig. 1. Contribution of each air pollution source in NO_X, CO, PM_{10}, and VOC pollutant emission.

Source: Collected by the Author from EEA (2021)

Emissions in the air increase as a result of congested traffic conditions as well as speed reduction compared to the conditions of free flow. Traffic congestion has several effects on traffic flow variables. The traffic-related variables include density, vehicle composition, flow, volume/capacity ratio, the number of stops per mile, traffic lights numbers per mile, and signal coordination [9, 10]. Traffic congestion has bad impacts on travelers such as wasting time and money, and increasing the hazards of accidents and localized air pollutants like particulate matter. But potentially increasing greenhouse gases is the most serious consequence of traffic road congestion, and even so, it is the least immediate [11]. The increase in this vehicle emissions rate is due both to the increase in engine loads from density of high acceleration and hesitation during unstable traffic as a result of traffic congestion and to the longer time of operating for each unit distance at slower speeds of travel [12, 13].

Road transport congestion is recognized to be a condition or state on any road transport network. The increase in the physical use of roads by vehicles is the common cause of traffic congestion on these roads. This is often evident when the demand for traffic increases, which leads to a reduction in the speed of traffic flow due to the overlap between vehicles [14]. Road congestion has regularly increased on different road networks of the United States, causing a delay estimated by 3.7 billion hours by 2003 and also wasting motor fuel by 2.3 billion gallons [15]. The vehicles which be forced to stop and then speed up are possible sources of released gaseous and particulate pollutants. Then, this process leads to urban traffic congestion and a very unhealthy quality of air, as well as an increase in exposure to risks of health [16]. The existence of large numbers of vehicles on urban road networks leads to an increase in the amounts of tailpipe emissions, which have both greenhouse gases (GHGs) and pernicious pollutants of air quality (AQ). Table 1 illustrates the roadway congestion effects on vehicles emissions.

4. Harmful effects of emission

The world is being faced with a double challenge of the environment and human life protection. The existence of toxic gases, particulates, and other materials in the air is one of the master reasons for air pollution. The pollutants released from vehicles and correlated to human and environmental diseases are nitrogen oxides (NO_X), carbon monoxide (CO), sulfur dioxide (SO_2), and particulate matter (PM) as well as carbon dioxide (CO_2). The two processes of combustion and friction from each vehicle produce pollutants with harmful effects on environment and human health [17].

4.1. Human health

In the WHO (World Health Organization) European Region, most assessments indicate that the air pollution formed by road transport causes murderous diseases which affect tens of thousands of people each year [18]. The increasing use of automobiles and traffic congestion has bad effects on human health, productivity, economy and society due to the air pollution emitted from vehicles. Transportation has more effect on public health in different ways, including traffic incidents, the breathing of polluted air, normal activity, affordability and physical approach to medicinal services [14].Pollutants in the air have negative effects on the respiratory system.. Due to the levels of air pollutants have increased, the number of cases who complain of diseases like asthma, chronic obstructive pulmonary disease (COPD), respiratory infection, and lung cancer have increased [19].

4.2. Plant health

There are two types of plant injury that can result from exposure to toxic air pollutants: chronic injury and acute injury. Prolonged exposure to contaminants at low concentrations may cause chronic harm to plants. On the other hand, plants exposed to high concentrations of contaminants for a brief period of time suffer acute damage [20]. The growth and development of plants are directly influenced by a wide range of air contaminants, including SO_2, NO_X, ozone, PM, and fluorides. The health and welfare of people are eventually impacted when these pollutants enter the food chain. In order to deal with any type of

Table 1: Summary of Roadway Congestion Effects on Vehicle Emissions.

Congestion Effect	Impacts on Motor Vehicle Emissions
Decreased average travel speeds	• Increases emissions rates at very low speeds [13, 21]. • Decreases emissions rates for moderate speed reductions on freeways [13]
Increased speed variability (accelerations)	• Increases emissions rates with acceleration intensity and frequency; impact varies with travel speed and facility [13, 22].
Suppressed travel demand (or induced demand with less congestion)	• Less vehicle miles travelled (VMT) decreases total emissions, but changes depend on the road network and other factors; much research still needed[23, 24].
Travel time unreliability	• No studies found on direct emissions effects (related to driving behavior or traffic characteristics of non-recurring congestion) • Indirectly, could suppress travel demand and so reduce VMT and emissions as above[25].

stress, plants have sophisticated recognition and response mechanisms [26]. The initial reaction of plants when they recognize stress circumstances is the creation of reactive oxygen species (ROS). High levels of ROS are harmful and interfere with a cell's ability to operate normally [27].

4.3. Animal health

The loss of biodiversity on Earth is believed to be primarily due to environmental pollution, which is a crucial component of our planet's ecosystem. Air pollutants can negatively impact wildlife through a number of exposure routes, including direct exposure (inhalation, skin contact, or ingestion) and indirect exposure (wet/dry deposition processes on soil/water surface) following their exposure to wildlife. When air pollution levels are high enough, animals may have health-related issues as a result of their exposure. Animal diseases, infertility, and birth abnormalities are caused by air pollution [28].

4.4. Global Warming and Climate Change

The overuse of fossil fuels as an energy source has led to an increase in the concentration of greenhouse gases (GHGs), such as CO_2, which is one of the main effects of human activity that led to global warming. The average surface temperature of the planet keeps increasing as long as people continue to participate in harmful environmental practices, particularly burning fossil fuels. By the end of the twenty-first century, experts expect the average surface temperature to rise by 2–6C based on CO_2 emissions increase [29]. In the atmosphere, greenhouse gases increase to high levels due to emissions released from transport sector, especially motor vehicles [30]. Global CO_2 emissions have a high production percent from transport, with a range of 22 %, so transport is the second-largest sector in producing CO_2 emissions [31].

5. Relative characteristics impact on emissions

The factors and characteristics related to emissions released from vehicles are consisting of three components: traffic, vehicle, and road characteristics as shown in Fig. 2. Some traffic characteristics, such as flow, queue length, and delay events, arise depending on the configuration of the junction, an intersection, or a signalized roadway [32].

5.1. Traffic characteristics

The air emissions released from motor vehicles depend on several elements. Traffic characteristics in urban areas are one of these elements. Traffic characteristics include average vehicle speed, vehicle composition, vehicle flow, and density. In turn, traffic management systems and procedures influence those characteristics. At high-density urban areas, there are an increase in vehicle emissions and fuel consumption as a result of the occurrence of the acceleration/deceleration events by vehicles [33]. Traffic variability on urban roads can produce a remarkable variation in total emissions released from motor vehicles [34]. During speeds of accelerating and decelerating whether sharp or continuous, high levels of CO, HC, and NO_X pollutants release from both passenger cars and auto- rickshaw [35]. The value of volume per capacity (V/C) of urban roads has a significant impact on vehicle emissions. A sharp increase in carbon emissions occurs as a result of increasing in V/C, particularly when V/C is larger than 0.5. The carbon emissions can be produced by vehicles with low rates when V/C is between 0.4 and 0.5. An imperceptible increase in carbon emissions from vehicles when V/C is fewer than 0.4 [36]. On Egyptian roads, vehicles produce large amounts of emissions, particularly CO_2 emissions. More CO_2 emissions are produced from vehicles because the driver has to start-stop the vehicle during peak hours than smoother driving during free-flow traffic [37].

5.2. Road characteristics

Road characteristics such as traffic junctions, intersections, and signalized roadways, have various influences on the released amount of pollutants from vehicles. According to all vehicles and pedestrians movement at junctions, there are interruptions of flow. The interruptions occur either among vehicles or between vehicles with pedestrians. These interruptions produce several conflict points, as well as generate different rates of emission pollutants within the junctions [38]. At junctions, the time of stoppage has a rise equal to about four times compared to the maneuver time that a vehicle takes during uncongested traffic. The emissions emitted from vehicles increased by 25% at the intersection due to Vehicle interferences, while the continuous movement of traffic in the condition of the roundabout is the main reason for vehicle emissions reduction [39]. Another road characteristic that leads to high traffic emissions is the signalized intersections with high traffic volumes due to many stops and the decelerations and accelerations of vehicles. A study at different intersections found that queue position, lane volume of downstream and upstream, incidents rates, percent of heavy vehicles, and posted link speed affected significantly driving patterns and vehicle speed. Therefore, those patterns have a direct effect on the amount of emissions released from vehicles [40]. Emissions produced from motor vehicles at a signalized intersection are higher by 50% than emissions produced at an un-signalized intersection [41]. According to a study of emissions under coordination and non-coordination of signal in Beijing, it is found that the emission factors of HC (Hydrocarbons) and CO decreased by 50% and 30%, but NO_X increased by 10% for coordinated signal-controlled road, Contrary to the emission factors of non-coordinated road. according to this result, HC and CO emissions can effectively be reduced by using signal coordination, but NO_X pollutants are increased [42].

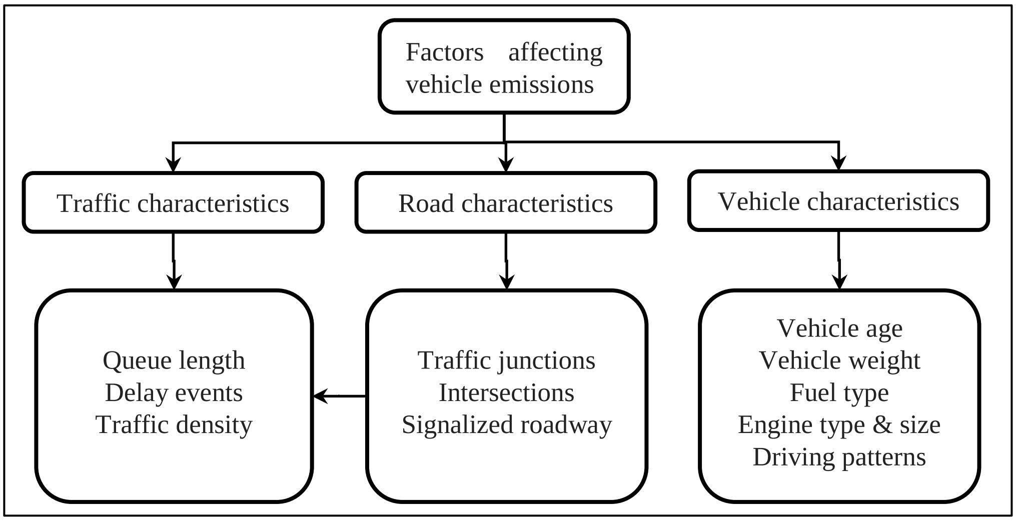

Fig. 2. The factors and characteristics vehicle emissions

5.3. Vehicle characteristics

The vehicle characteristics include engine type, age, size and condition, the nature and condition of equipment which control emissions, and the operation way of the vehicle. These elements have great importance and influence on the amount of vehicle emissions [43]. Different characteristics of vehicle and engine are correlated to emission rates from Motor vehicles such as (weight, engine size, transmission type, emission control equipment, etc.), operating techniques (idle, cruise, acceleration, and deceleration), and conditions of the transportation system (pavement, road grade condition, etc.) [44]. More emissions and higher pollutant concentration are released from idling motor vehicles, particularly at junctions as a result of an unprecedentedly increase in queuing time [38]. M. Ritner, et al. [45] showed that emissions of acceleration conditions were larger than emissions at constant speed movement, while emissions of deceleration conditions are smaller than emissions at constant speed movement. The vehicle emissions in the existent traffic conditions varied considerably between mismatched drivers, they found that driving in an aggressive way resulted in an intense increase in emissions and fuel consumption Contrary to normal driving [46]. The engine cylinders of vehicles need more fuel as a result of sharp acceleration or deceleration, which leads to an increase in the load on the engine producing more high levels of CO and HC [35]. The emissions released from all classes of vehicles have been influenced by the poor maintenance and age of a vehicle. Further, the quality of fuel has a through influence on motor vehicle emissions [32]. For Petrol vehicles, the vehicle speed, ambient temperature, ambient pressure, ambient relative humidity, horizontal alignment bearing angle, and profile road grade have a positive influence on the CO_2 emission of vehicles. The numbers of rotation per minute for vehicle engines have a negative influence on the CO_2 emissions of vehicles [47]. In Egypt, 97 and 3 percent of CO_2 pollutants that are released from the transport sector are from light-duty vehicles (LDV) and heavy-duty vehicles (HDV) respectively [48].

6. Traffic and emission modeling

Estimating the amount or factors of emissions from in-motion sources on roads is in need of traffic modeling. Traffic modeling introduces the assortment of a considerable number of required data in the interested zone. Traffic flow modeling contains main two elements of modeling. These elements are macroscopic and microscopic. The macroscopic modeling depends on that the flow is considered continuous (hydrodynamic flow). The microscopic depends on the behavior of drivers and vehicles, as well as comprise lane changing and the maneuvers of vehicle drivers [3]. Emissions formed by road vehicles are estimated using two main approaches, namely, the macro simulation approach and the micro-simulation approach. Typically, emission models based on average speed are combined with static traffic models (macroscopic). The microscopic traffic model was used to determine time-dependent speeds and accelerations for each vehicle, which are then entered into the instantaneous emission model (microscopic). [49].

6.1. Macroscopic modeling

SATURN (Simulation and Assignment of Traffic to Urban Road Networks) is an important macroscopic traffic model for transport which used to estimate flows of traffic and the traffic volume on each link located on the road network in the UK. These output data are required to be input data for the model of emission by TEMMS programs (Traffic Emission Modeling and Mapping Suite). Then, CO and NO_X pollutants can be calculated for each road by the ROADFAC model supported by link variables from SATURN [50]. The total emission for a specific hour *h* can be considered as in Eq. (1).

$$Q_h = \sum_h N_{k,h} \times q_k \qquad (1)$$

Where $N_{k,h}$ are the flow of traffic for the *k'th* vehicle category and q_k are the factor of emission for *k'th* category.

COPERT evolved by the European Environment Agency, MOBILE6 evolved by the United States Environmental Protection Agency (USEPA) and EMFAC evolved by the California Air Resources Board, are macroscopic emission models. These models depend on cycles of assumed standardized driving and are used to configure models of the factors of vehicle emissions [51]. According to the methodology of COPERT III, factors of Emissions are established to be used in estimating emissions [52]. Hot emissions, emissions of cold-start, and emissions of evaporation are three modes of produced emissions that are taken into account during the calculation of emission factors CO, NO_X and PM_{10} by the methodology of COPERT II in Hong Kong [53]. In the street Jagtvej, Copenhagen, Denmark, the modeling of urban traffic pollution, from which the factors of emissions (CO and NO_X) can be predicted, is performed by the Danish Operational Street Pollution Model (OSPM). The methodology of COPERT is the master source for the formation of this module [54].

6.2. Microscopic modeling

The particular behavior of driver and individual space-time trajectories of vehicles in real time are the master elements that are dependent on by micro-simulation models of traffic. One of the important packages of micro-simulation models is the DRACULA (Dynamic Route Assignment Combining User Learning and micro-simulAtion) from which the movements and speed of a vehicle on road networks have been simulated. In addition, second-by-second functions of emissions are utilized with micro-simulation models of traffic to calculate the pollutants (NO_X, CO_2, and PM) [46]. For vehicles that are accelerating, the calculation of fuel consumption by DRACULA based upon Eq. (2) [55].

$$F = C_0 + C_1 * a * v, \qquad (2)$$

Where F is the factor of fuel consumption, v, the speed of certain vehicle, a, the acceleration of certain vehicle, and C_0 and C_1 are constants.

The operations of both transit and mixed traffic in highway lanes and networks of urban roads can be modeled by a microscopic simulation model defined as VISSIM, which depends on the time-step and the behavior. The static and dynamic data are two prime sorts of data surveyed from the field to establish a network on VISSIM. Static data includes link end and start, width, length, and grade as well as the number of lanes. Dynamic data includes volumes of traffic for different movements, different routes and times, and timing plans of signals and rules of priority [56]. The module of 'Enviver Pro' is an add-on to VISSIM. This module is used for the calculation of all or additional pollutants in the area of the study. It imports data of vehicles from VISSIM and results in a table of emission amounts as well as a graph of air pollution [57]. Eq. (3) has been used to evaluate emissions on this module.

$$TE_j = \sum_{k,m}(E^F_{j,k,l} \times TV_{k,m} \times L_m) \qquad (3)$$

Where $E^F_{j,k,l}$ indicates to the evaluated factor of mean emission (g/km) for pollutant j, class of vehicle k and profile of speed-time l, $TV_{k,m}$ indicates the volume of traffic (vehicles/hour) related to each class of vehicle k for a certain section of road m, and L_m indicates the section length of the road m (km) [58].

The microscopic model of modular emissions CMEM (Comprehensive Modal Emission Model) is beneficial for the computation of vehicle emissions as well as fuel consumption for Light-Duty Vehicles (LDV). These calculations from the model of CMEM that is developed by the university of California-riverside, are made under several modes of operations of vehicles such as accelerating, decelerating, and idling modes [56]. According to a study by A. Abdel-Rehim [59], the software of SIDRA is a commercial bundle that is used in the assessment of pollution in the air, for example estimating fuel consumption and pollutant from vehicle emissions as well as the cost of operating processes. The general simulator developed by the USEPA for estimating various pollutants on links of a road is known as MOVES (The Motor Vehicle Emission Simulator). For MOVES input information, the length of each link, number of vehicles, composition of traffic, speed, and grade of the road are required. The emission model by MOVES is more embodiments of conditions of actual driving. These conditions for the drive-cycle that include idling, acceleration, deceleration, and cruising, are used in the calculation of emissions [60]. In Europe, C. Borrego, et al. [61] used the methodology of' Vehicle Specific Power/Co-operative Program for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants' (VSP/EMEP) to evaluate the amount of pollutants (NO_X and PM) for passenger cars, vehicles light and heavy, as well as motorcycles. In an urban roundabout with high density, in Madrid, several scenarios were applied by C. Quaassdorff, et al. [62] on two micro-simulation programs for trying to decrease emissions of NO_X and PM_{10}. VISSIM (simulate the scenarios of traffic) and VERSIT+micro through ENVIVER (compute emissions related to these scenarios by using outputs of VISSIM) are the two software that have been used in this study. A number of studies have been implemented to show procedures of reduction in levels of estimated emissions by using combinations of models as shown in lists of Table 2 [63].

7. Emission measurement methods

The various methods that are implemented for measuring or estimating factors of motor vehicle emissions may need to be performed in the field or laboratory testing methods. The chassis dynamometer test is conducted by operating the vehicle through a specific pattern of speed and time (driving cycle) while it is on a dynamometer. Fig. 3 shows the emission measuring test of the chassis dynamometer (process and component) [64].

The closed area of the laboratory where this test is conducted forms an extensive difficulty for the test implementers, for reflecting the situations of real-world roads [72]. One of the other methods used for measuring vehicle emissions on different roads is PEMS (the Portable Emissions Measurement System). The instruments used during the implementation of this method are established on the board of the tested vehicles (inside or outside of it) where the tailpipe of the vehicle is connected to the PEMS as shown in Fig. [72]. Another measurement method is the instruments of remote sensing. The systems of remote sensing depend upon a shot of the exhaust plume of the tested vehicle during measuring concentrations of various pollutants in the plumes of exhaust as shown in Fig. [73].

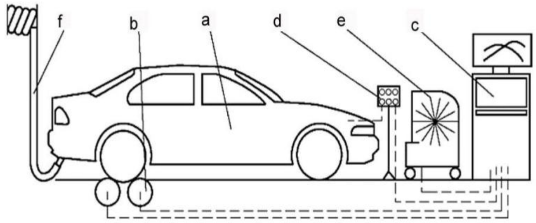

Fig. 3. Chassis dynamometer test stand [64].

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.

For the indirect method of measurement, the variation of the topography of the area and the factors of meteorological have a high influence on measuring concentrations of pollutants. The measurements by PEMS and plume chasing method cannot be exercised for a great number of vehicles because it is very expensive [74]. Remote sensing method is applied for vehicles with larger numbers, so this method has less cost for vehicles basis than other methods.

Table 2: Combination of micro-simulation models for vehicle emission

Topic related to emissions	**Models used**	**Reduction in pollution**	**Citation**
Effects of different driving behaviors	VISSIM and CMEM	2.6 to 16.5%	[56]
Strategies for high-occupancy vehicle (HOV) lanes	PARAMICS and CMEM	3 to 17%	[65]
Strategies for high-occupancy vehicle (HOV) lanes	VISSIM and VSP	37 to 43%	[66]
optimize signal timing on a large intersection	VISSIM / SUMO and CMEM	2.5 to 6.3%	[67]
optimization of signal timing	VISSIM and CMEM	4.5% (fuel consumed)	[68]
active speed management	SUMO and CMEM	3.8 to 8.0%	[69]
different designs of intersections	MOVES and AEROMOD	81.7%	[70]
license plate restrictions	VISSUM and MOVES	6.9%	[71]

Fig. 4. Portable emissions measurement system [72].

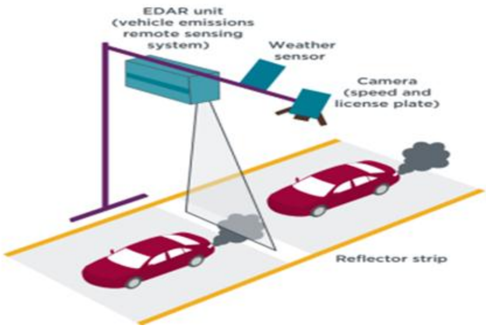

Fig. 5. Remote sensing [73].

8. Emission analysis and reduction

The implementation of traffic restriction measures after 1983 had led to a slight reduction in CO emissions of vehicles. This conclusion is not totally accessible as a result of the insufficiency of the pure data [75]. The NO pollutant has a reduction from 5 to 15% as a result of the influence the Implementation of bus lanes, as well as the reduction of particulate emissions (g/kin) produced from the buses. These pollutants were reduced by 15-30%, due to the influence of bus priority [76].

In the coming years, we need to change current habits of transport to achieve huge reductions in vehicle emissions. The minimization of usage of the all-inclusive level of transport, improving more desirable usage of capacity of the existing transport, and utilization of less polluting transportation instead of the usage of actual transport capacity are the measures that should be applied to reduce the amount of vehicle emissions. The pollutants of CO, HC, and NO_X emitted from the individual car were minimized by 70-80% as a result of the application of the new technology of closed-loop catalysts [77]. Traffic light synchronization is one of the solutions that is used to minimize emissions emitted by motor vehicles through facilitating the flow of traffic, which reduces extreme acceleration that can cause significant spikes in total vehicle emissions [78]. On arterial roads, the decrease in the use of more heavy vehicles can be reflected positively on the flow of traffic, and therefore the pollutants emitted from vehicles can be decreased. In addition, electric cars and hybrid gasoline-electric vehicles are among the most advanced vehicles which are one of the solutions used to mitigate the emissions inflation caused by congestion on urban roads [79].

In greater Cairo, the emissions from vehicles are predictably reduced in the range of 1.3 to 2.3 million tons of CO_2-equivalent emissions from 2010 to 2019 as a result of the existing policy in Egypt. This policy is using natural-gas taxicabs instead of old taxicabs [80]. In traffic networks of urban areas, vehicle emissions can be produced at a lower rate as a result of fewer numbers of stops for all vehicle types during traffic flows, as well as shorter delays and moderate average speed [81]. As a result of limiting illegal parking behavior, the CO_2 vehicle emissions could be minimized by a range of 16.4 to 87.6 tons, as well as a reduction of CO_2 amount by a range of 32.1 to 171.3 tons because of the elimination of the behaviors of illegal double parking [82]. Setting a price for on-street parking increases the positive effects on traffic congestion and emissions production due to some road users abandoning heading to the city's central area [83]. Several strategies have many influences on bus operations and then on emissions produced from buses. These strategies such as transit signal priority (TSP), changing the location of bus stops, and lanes of queue jumpers. After the implementation of these strategies, GHG emissions can be minimized by 14% in congested conditions by TSP only and achieve a decrease of 23% when TSP is combined with improved technology [84]. Traffic signals, U-turns, and roundabouts are good designs of traffic that are implemented to reduce the influences of traffic congestion such as the Long travel distance, the increase in total journey time (including idle time), fuel consumption, and higher levels of exhaust emissions [59].

9. Air quality evaluation

Science has been concerned about air pollution because of its direct effects on the environment and public health, particularly in urban areas. Therefore, it is crucial to conduct nearly constant monitoring of air pollutants and air quality. There are a number of indicators that can be used to assess how pollutants affect human health and air quality. In the late 1960s, the National Wildlife Federation of U.S. developed the environmental quality index (EQI). The environmental quality index (EQI) has correlated strongly by Air quality index (AQI) [85]. Pollutant Standard Index (PSI) had been established in 1976 by the USEPA (United States Environmental Protection Agency) and had a rating of air quality. Pollutant Standard Index (PSI) had been established in 1976 by the USEPA and had a rating of air quality from 0 to 500. Using the largest value of one of five prime

pollutants in the air (CO, NO_2, O_3, PM, and SO_2), the PSI value for a day can be defined [86]. The definition of AQI is an equation with a combination of several pollutants in some arithmetical expression to get a singular number to indicate the condition of air quality [87]. The AQI focuses on health effects one may experience within a few hours or days after breathing polluted air. Table 3 shows several indices of air quality according to EPA [4]. The EPA calculated the index for a pollutant using the mathematical expression in Eq. (4) [86].

$$I_p = \frac{I_{Hi} - I_{Lo}}{BP_{Hi} - BP_{Lo}} (C_P - BP_{Lo}) + I_{Lo} \qquad (4)$$

Where, I_P = the index value for pollutant, P; C_P = the truncated concentration of pollutant, P; BP_{Hi} = the breakpoint that is $\geq C_P$; BP_{LO} = the breakpoint that is $\leq C_P$; I_{Hi} = the AQI value corresponding to BP_{Hi}, I_{LO} = the AQI value corresponding to BP_{LO}.

For the calculation of API (Air Pollution Index) in China, the NAAQS-1996 (national ambient air quality standard) of China has been issued in 1996. The calculation of API by the NAAQS-1996 contains pollutants (PM_{10}, SO_2, and NO_2) [88]. The IAPI (Individual Air Pollution Index) of each pollutant is determined as in Eq. (5).

$$IAPI_p = \frac{IAPI_{Hi} - IAPI_{Lo}}{BP_{Hi} - BP_{Lo}} (C_P - BP_{Lo}) + IAPI_{Lo} \qquad (5)$$

“where $IAPI_P$ is the individual air pollution index for pollutant P. C_P is daily mean concentration of pollutant P and (BP_{Hi} and BP_{Lo}) are the nearby high and low values of C_P. $IAPI_{Hi}$ and $IAPI_{Lo}$ are the individual air pollution indexes in terms of BP_{Hi} and BP_{Lo}.

According to NAAQS-2012, the API was replaced by AQI (Air Quality Index) which is determined for every 7 pollutants (concentration of daily average $PM_{2.5}$, daily average concentration of PM10, maximum daily concentration of 1-h Ozone,

Table 3: Pollutant concentration for each AQI category according to EPA [4].

Category	Good	Moderate	Unhealthy for sensitive groups	Unhealthy	Very unhealthy	Hazardous	Severe
Index value	0–50	51–100	101–150	151–200	201–300	301–400	401–500
Pollutant	Conc. range	–	–	–	–	–	–
CO 8 h (ppm)	0.0–4.5	4.5–9	9–12	12–15	15–30	30–40	40–50
NO_2	–	–	–	–	–	1.2–1.6	1.6–2.0
O_3 daily max (ppm)	–	–	–	–	0.20–0.40	0.40–0.50	0.50–0.60
O_3 8 h	0.00–0.06	0.06–0.08	0.08–0.10	0.10–0.12	0.12–0.37	–	–
PM 10 daily mean (ppm)	0–50	50–150	150–250	250–350	350–420	420–500	500–600
SO_2	0.0–0.03	0.03–0.14	0.14–0.22	0.22–0.3	0.3–0.6	0.6–0.8	0.8–1.0

maximum 8-h concentration of Ozone, daily average concentration of SO_2, daily average concentration of NO_2 and daily average concentration of CO) as in Eq. (6).

$$IAQI_p = \frac{IAQI_{Hi} - IAQI_{Lo}}{BP_{Hi} - BP_{Lo}} \left(C_P - BP_{Lo}\right) + IAQI_{Lo} \quad (6)$$

Where $IAQI_{Hi}$ and $IAQI_{Lo}$ are the individual air quality indices in terms of BP_{Hi} and BP_{Lo}, respectively.

10. Conclusions

Traffic congestion problem on urban networks has become the reason for the emitted toxic pollutants that influence surrounding air quality. Different characteristics of traffic flow can be simulated using different scales of modeling. Macroscopic and microscopic are the prime scales of traffic modeling and emissions estimation. By using COPERT, MOBILE, and EMFAC, the factors of emissions (CO, NO_X, and PM_{10}) and fuel consumption for an individual vehicle can be estimated. Several micro-simulation models can be used for emissions calculation. Models of VISSIM and CMEM, PARAMICS and CMEM, VISSIM and VSP, and, VISUM and MOVES can be used for traffic and emission models. Different techniques of traffic for emission mitigation can be implemented in the models to achieve emission reductions. These techniques include: (1) using bus lanes and bus priority, (2) limitation of illegal parking, (3) decreasing the rate of usage of the urban network by heavy vehicles, (4) using closed-loop catalysts, (5) using natural-gas taxicabs instead of old taxicabs, (6) optimization of signal timing, (7) Effects of different driving behaviors. AQI is an index that presents the quality of surrounding air in urban areas. This index is a number calculated for each estimated pollutant by using a numerical equation. The categories of AQI are correlated to health effects from good to severe.

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