International Journal of Chemical and Biochemical Sciences
(ISSN 2226-9614)

Journal Home page: www.iscientific.org/Journal.html

Impact of traffic composition instead of traditional PCU system on emissions calculations using SIDRA

Mohamed Shalaby [(1)], Shaimaa Gamal [(2)], Ahmed Mohamady [(1)], Hassan Darwish [(1)]

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

[(2)] Civil engineering, M.Sc. researcher

Abstract

The emissions produced by motor vehicles, which are a significant contributor to air pollution in urban areas, are becoming an increasingly acute issue in large cities. The emissions levels are influenced by several elements, including the volume of vehicles in circulation, the technology of the vehicles, the geometry and traffic circumstances of highways and intersections, environmental conditions, and the behaviors of the drivers. Mostly, traffic flow is disrupted at intersections in local traffic, particularly in the downtown area. Generation of emissions from these locations, where variations in traffic behavior, characterized by frequent stops and goes, are more pronounced than continuous flow. In comparison to the traditional PCU model, the present study also investigates the impact of specific traffic composition on emissions calculation. The present investigation involved the computation of emissions at Zagazig City intersections using SIDRA Intersection software and PTV Visim. Afterwards, the same programs were used to calculate new emissions following improvements in signalization or changes in movement direction. Following the study, fuel consumption and pollutants emissions were computed both before and after the enhancement. These models were created to evaluate the impact of emissions from traffic composition on the levels and concentrations of carbon monoxide (CO), nitrogen oxides (NOX), carbon dioxide (CO2), and fuel consumption. Results indicate that the traditional PCU system underestimates emissions, especially where heavy vehicle traffic is predominantly concentrated.

Keywords: intersections, Modeling, Vehicles Emissions, Air Quality, PCU, SIDRA, PTV Visim.

Full length article **Corresponding Author*, e-mail: engshaimaa088@gmail.com

1. Introduction

The rapid expansion of Egypt's economy and population has made transport a necessity in modern life. As a result, vehicular traffic and air pollution have increased. When vehicles slow down or stop completely due to traffic jams on crowded routes, they emit more pollutants into the air. These massive amounts of car exhaust could release harmful elements that endanger both humans and the environment. The rising number of car owners has aggravated urban air pollution, largely due to vehicle exhaust emissions. Furthermore, the expansion of public transportation has not kept pace with the development of automobiles. Acute traffic congestion in cities, particularly in developing nations, has resulted in more emissions, worse air quality, and more people's health risks [1-2]. The transport sector's high fuel consumption and pollution levels are major concerns for Egypt's planners and authorities. Around 27% of the total fuel-related greenhouse gas emissions in the United States originate from the transportation sector[3]. Urban arterial intersections, characterized by congestion and multiple stop-and-go operations, account for approximately 30% of the additional petrol consumption. The increasing number of motor vehicle emissions, which are a significant contributor to urban air pollution, is becoming an increasingly serious issue, particularly in urban areas.

Emissions of carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), and carbon dioxide (CO_2) significantly influence air pollution in urban areas. In these regions, human activities and traffic intensity contribute to elevated pollutant emissions. There are many factors that influence traffic emissions. Some of these factors include the number of vehicles in traffic, vehicle technology, road and intersection geometry, and intersection signalization[4]. Moreover, the rise in FC has adverse effects on the environment as it increases carbon dioxide (CO_2) emissions into the atmosphere and poses a threat to human health by contributing to the growth of particulate matter (PM) and other hazardous pollutants [5]. Greater Cairo is currently facing a significant crisis in its urban transport system. Within urban areas, there exist numerous transportation challenges. Among the most critical problems congestion, insufficient public transportation, and pollution. These concerns adversely affect both the standard of living and economic growth. In Greater Cairo, the transportation sector is responsible for 26% of all emissions of particulate matter with a diameter of 10 microns (PM10), 90% of carbon monoxide (CO), 90% of hydrocarbons, 22% of sulphur oxides (SOx), and 50% of nitrogen oxides (NOx). Additionally, the national GDP can lose up to 4% of its value due to on-road traffic congestion, owing to poor public transit, old vehicles, and overcrowding. Carbon dioxide emissions are the most significant form of pollution coming from the transportation sector.

In internal combustion engines, the burning of petroleum-based products such as petrol and diesel releases this pollutant into the environment. Fuel combustion significantly reduces the emission of methane (CH_4) and nitrogen oxides (NOx). Because of their large volume, cars and truck vehicles are the primary contributors to greenhouse gas emissions in the transportation sector. Furthermore, these sources account for almost 50% of the emissions in the sector[4]. At road and street junctions, cars have to stop and slow down. The vehicle uses more fuel and emits more emissions the longer it stops. In light of increasing emissions from vehicles, it has become critical to identify effective traffic control strategies that can improve traffic flow and decrease emissions per vehicle kilometer [6]. Research has demonstrated that vehicle emissions increase the risk of morbidity and mortality among drivers, commuters, and community [7]. Furthermore, it negatively impacts pregnancy, leading to an early birth, hereditary impairment, and a lower birth weight [8]. The transport sector was responsible for production of approximately 32% of Egypt's total emissions in 2019 [9-10].

The World Health Organization (WHO) ranks Egypt as the nation with the highest greenhouse gas emissions [11-12]. The World Health Organization (WHO) estimates that air pollution in developing countries results in approximately 4 million fatalities annually, as well as a significant number of respiratory illnesses [13-14]. [6] Conducted a study at three locations in Kansas where a modern roundabout has supplanted a stop-controlled intersection. They selected HC, CO, NOX, and CO2 in kg/hr as air pollution indicators. They reported a reduction of 45% in carbon monoxide (CO), 61% in carbon dioxide, 51% in nitrogen oxides (NOx), and 68% in hydrocarbons (HC). The results of the study indicated that the modern roundabout outperformed the current intersection control system (halt signs) in terms of reducing vehicular emissions, thereby having a beneficial effect on environment [4].

2. Study Objectives

The objective of this investigation is to assess the traffi c characteristics and emission results of various intersectio ns in Zagazig city, as well as to propose a variety of scenari os for each intersection under investigation in order to enha nce the traffic and emission results. The development and implementation of the study methodology enabled the achievement of the study objectives.

3. Study Methodology

In order to reach the study objectives, a comprehensive methodology was established and implemented. The study technique includes both office work and fieldwork. The study technique is illustrated in the flowchart (seen in Figure 1).

3.1 Materials and Procedures

3.1.1 Study Area

The study was conducted in Zagazig City, which considered as a large city along the eastern section of the Nile Delta in Egypt. Zagazig is the capital of Al Sharqia Governorate in the east section of the Delta and is located 86 kilometers northeast of Cairo. Zagazig City's study area is limited by Harayah to the north, Al-Shobak to the east, Al-Zanklun to the south, and El-Qanayat to the west. The evaluation focused on two intersections in Zagazig City: Alqawmia (intersection 1) and Swares (intersection 2). These intersections are very active during the day because they are significant intersections in Zagazig City. These signalized intersections are considered the most significant due to their strategic positions in the downtown area. Figure 2 illustrates the Alqawmia intersection, while Figure 3 represents the Swares intersection. Consequently, it was determined that traffic-related emissions are one of the primary sources of air pollution in the city Centre. In order to properly take precautions, it is crucial to determine the degree to which vehicular emissions contribute to air quality, particularly at intersections.

3.1.2. Scenarios Selection

Five different scenarios were proposed for evaluation for the Alqawmia intersection, whereas three alternative scenarios were offered for the Swares intersection, including the base scenario. The basic scenario illustrates the current circumstances at the study intersection, which is affected by congested traffic flow. Additional scenarios have been suggested, including intersection management by signal design and modifying road geometry, such as reversing the direction of travel. All modifications were proposed as trials to improve traffic flow and decrease emissions from vehicles. Table 1 and Table 2 illustrate various scenarios for the analyzed intersections of Alqawmia and Swares, respectively.

3.1.3 Traffic Volumes

The following phase, illustrated in Figure 1, involved the construction of traffic simulation models for the analyzed intersections. This project required the collection of comprehensive geometry and traffic data for the studied intersections. The geometric data of the analyzed intersection included the number of links and phases, link length, lane width, number of lanes, and signal timing. The length of each link was determined using goggle maps. The width of the link, the number of lanes, and the signal duration were manually assessed during fieldwork. Subsequently, a precise traffic count was performed at the analyzed intersections to develop the SIDRA and VISSIM models. The varying vehicle traffic volumes at the examined intersections were converted to passenger car (PC) equivalents based on the passenger car equivalent (PCE) variables outlined in Table 3 to assess the impact of traffic composition on emission calculations. As mentioned before, it is essential to input specific values into the program for the modelling process. The particular categories of data include intersection geometry, traffic data, and signal data.

The data obtained from field research were entered into the computer along with the data which collected over the peak hour. Furthermore, the current state's cycle time and phase diagram were inputted. Consequently, the analysis of the present circumstances at the intersection was completed, also future demand was estimated. It is essential to recognize that while utilizing previous stages, that volume was increased and incorporated a growth factor of 2.1% over a ten-year period. Subsequently, a new cycle period was established, or alternatively, the direction of movement was switched. Another analysis was conducted using the updated cycle time or movement for the peak hour, but keeping all other data unchanged. The objective was to enhance the intersection by adjusting the cycle time or inverting the direction. Comparisons were made between the emission values observed in various analyses. Tables 4 and 5 represent the traffic volumes at the Alqawmia intersection under both current and future conditions. Also, tables 6 and 7 illustrate traffic volumes at the Swares intersection for current and forecast demand, respectively.

3.1.4 Traffic Emission

The IPCC Implementation Guidelines [15] regard emission sources as the primary contributors to a country's total greenhouse gas emissions, accounting for 95% of the cumulative CO2 equivalents. Transportation is an important contributor noted in these rules and comes within the scope of the energy sector. The transportation sector includes roadway, railway, international civil aviation, and national maritime operations. Specifically, the application guide provides three different formulas for computing emissions: Tier 1, Tier 2, and Tier 3. The amount of data available determines the formula choice [16]. The European Environment Agency publishes the EMEP/EEA Emission Inventory Guide, directly providing the emission factors needed for computations. The traditional approach to creating an emission inventory involves multiplying the emission factors by the activity statistics and the overall number of vehicles. The present work employed the SIDRA program as an alternative to the traditional approach for calculating emissions. Then used VISSIM program to make calibration. SIDRA is a microsimulation model that accurately evaluates road traffic conditions by utilizing data from in-traffic vehicles or predefined driving cycles provided by the user. It employs a power-based vehicle model to predict the percentage of delay, fuel consumption, and emissions of carbon dioxide (CO2), hydrocarbons (HC), carbon monoxide (CO), and nitrogen oxides (NOx).

The version utilized in this investigation was SIDRA Intersection 8. Evaluating traffic and travel circumstances prior to and subsequent to intersections and road enhancements is an ideal strategy[17]. SIDRA Intersection software was specifically designed for professionals in traffic engineering. The software is always updated to satisfy the criteria. The most significant upgrade in environmental engineering was the assessment of fuel use and emissions. The most significant result in our study was that the enhancements in signalization at intersections have dramatically decreased emissions. SIDRA is a critical software used globally to obtain accurate data in many investigations. This program is more advantageous than traditional computation methods for preparing emission assessments. The traditional approach categorizes the road type as urban, rural, or highway, assuming that cars maintain a constant speed while transiting. In SIDRA, cars are not assumed to maintain a constant speed; rather, deceleration and stop-and-go actions are also accounted for. Consequently, the emissions computed by this software are considered to be more sensitive. For fuel demand and emission calculations, the SIDRA Intersection program categorizes vehicles as either "light duty" or "heavy duty." Heavy-duty cars are distinguished by having more than two axles or dual tires on the rear axle, which is equivalent to a vehicle with more than four tires. Light-duty vehicles include all other vehicles, vans, and small trucks.

The fuel consumption and emissions at intersections are computed based on a standard driving cycle including cruise, deceleration, idle, and acceleration. Model estimates carbon monoxide (CO), hydrocarbons (HC) and nitrogen oxides (NOx) emission rates (mg/s) by using the same procedure with different parameters [18]. The parameters are presented in Table 8 for light-duty vehicles, Table 9 for heavy-duty vehicles, and Table 10 for public transit vehicles, which considered properly.

Traffic simulation software VISSIM was utilized to simulate and calibrate models employed at the SIDRA intersection. The software can assess various traffic and transit operations under varied conditions and aid in analyzing traffic impacts of various physical and operational strategies in transportation planning. This study focuses on calibrating emissions at signalized intersection in Alqawmia and Swares using the VISSIM simulation model. Subsequently, the EU emission standard was implemented, as it is most commonly used globally. The EU standards that implemented for new gasoline-powered vehicles establish precise definition of a standard. In general, calculation of vehicular emissions can be calculated using following equation:

$$Emission = Ef * d$$

Where, Emission is the amount of emission (CO, NOx, VOC), E_f is relative emission factor per unit of activity, and d is the travel distance and equation have to be used for each category of vehicle and number of transport activity.

4. Results

The present and future state of intersection initially modelled using SIDRA and VISSIM based on observations. Afterwards, the total fuel consumption, delay percentage, and emissions of carbon dioxide, carbon monoxide, and nitrogen oxide calculated. Subsequently, same characteristics calculated for all proposed options, including modifications to cycle time or alterations in direction. As previously mentioned, two types of models were employed: first included entering amounts with traffic composition (TC), while second converted volumes to passenger car units (PCU) using passenger car equivalents, relevant to both current and future scenarios. Tables 11 and 12 present measurements for total delay, fuel consumption, and air pollution emissions during peak hour at Alqawmia and Swares intersections, both current, future, and scenarios.

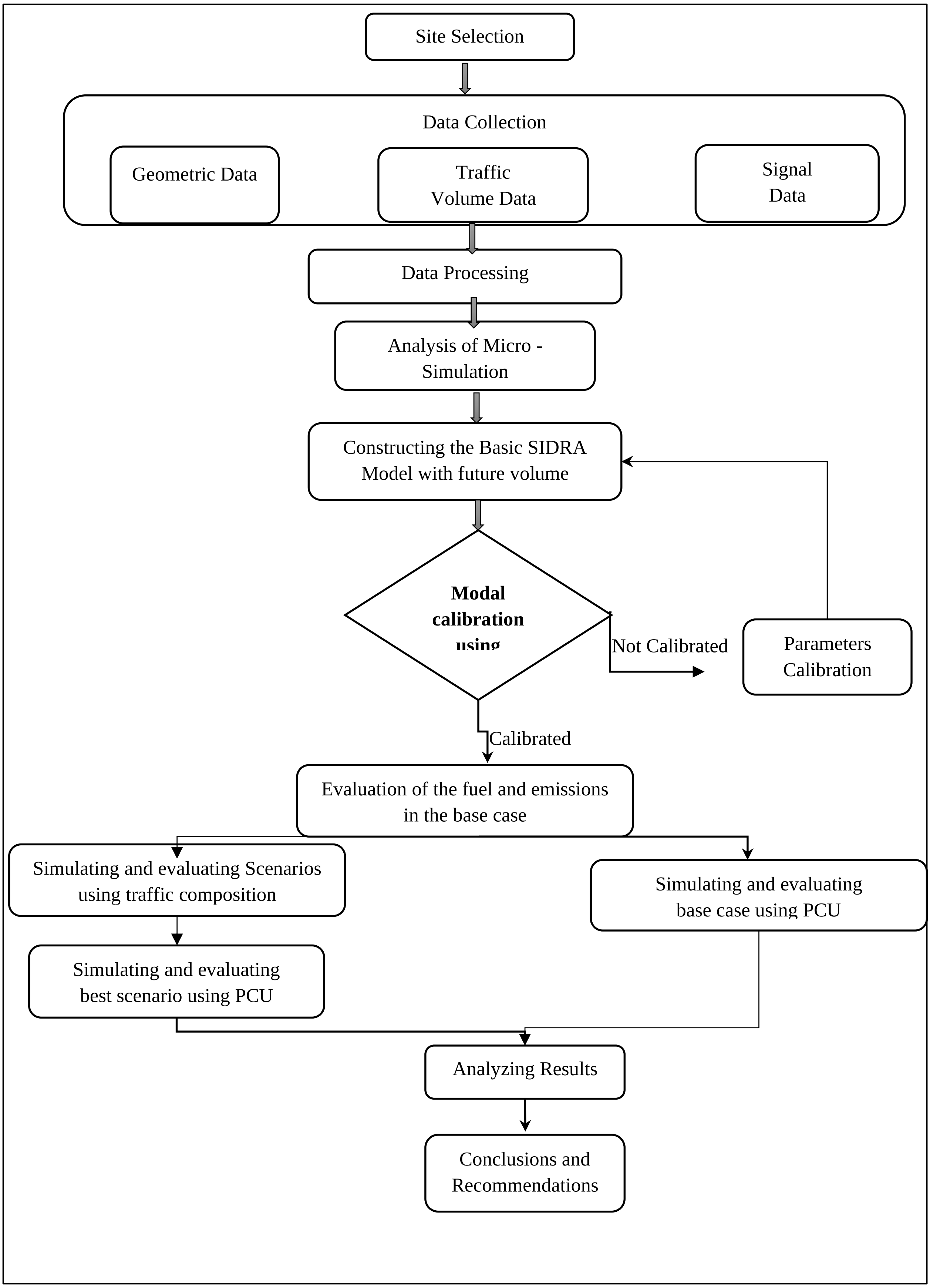

Figure 1: Study Methodology Flowchart

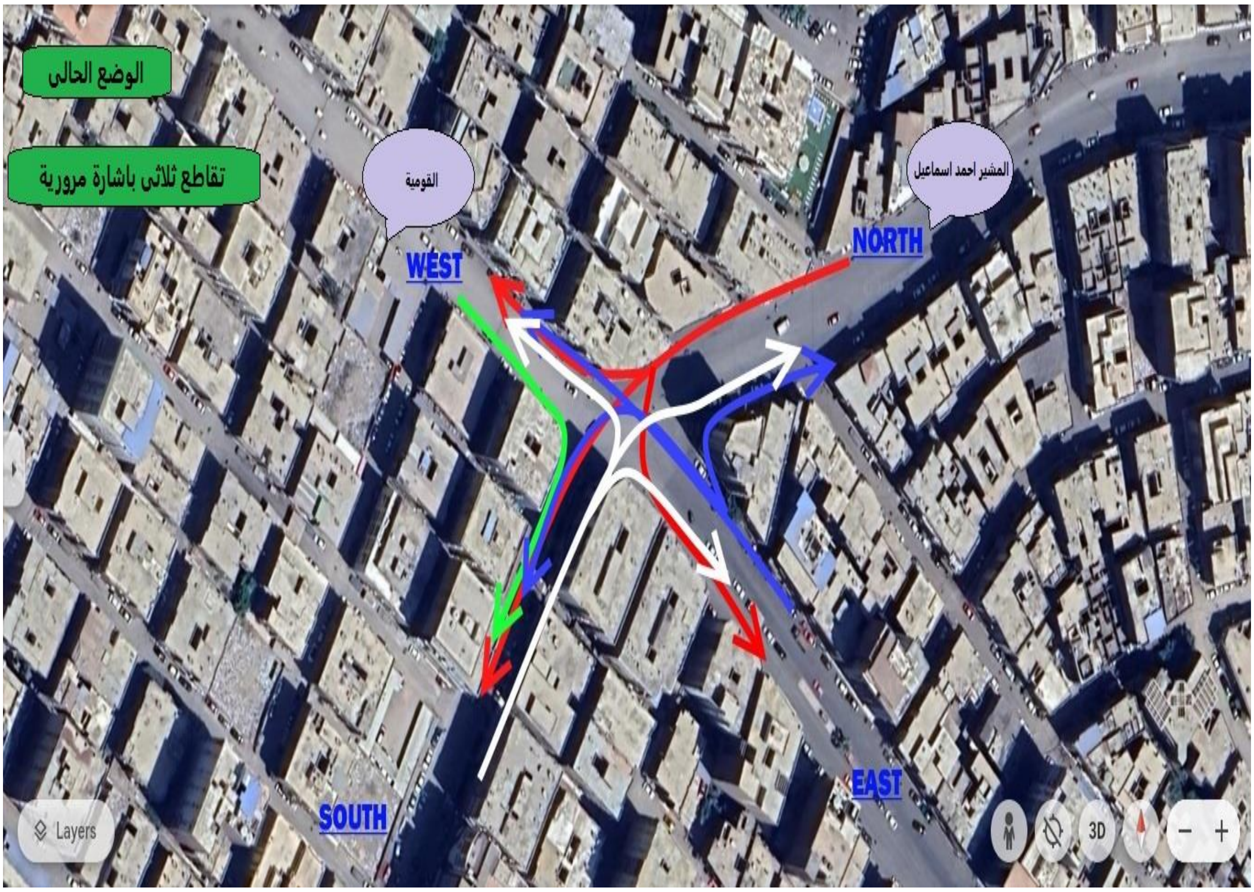

Figure 2: Shows a map of the Alqawmia intersection

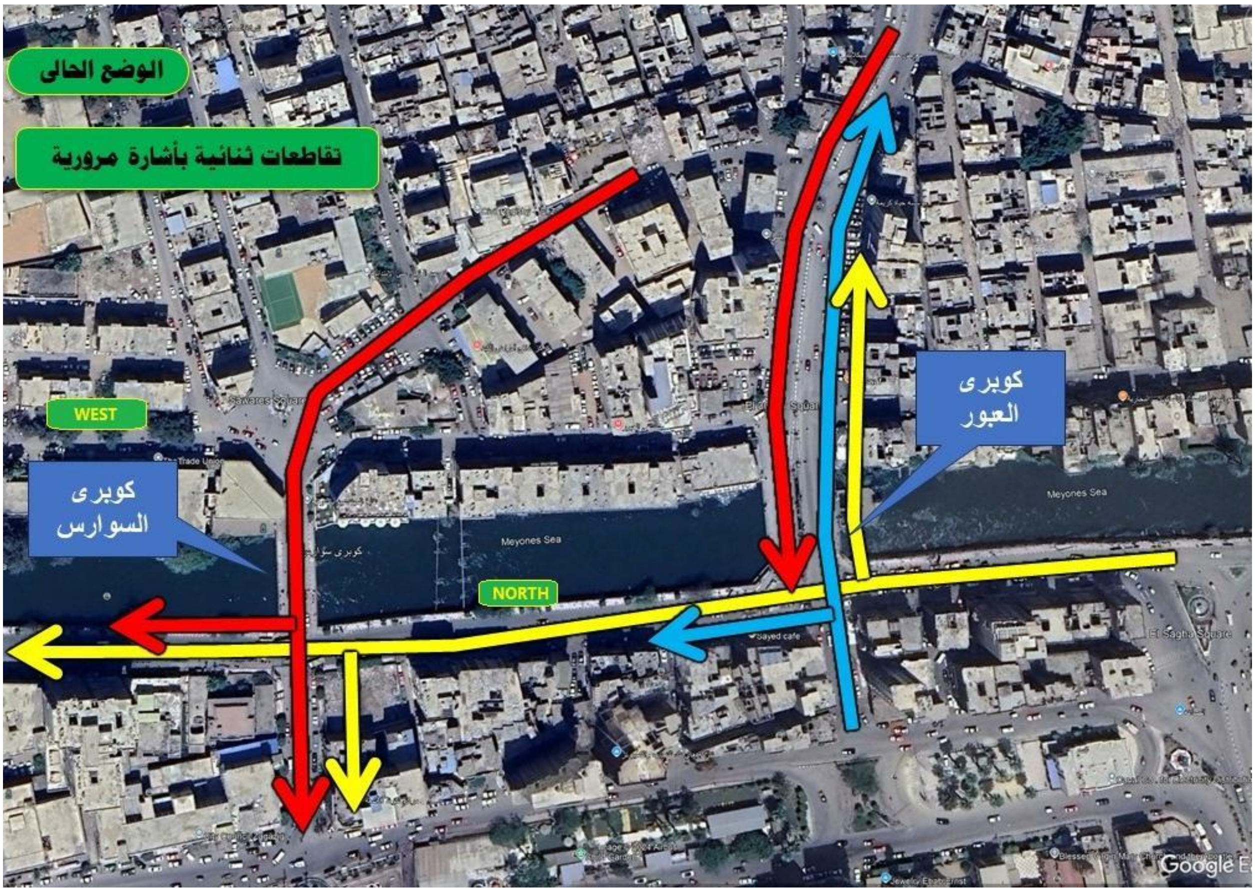

Figure 3: Shows a map of the Swares intersection

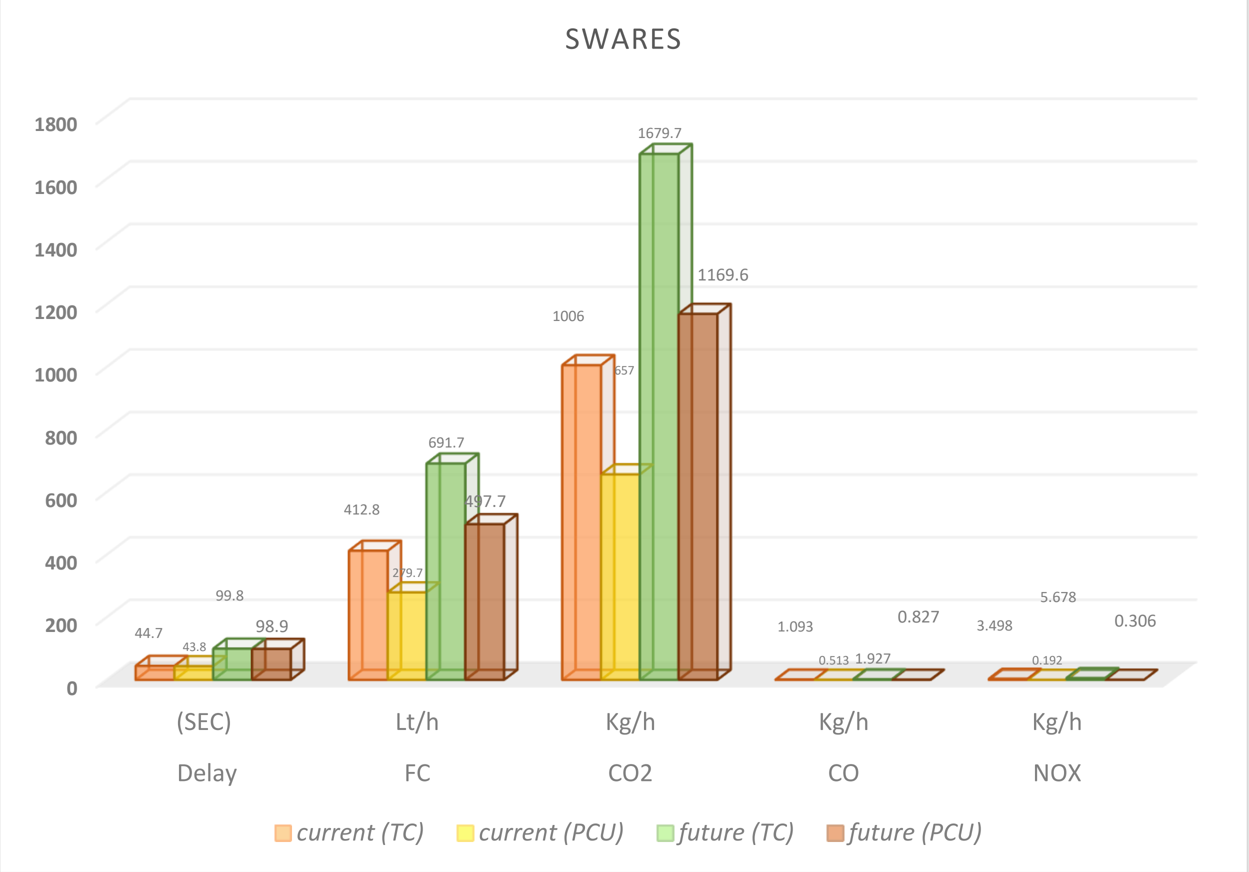

Figure 4: Depicts fuel use and emissions in both current and future scenarios utilizing PCU or TC.

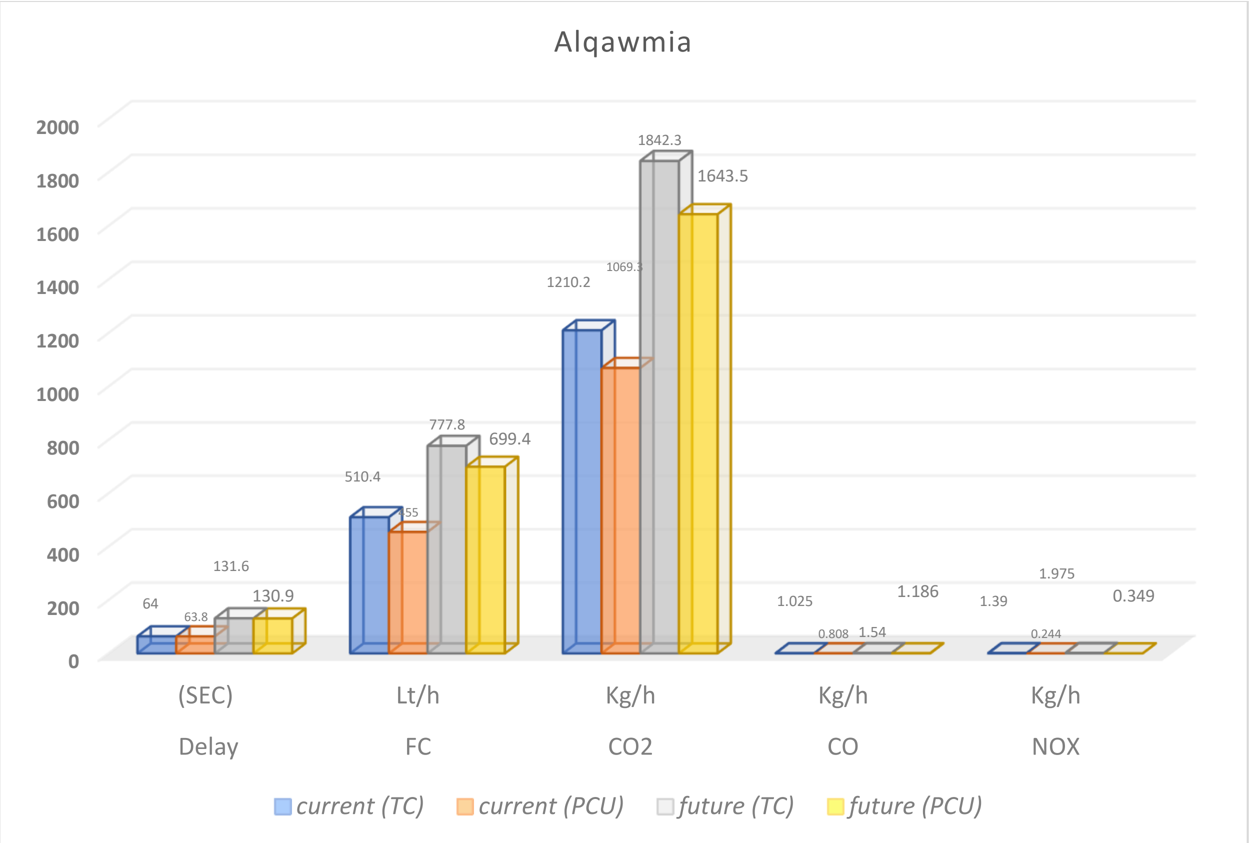

Figure 5: Illustrates fuel and emissions in both current and future situations applying PCU or TC.

Table 1. Details of Different Scenarios of the Studied Alqawmia intersection.

SENARIOS(AL-Qawmia Intersection)				
Basic Senario	Proposed ALT 1	Proposed ALT 2	Proposed ALT 3	Proposed ALT 4
3 phase signal with cycle 132 sec	signal with cycle time 64 sec instead of 132 sec	One way approch at WEST link	One way approch at WEST link	One way approch at WEST link
		One way exit at SOUTH link	One way approch at EAST link	One way exit at EAST link
		Optimum signal with cycle time 75 sec instead of 132 sec	One way exit at SOUTH link	One way exit at SOUTH link
		Free movement for (Right) at east	Signal with cycle time 50 SEC	Signal with cycle time 50 SEC
		Free movement for (Right)at west only with north signal	Signal at West with green time 22	Signal at West with green time 22
				Signal at NORTH green time 22
		Free movement for (left)at west only with east signal	Signal at EAST and same lt at NORTH with green time 22	Free movement for (Right)at west

Table 2. Details of Different Scenarios of the Studied Alqawmia intersection.

SENARIOS(Swares Intersection)			
Basic Senario	Proposed ALT 1	Proposed ALT 2	Proposed ALT 3
2 phase signal with cycle 111 sec	Separate (Right & Left)LANE	Separate (Right & Left)LANE	Without Intersection
		Free movement for (Right&Left)Lane	One way approch at NORTH link
	Optimum signal with cycle time 50 sec instead of 111 sec	Optimum signal with cycle time 50 sec instead of 111 sec	One way exit at WEST link

Table 3. Passenger Car Equivalent Factors

Type	Passenger Car	Taxi	Motorcycle	Three Wheels	Microbus	Bus
PCE	1	1	0.25	0.5	1.5	2.5

Table 4. Traffic volumes at Alqawmia intersection in the morning, mid-day and evening hours (2021).

approach	AM			Midday			PM		
	CAR	PT	HV	CAR	PT	HV	CAR	PT	HV
N	1023	35	0	1328	4	26	1084	31	0
S	941	93	0	1225	60	0	1096	58	0
E	744	13	13	1040	12	33	853	12	12
W	613	10	33	760	8	32	679	6	5

Table 5. Traffic volumes at Alqawmia intersection in the morning, mid-day and evening hours (2031).

approach	AM			Midday			PM		
	CAR	PT	HV	CAR	PT	HV	CAR	PT	HV
N	1258	43	0	1633	5	32	1333	38	0
S	1157	114	0	1507	74	0	1348	71	0
E	915	16	16	1279	15	41	1049	15	15
W	754	12	41	935	10	39	835	7	6

Table 6. Traffic volumes at Swares intersection in the morning, mid-day and evening hours (2021).

approach	AM			Midday			PM		
	CAR	PT	HV	CAR	PT	HV	CAR	PT	HV
N	1951	69	276	2266	255	25	1908	258	412
W	1080	59	35	1333	91	0	1527	64	0

Table 7. Traffic volumes at Swares intersection in the morning, mid-day and evening hours (2031).

approach	AM			Midday			PM		
	CAR	PT	HV	CAR	PT	HV	CAR	PT	HV
N	2400	85	339	2787	314	31	2347	317	507
W	1328	73	43	1640	112	0	1878	79	0

*PT: Public transportation, HV: Heavy vehicle

Table 8. Fuel and emission parameters for light duty vehicle

	Fuel	CO	HC	NOx
Idling Rate, fi	1200.0	1620.0	340.0	300.0
Drag Parameter, A	16.0	-138.0	-9.0	-14.0
Drag Parameter, B	0.004	0.0743	0.0031	0.0068
Efficiency Parameter, beta	0.1	0.294	0.029	0.166

*Mass: 1600 kg, Max power: 120 KV, CO2 to Fuel consumption rate: 2.35

Table 9. Fuel and emission parameters for heavy vehicle

	Fuel	CO	HC	NOx
Idling Rate, fi	2300.0	25000.0	3000.0	44000.0
Drag Parameter, A	200.0	320.0	1.0	2820.0
Drag Parameter, B	0.009	-0.06	-0.0016	0.21
Efficiency Parameter, beta	0.075	0.04	0.0013	1.9

*Mass: 15000 kg, Max power: 170 KV, CO2 to Fuel consumption rate: 2.63

Table 10. Fuel and emission parameters for PT vehicle.

	Fuel	CO	HC	NOx
Idling Rate, fi	2100.0	12000.0	6800.0	49000.0
Drag Parameter, A	180.0	240.0	-5.0	350.0
Drag Parameter, B	0.0005	0.01	0.001	0.25
Efficiency Parameter, beta	0.09	0.6	0.005	1.4

*Mass: 8000 kg, Max power: 170 KV, CO2 to Fuel consumption rate: 2.63

Table 11. Calculated fuel and emissions in Alqawmia intersections using (TC)

Emissions	PHASE NO	CYCLE Time(Sec)	Delay (Sec)	FC Lt/h	CO2 Kg/h	CO Kg/h	NOX Kg/h
Current situation	3	132	64	510.4	1210.2	1.025	1.39
Future situation	3	132	131.6	777.8	1842.3	1.54	1.975
Alternative 1	3	64	76.9	661.5	1567.9	1.337	1.826
Alternative 2	3	75	38.4	611	1448	1.385	1.951
Alternative 3	2	50	10.9	535.6	1270	1.208	1.796
Alternative 4	2	50	19.4	566	1341	1.317	1.838

Table 12. Calculated fuel and emissions in Swares intersections using (TC)

Emissions	PHASE NO	CYCLE Time(Sec)	Delay (Sec)	FC Lt/h	CO2 Kg/h	CO Kg/h	NOX Kg/h
Current situation	2	111	44.7	412.8	1006	1.093	3.498
Future situation	2	111	99.8	691.7	1679.7	1.927	5.678
Alternative 1	2	50	38.2	547.1	1334.8	1.551	5.013
Alternative 2	2	50	25.6	496.5	1212.3	1.35	4.563

Table 13. Calculated fuel and emissions in Alqawmia intersection using PCU (2021)

Emissions	Delay (SEC)	FC Lt/h	CO2 Kg/h	CO Kg/h	NOX Kg/h
Traffic Composition	64	510.4	1210.2	1.025	1.39
PCU	63.8	455	1069.3	0.808	0.244
Difference	0.2	55.4	140.9	0.217	1.146
Difference%	0.3%	10.9%	11.6%	21.2%	82.4%

Table 14. Calculated fuel and emissions in Alqawmia intersection using PCU (2031)

Emissions	Delay (SEC)	FC Lt/h	CO2 Kg/h	CO Kg/h	NOX Kg/h
Traffic Composition	131.6	777.8	1842.3	1.54	1.975
PCU	130.9	699.4	1643.5	1.186	0.349
Difference	0.7	78.4	198.8	0.354	1.626
Difference%	0.5%	10.1%	10.8%	23.0%	82.3%

Table 15. Calculated fuel and emissions in Swares intersection using PCU (2021)

Emissions	Delay (SEC)	FC Lt/h	CO2 Kg/h	CO Kg/h	NOX Kg/h
Traffic Composition	44.7	412.8	1006	1.093	3.498
PCU	43.8	279.7	657	0.513	0.192
Difference	0.9	133.1	349	0.58	3.306
Difference%	2.0%	32.2%	34.7%	53.1%	94.5%

Table 16. Calculated fuel and emissions in Swares intersection using PCU (2031)

Emissions	Delay (SEC)	FC Lt/h	CO2 Kg/h	CO Kg/h	NOX Kg/h
Traffic Composition	99.8	691.7	1679.7	1.927	5.678
PCU	98.9	497.7	1169.6	0.827	0.306
Difference	0.9	194	510.1	1.1	5.372
Difference%	0.9%	28.0%	30.4%	57.1%	94.6%

Table 17. Calculated fuel and emissions in alternative 3 at Alqawmia intersection

Emissions	Delay (SEC)	FC Lt/h	CO2 Kg/h	CO Kg/h	NOX Kg/h
Traffic Composition	10.9	535.6	1270	1.208	1.796
PCU	10.8	474.1	1114.1	1.052	0.303
Difference	0.1	61.5	155.9	0.156	1.493
Difference%	0.9%	11.5%	12.3%	12.9%	83.1%

Table 18. Calculated fuel and emissions in alternative 2 at Swares intersection

Emissions	Delay (SEC)	FC Lt/h	CO2 Kg/h	CO Kg/h	NOX Kg/h
Traffic Composition	25.6	496.5	1212.3	1.35	4.563
PCU	24.1	317.3	745.6	0.611	0.243
Difference	1.5	179.2	466.7	0.739	4.32
Difference%	5.9%	36.1%	38.5%	54.7%	94.7%

Vehicle emissions primarily associated with fuel use. Consequently, an examination of fuel consumption rates reveals a significant reduction in fuel usage following an improvement of cycle times or modification of intersection phases from three to two by adjusting movement. According to results, traditional PCU approach causes an underestimation of emissions, particularly in areas where heavy vehicle traffic is largely concentrated. Tables 13, 14 and 15, 16 present values for total delay, fuel consumption, and air pollution emissions during peak hour, utilizing PCU and traffic composition, and clarify differences at Alqawmia and Swares intersections in current and future, respectively. In an experiment to verify that the PCU method reduces estimated emissions, PCU methods were implemented in optimal scenarios at Alqawmia and Swares intersections, characterized by little delay and minimal emissions. Tables 17 and 18 display results for total delay, fuel consumption, and air pollution emissions in optimal scenarios at Alqawmia and Swares intersections, respectively. It is verified that using traditional techniques reduces emissions.

5. Discussion and Conclusions

Table 14 illustrates that, in the future, Alqawmia's fuel consumption rate was 777.8 l/h based on the traffic composition, which subsequently decreased to 699.4 l/h after converting volumes to PCU. Following the reduction in consumption rates, emissions of CO2, CO, and NOx decline by 10.8%, 23%, and 82.3%, respectively, post-improvement. Furthermore, Table 12 in Swares indicates that the fuel consumption rate was 691.7 l/h for the traffic composition, which reduces to 497.7 l/h upon converting volumes to PCU. Following the reduction in consumption rates, emissions of CO2, CO, and NOx decline by 30.4%, 57.1%, and 94.6%, respectively, when PCU are implemented. The fuel consumption and emissions are gathered in Figures 4 and 5, which use either PCU or TC to represent both the current and future scenarios for the Swares and Alqawmia intersections, respectively.

References

[1] M. Bogacki, P. Bździuch. (2019). Predicting the spatial distribution of emissions from urban buses based on previously measured data and scenarios for their modernization in the future. Case study: Krakow, Poland. Atmospheric environment. 199: 1-14.

[2] A. Liaquat, M. Kalam, H. Masjuki, M. Jayed. (2010). Potential emissions reduction in road transport sector using biofuel in developing countries. Atmospheric environment. 44(32): 3869-3877.

[3] A. Harvey. (2020). Climate Change & Greenhouse Gases: Keeping Our Vehicle Emissions Standards

Safe. University of Baltimore Law Review. 49(3): 5.
[4] H. Namazi, A. Taghavipour. (2021). Traffic flow and emissions improvement via vehicle-to-vehicle and vehicle-to-infrastructure communication for an intelligent intersection. Asian Journal of Control. 23(5): 2328-2342.
[5] A.J. McMichael, J. Haines, R. Slooff, R. Sari Kovats, W.H. Organization *Climate change and human health: an assessment*; World Health Organization: 1996.
[6] S. Mandavilli, E.R. Russell, M. Rys In *Environmental Impact of Kansas Roundabouts*, Annual Conference of the Transportation Association of Canada, Toronto, Ontario, 2003; 2003.
[7] Z. Luo, Y. Wang, Z. Lv, T. He, J. Zhao, Y. Wang, F. Gao, Z. Zhang, H. Liu. (2022). Impacts of vehicle emission on air quality and human health in China. Science of The Total Environment. 813: 152655.
[8] B. Jiang, S. Liang, Z.-R. Peng, H. Cong, M. Levy, Q. Cheng, T. Wang, J.V. Remais. (2017). Transport and public health in China: the road to a healthy future. The Lancet. 390(10104): 1781-1791.
[9] Y. Mansour, W. Taha, K. Tarabieh, Carbon footprint report. The American university in Cairo. In 2019.
[10] R.R. Moussa. (2019). The reasons for not implementing Green Pyramid Rating System in Egyptian buildings. Ain Shams Engineering Journal. 10(4): 917-927.
[11] R.R. Moussa. (2020). Installing piezoelectric tiles in children outdoor playing areas to create clean & healthy environment; case study of el-shams sporting club, Cairo_Egypt.
[12] I. Hegazy, W. Seddik, H. Ibrahim. (2017). Towards green cities in developing countries: Egyptian new cities as a case study. International Journal of Low-Carbon Technologies. 12(4): 358-368.
[13] S.M. Gamal, A. Mohamdy, M.A. Shalaby, H. Darwish. (2024). Evaluation of Urban Vehicle Emissions Using Traffic and Emission Models-An Overview. The Egyptian International Journal of Engineering Sciences and Technology. 47(1): 12-24.
[14] W.H. Organization. (2016). World Health Statistics 2016 [OP]: Monitoring Health for the Sustainable Development Goals (SDGs). World Health Organization: pp.
[15] I. Change. (2006). 2006 IPCC guidelines for national greenhouse gas inventories. Institute for global environmental strategies, Hayama, Kanagawa, Japan.
[16] E. Emep, E.A.P.E.I. Guidebook. (2016). 2016Technical Guidance to Prepare National Emission Inventories; EEA Report. European Environment Agency: Copenhagen, Denmark.
[17] R. Akçelik In *Issues in performance assessment of sign-controlled intersections*, Proc. 25th ARRB Conf. Perth, Australia, 2012; 2012.
[18] R. Akçelik, R. Smit, M. Besley In *Calibrating fuel consumption and emission models for modern vehicles*, IPENZ transportation group conference, Rotorua, New Zealand, 2012; 2012; pp 1-13.