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Statistic Equation to Estimate the Amount of CO_2 Emission Produced From High Traffic Density Roads

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Abstract: - Energy consumption, especially the energy used for electricity supply has doubled in the past three decades, causing a drastic increase in the carbon emissions produced. Between 1990 and 2005 globally, the amount of CO_2 emissions increased 25%. It is estimated that vehicles produce approximately 30% of the global NOx and 14% of global CO_2 emissions. Egypt is the fourteenth biggest wellspring of CO_2 emissions among all GEF program nations. It was proven that 66% of CO_2 emissions comes from fossil fuel as a primary energy consuming source, playing a key role in the overall carbon intensity. The problem of this research is that the roads in developing countries produce a high level of carbon emissions, and the level is increasing due to the heavy usage of fossil fuels in the transportation sector. This research presents statistical analysis equation to analyse the amount of CO_2 emissions produced from roads without using heavy and expensive equipment's. Moreover, the equation can be used as a tool to estimate the amount of CO_2 emissions produced from roads during the design phase in order to improve the design and reduce carbon emissions in roads. According to the statistics the main factors affecting the amount of CO_2 produced in roads are the electricity generations, types of vehicles and vehicles speed. The research used experimental method to validate the equation by measuring CO_2 emissions in high traffic density road using measuring device and compared the measuring results with the statistic equation results. The presented equation should help in reducing the amount of CO_2 produced in roads, in return it will help in reducing the growth of global problems such as climate change and ozone depletion.

Key-Words: - Carbon emissions, Vehicles emissions, Electricity generation, Traffic congestions, Air pollution.

1 Introduction

Today, the whole world considers Energy as the major aspect effect urban developments; it is the ruler for all human activities such as industry, services, housing, agriculture, and transportation. Egypt as many countries, depend heavily on traditional energy sources like crude oil, hydroelectric energy and natural gas. According to Egyptian-German Private Sector Development Program, the situation of energy in Egypt is unstable due to the present or foreseeable descent of natural gas and domestic oil resources [13]. Petroleum in Egypt and different liquids production are diminishing and the consumption demand is growing, that means that depending on fossil fuel is no longer an option for this country. The production of Egyptian oil decreased for over a decade subsequent to reaching a high point in the mid-1990s for over 900,000 b/d. In 2008, The production grew over the following few years due to the help of Western Desert and offshore output growth, but production growth started to diminish again in a

short time after that [17]. Since the Industrial Revolution, a rapid increase CO_2 happened due to consumption of fossil fuel. This has led to many problems as this disturbs the global carbon cycle. This disturbance is basically leading to a planetary warming impact. This huge consumption brings about the generation of carbon dioxide (CO_2) [17], Since the Industrial Revolution, a rapid increase CO_2 happened due to consumption of fossil fuel. This has led to many problems as this disturbs the global carbon cycle. This disturbance is basically leading to a planetary warming impact. This huge consumption brings about the generation of carbon dioxide (CO_2) [17], and since it is a gas absorbing and also emitting thermal radiation, it creates 'greenhouse effect', in addition to other greenhouse gases. The effect of global warming ranges from different impacts such as: physical, ecological and health impacts, including extreme conditions of weather as floods, heat waves, storms and floods; leading to rising in sea-level, water systems disruptions and altered crop growth [19]. In 2018,

CO_2 global energy-related emissions were increased 1.7% to reach its peak of 33.1 giga tons (Gt) CO_2. This was the highest recorded growth rate, and 70% higher than the average increase since 2010. The main reasons behind this drastic raise is the higher energy consumption resulting from a booming global economy, and the high-energy demand needed to heat or cool some countries [12].

The atmosphere concentration of CO_2 has risen over the last two centuries, it went from 280 to over 380 parts per million by volume, and it is still increasing daily. The electricity generation sector shared with 40% approximately (12Gt) of the CO_2 emissions globally, produced from the combustion of fossil fuels (natural gas, coal and oil) to generate heat that is used to power steam-driven turbines. Carbon dioxide is the primary cause of heat trapping which is known as "Greenhouse gas (GHG)". Heat trapping or Greenhouse is responsible for global warming, in addition to other nitrogen and sulphur oxides responsible for various environmental impacts such as ozone depletion and climatic changes [1] & [8]. Despite the proof of dangers caused by change of climate, attempts to reduce carbon emissions still are insufficient, unsuccessful and in a lot of countries, does not exist. By year 2050, 80% of Carbon emissions need to be reduced [1], [7]. According to the world resources institute, globally, the main sources of CO_2 emissions are heat and electricity with share of 31%, while agriculture share 11%, transportation share 15%, forestry share 6% and manufacturing share 12%. Energy production of all types accounts for 72 % of all emissions. Electricity sector shares approximately 31% of the global CO_2 emissions; it is followed by transportation and industry [5]. The CO_2 emissions which are estimated globally from electrical power industry were about 12 billion tones/yearly in 2010. with shared almost 25% comes from USA, 25% from China, 25% different pioneer countries in industry, and lastly 25% from the rest of the world. Egypt is in the 30th place. Which produce about 64 million tons of CO_2 emissions each year as a result of electrical power plants (almost 0.5% of emissions globally) [23]. Some relevant studies can be found in [11] & [10].

2 Air Quality in Egypt

In 2009, Egypt depends heavily on coal as the main source of electricity generation. Egypt is planning to increase the growth of renewables in generating electricity, to approach total of 20% of energy generation by 2020, where hydropower is 5.8%, wind 12% and for solar energy is 2.2% [1]. One of the most cheap and clean of power generation sources in Egypt is Hydropower. Since 1985 to around 1995, hydropower added around 28 to 22 % of the overall produced energy by Power-plants in Egypt, while hydro capacity contributed with 32.4 to 21.5% [2]. The Egyptian ministry of Electricity has a plan of building the first hydropower plant in the middle east, reaching a capacity of 2,400 MW by the technology of pumped-storage hydropower (PSH) at Ataqa Mountain, Red Sea, to harness resources of renewable energy, Mohamed Shaker Said, Minister of Electricity [18]. Egypt has several wind resources which considered the best in the world. Presently, about 550MW of electrical energy generated in Egypt from Zafarana wind farm situated on the Suez Coast Gulf, over Red Sea Coastline. Egypt is planning to generate more than 20 % of its power from renewable sources, while 12% will be generated from wind farms by year 2025 [15] and [18]. Renewable resources have a big prospect in the Middle East, which have remained largely not used. There is very big potential for using solar energy in Egypt, its utilization is crucial for national sustainable development up to the hilt of efficiently active energy planning in addition to gradually becoming independent from fossil fuel [7]. That specific truth of solar power, since its prospect in the MENA region only quite exceeds the demands of global electricity. The towering intensity of direct solar radiation (2,000-2,600 kWh/m^2) in Egypt provides big prospect for solar energy development, specifically in Upper Egypt [14] & [18].

2.1 The Quality of Atmospheric Air

In Egypt, there are a lot of sources of air pollution, same as many countries. However, the formation and levels of dust, tiny particles and soot are more characteristic in Egypt than currently founded in different industrialized countries. Several sources for those pollutants are open-air waste burning, industries and transportation. Cairo is considered one of the most polluted cities due to the rapid urbanization, industrialization and the growing number of vehicles [16]. Not long passed, "episode" of air pollution occurred during autumn 1999 and early winter 2000 (October 1999 – January 2000). Therefore, a program for air quality management based in scientific basis became pressing issue to keep air quality in major industrial and urban centres in Egypt. Air pollution is a pressing seniority in the development agenda for Egyptian government because of peaking levels of locally emitted pollutants experienced in dense cities. In Cairo between 1997 & 2004, Air Improvement Project (CAIP), a Source-Attribution-Study (SAS)

was conducted to characterize the contribution of different sources that pollute the air in Egypt. The study revealed that 32% of air pollution is accounted from vehicle exhaust [4]. Other researchers also approved that vehicle exhausts are the mainly dominant source of different pollutants in Cairo like black Carbon (BC) and the carcinogenic VOCs, benzene, toluene, ethylbenzene and xylenes (BTEXS), and hydrocarbons (HCs) in fine street dust. The Egyptian government arranged some procedures to eliminate Greenhouse Gas emissions in the transportation sector; including the improvement of the public transport, vehicles fuel efficiency and surveillance on-road vehicle emissions, in the company of different measures. However, the incorporation of strategies into planning and workable achievements is not yet assessed [2].

2.2 Percentage of Carbon Emission
Energy is considered Egypt's Greenhouse gases dominant sector. Within this sector, electricity and heat production is responsible for 41%, transportation 24%, manufacturing and construction 17%, other fuel combustion 11%, and fugitive emissions 7% of energy sector GHG emissions [24]. According to the International Energy Agency (IEA), it was concluded that between 1990 and 2012, Egypt's total primary energy supply more than doubled during this time, with fossil fuels accounting for 94% and renewable energy sources with only 4% in 2012 [12]. Egypt's dependence on hydrocarbons becomes predictable to keep increasing with the continuous social and economic developments. The increasing in energy demand is relentlessly compelled by 30 urbanizations, growing output of industry, energy-intensive industries, motor vehicle sales, and energy subsidies. However, the most rapidly increasing emissions are coming from the transportation sector, as a result of major dependence on roads and private fuel vehicles used as the primary mean for transportation [24].

2.3 Transportation Sector
Egypt is considered the largest Arab country, with a population of more than 90 million people which makes it the second most populous country in Africa. According to research in 2013, the total number of licensed vehicles in Egypt was 7.04 million vehicles, and about 50% of them are in the Cairo. Almost half of all vehicles in Egypt are cars, specifically 3.83 million cars. The amount of people transported by roads was around 115.6 billion passengers/km, where the freight transport amounted to around 43.1 billion tons/km. In Egypt,

the transportation sector has a huge share of the countries Greenhouse gases due to the heavy use of fossil fuels [3]. In 2004, the transportation sector shared with an average of 29.16% of the overall energy consumption in Egypt [9]. Moreover, it produced around 31.6 million tons of CO_2 Emissions which is approximately 26% of the total CO_2 emissions produce from energy generation. The more the population grows, the more the need for energy in the transportation sector will be needed [2].

2.4 The Effects of CO_2 Emissions on the Egyptian Environment
Carbon emissions contribute to climate change, which can have serious consequences on the environment, consequently, on humans. The problem is that After CO_2 is emitted into the atmosphere, 20% will remain in the atmosphere for thousand years, while 40% will remain for hundred years, and the final 10% will take years to turn over. This means that the heat trapping emissions released today from the vehicles and the other mentioned sources are setting the climate the future generations will inherit [15].

2.4.1 Acid Rain
Acid rain is the scientific term for the excessive ratio of acidity in rain as a result of gases (from different processes whether industrial or natural) these gases dissolve in rainwater forming several types of acids. The effect of Carbon emissions is of concern as it dissolves in rain, converting into weak acid, aka Carbonic Acid. The acidity spreads through wet and dry deposition. Wet deposition is the most common form of acid rain which usually falls in the form of snow, rain, hail or fog. While the particles of acid and gases can precipitation from the atmosphere during lack of moisture as dry deposition. The acidic particles and gases may deposit to surfaces (water bodies, vegetation, buildings) fast enough or it can react over transport of atmosphere to create bigger harmful particles that can affect human health. However, the cumulative acids got washed off the following rain, when that happened that acidic rainwater goes through the ground, gets a chance to harm plants and wildlife, including insects and fish. The deposited acidity to the ground through dry deposition, mainly depend on rainfall quantity that specific area received [21].

2.4.2 The Rise of Water Level
Egypt's Carbon emission rate makes it easily affected by climatic changes. Moreover, its densely-populated Nile delta is at high risk of raising the sea

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level. The studies of vulnerability estimation by the sector of priority are done as a part of the national developments action plan. The study results have indicated that the coastal zones, agriculture, fisheries and aquaculture, water resources, settlements and human habitat, and human health are most susceptible in order of severity and certainty of results [22]. While other studies suggested that during the growth of global temperatures, this will create growth in Nile River evaporation causing inclination of water supply and eventually water shortage, that will grow downpour in the Ethiopian highlands (as a result of Egypt upstream) leading to increasing runoff in the Nile River flows downstream in Egypt.

2.5 Streets and CO_2 Emissions

In previous years, governments had less attention on the reduction of CO_2 Emissions which could be achieved by reducing traffic congestion in the Egyptian streets. Previous studies proved that when the congestion increases, the CO_2 Emissions automatically increases [3]. That is the reason why, some guidelines are rules should be set and followed in order to reduce any amount of congestions. However, the challenge is in how big the Emission reduction could be 33 when we reduce the congestions? Different factors exist; which includes the behaviour of individual in driving, type of roads and vehicles and the condition of traffic; whether good or bad [22]. The average emissions produced of different types of vehicles in (Lit/Km). The results showed that cars produce around 0.24 KG of CO_2 Emissions, a bus produce around 0.60 kg of CO_2 Emissions and a motorcycle produce around 0.10 kg of CO_2 Emissions in 1 km. However, some vehicles could differ depending on its weight, power and other factors [3] & [9].

3 Carbon Emission Statistical Equation

To calculate the carbon emissions in roads and streets, heavy and expensive equipment's are required and it is only used in existing sites. In this section the research will present a new model for measuring CO_2 emission as result of electricity consumption and vehicles motion in highway roads that has length L Kilometers (km).

This model can also estimate the average of CO_2 emission produced from a designed and under construction highway roads by considering two main variables, these variables are the average traffic density and the amount of electricity consumed in the highway roads.

According to previous studies and to the literature presented in this research, the main factors affecting the percentage of carbon emission in roads is the number and type of vehicles passing through the roads and the electricity consumed to electrify the road. According to the studies, these two factors (electricity consumption and traffic flow) affecting the percentage of carbon emission directly and indirectly. Directly, the type and number of vehicles passing through the road affecting the percentage of CO_2 while electricity affect the atmospheric emission through burning fuel to generate electricity and this action may not take place around the road.

The highway roads carbon emissions are produced from the electricity consumed to power the roads and from the type and fuel used during vehicles motion. Therefore, CO_2 model is divided into two parts; the first is calculating the carbon emissions produced from electricity consumption and the second part is calculating the carbon emissions produced from vehicles motion. In order to calculate the carbon emissions using this model, a site survey need to be done first to identify the following data; electricity consumption features, traffic density and types of vehicles.

3.1 CO_2 Emissions from Electricity Consumptions

On both sides of highway roads, there are some features that consume electricity such as lighting features, traffic controlling devices, electronic signs and monitoring cameras. Each of which consumes electricity energy E kilowatt-hours (kWh). The energy E in (kWh) per day is equal to the power P in watts (W) times' number of usage hours per day t divided by 1000 watts per kilowatt as shown in equation (3.1).

$$E(kWh=day) = P(W) \times t(h/day)/1000(W/kW). \quad (3.1)$$

Table [1] and figure 1, represents the average grams of CO_2 emitted to produce one kWh of electricity and heat using various energy sources as shown in table 1, the data varies depending on the performance of power plants.

Table 1. CO_2 emitted against various energy sources [20]

Fi	Fuel	CO_2 g/kWh
i=1	Other bituminous coal	840
i=2	Sub bituminous coal	930
i=3	Lignite brown coal	950
i=4	Patent fuel	860
i=5	Natural gas	380

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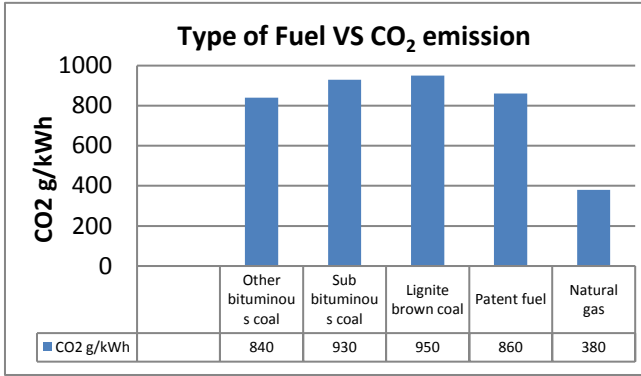Mahmoud M. M. Mansour,
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Fig.1. Amount of CO_2 produced from different type of fuel [21]

Then for any fuel source $F_i, i = 1,2,\ldots,5$, the CO_2 emission (CE) as result of usage electricity consuming features such as lighting features, traffic controlling devices, electronic signs and monitoring cameras in highway of length L is shown in equation (3.2).

$$CE_e(A,E,F_i) = AEF_i \qquad (3.2)$$

3.2 CO_2 Emissions from Vehicles Motion

In this model, two types of vehicles are considered. The first type of vehicles moved by gasoline and is divided into g1, g2, …, gn according to the type of vehicle such as Honda, Ford, etc. Each one of these types has fuel consumption rate rg1, rg2, …., rgn, (mile per gallon). The second type of vehicles moved by diesel and is also divided into d1, d2, …., dm according to the type of vehicle, each one of these types has fuel consumption rate rd1, rd2, …., rdm, (mile per gallon). Then the CO_2 emission as a result of the motion of two types of vehicles (operating by gasoline (g) and diesel (d)) in highway of length L is given as shown in equation (3.3).

$$CE_{vm}(g,d) = L(\sum\nolimits_{j=1}^{n} [No.\ of\ (g_j)] \times C(r_{gj}) + \sum\nolimits_{j=1}^{m} [No.\ of\ (d_j)] \times C(r_{dj})). \qquad (3.3)$$

Where $C(r_{gj})$ represent the grams of CO_2 per km as a result of fuel consumption rate rg1(mile per gallon) and $C(r_{dj})$ represent the grams of CO_2 per km as a result of fuel consumption rate rdj (mile per gallon). From Equations (3.2) and (3.3), the CO_2 emission (in gram) as a result of electricity consumption and vehicles motion through highway has length L is shown in equation (3.4).

$$CE = CE_e(A,E,F_i) + CE_{vm}(g,d)$$
$$= AEF_i + L (\sum\nolimits_{j=1}^{n} [No.\ of\ (g_j)] \times C(r_{gj}) + [No.\ of\ (d_j)] \times C(r_{dj})), i = 1, 2,\ldots,5. \qquad (3.4)$$

The two terms $C(r_{gj})$ and $C(r_{dj})$ can be computed using the following source [3], after

knowing rgj and rdj, respectively. The values of rgj and rdj can be found in [4].

3.3 Example (Simulated Data)

Data in this example is collected across four stages as following in Tables 2,3,4 and 5, through highway has length L = 10km: On other hand the number of light poels A = 4000; each of which has power P = 500W and the number of usage hours per day is t = 12h: If the energy source is Natural gas, then F5 = 380g/kWh emitted carbon. Using Equation (3.2) and (3.3), then.

Table 2. CO_2 emission from 12 am. to 6 am. based on vehicles:

Gasoline		Diesel	
g1 (BMW)	No. of (g1) = 7	d1 (Chevrolet)	No. of (d1) = 30
g2 (Fiat)	No. of (g2) = 12	d2 (Mazda)	No. of (d2) = 50
g3 (Ford)	No. of (g3) = 4	d3 (Honda)	No. of (d3) = 44
g4 (Honda)	No. of (g4) = 32	d4 (Volvo)	No. of (d4) = 12
g5 (Jeep)	No. of (g5) = 16	d5 (Kia)	No. of (d5) = 16
g6 (Volvo)	No. of (g6) = 10		

Using Equation (3.3): $CE_{vm}(g,d)$ = ……..g emitted carbon.

Table 3. CO_2 emission from 6 am. to 12 pm. Based on vehicles:

Gasoline		Diesel	
g1 (Mitsubishi)	No. of (g1) = 27	d1 (Chevrolet)	No. of (d1) = 30
g2 (Fiat)	No. of (g2) = 12	d2 (Mazda)	No. of (d2) = 50
g3 (Ford)	No. of (g3) = 24	d3 (Mercedes-Benz)	No. of (d3) = 44
g4 (Honda)	No. of (g4) = 52	d4 (Volvo)	No. of (d4) = 12
g5 (Jeep)	No. of (g5) = 36	d5 (Kia1)	No. of (d5) = 43
g6 (Volvo)	No. of (g6) = 20	d6 (Kia2)	No. of (d6) = 50

Using Equation (3.3) $CE_{vm}(g,d)$ = ……..g emitted carbon.

Table 4. CO_2 emission from 12 pm. to 6 pm. Based on vehicles:

Gasoline		Diesel	
g1 (BMW)	No. of (g1) = 7	d1 (Chevrolet)	No. of (d1) = 30
g2 (Fiat)	No. of (g2) = 12	d2 (Tesla)	No. of (d2) = 50
g3 (Nissan)	No. of (g3) = 4	d3 (Honda)	No. of (d3) = 44
g4 (Honda)	No. of (g4) = 32	d4 (Volvo)	No. of (d4) = 12
g5 (Jeep)	No. of (g5) = 16	d5 (Kia)	No. of (d5) = 43
g6 (Volvo)	No. of (g6) = 10		

Using Equation (3.3) $CE_{vm}(g,d)$ = ……..g emitted carbon.

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Table 5. CO_2 emission from 6 pm. to 12 am. Based on vehicles:

Gasoline		Diesel	
g_1 (BMW)	No. of (g_1) = 17	d_1 (Chevrolet)	No. of (d_1) = 40
g_2 (Fiat)	No. of (g_2) = 22	d_2 (Mazda)	No. of (d_2) = 60
g_3 (Mazda)	No. of (g_3) = 14	d_3 (Toyota)	No. of (d_3) = 10
g_4 (Honda)	No. of (g_4) = 52	d_4 (Volvo)	No. of (d_4) = 12
g_5 (Mercedes-Benz)	No. of (g_5) = 36	d_5 (Kia1)	No. of (d_5) = 13
g_6 (Volvo)	No. of (g_6) = 20	d_6 (Kia2)	No. of (d_6) = 50
		d_7 (Honda)	No. of (d_7) = 25

Using Equation (3.4) CE_{vm} (g,d) = …….g emitted carbon. Using Equation (3.5) the CO_2 emission (in gram) as a result of electricity consumption and vehicles motion through highway has length L = 10km is……..g carbon on a random day.

$$CE_e \ (A, E, F_5) = 4000 \ x \ (500 \ x \ 12/24 \ x \ 1000) \ x \ 380 = 38 \ x \ 10^{10} \ g \ emitted \ carbon. \quad\quad (3.5)$$

4 Experimental Method

In order to validate the statistical equation, the project team purchased CO_2 measuring device to measure the amount of CO_2 in high traffic density road in Cairo, Egypt and to compare the device reading with the data produced from the statistical equation.

4.1 Study Area

The study area of this research is Shuhada Road. This road used to be called Mubarak road which was named attributed to President Mubarak, the name of the road has been change to Shuhada Road after the Egyptian revolution in June 2013 which means Martyrs. Shuhada Road located in El-Sherouk city, Cairo-Egypt. Shuhada Road has been chosen to be the study area of this research due to the availability of data and because it is a crowded road that links Ismalia-Cairo desert road with Sues-Cairo desert road,

Shuhada Road is considered the main road in El-Sherouk city, knowing that El-Sherouk city is one of the most crowded new suburbs in Cairo, it includes many public facilities, the most important facilities in this suburb is the two private high educational facilities which are "the British university in Egypt (BUE)" and "El-Sherouk Academy" and both of them are located on Shuhada Road as shown in figure 2.

Fig.2: The location of Shuhada Road [16].

4.2 Components of Shuhada Road

Shuhada Road is a main two directional road; as shown in figure 3. Each direction has four lanes with a total width of 10m. There is a pedestrian sidewalk on the right side of each direction with a total 1 meter width and 20 cm height. Moreover, there is a landscape strips that cuts the street into two directions with 1m width and 20cm height as shown in figure 3.

Fig.3: A section View for Shuhada Road [19]

Lighting units exist on the both sides with 35 meters between each lighting unit. The total number of lighting units is 456 units in each direction. Trees and shrubs exist in the street Landscape strips.

4.3 Equipment

The Activity of vehicle will be measured by electrochemical sensor for CO measurement and a shock-resistant infrared CO_2 sensor. The instrument used (testo 315-3) is equipped to resist external influences by its robust design and the optionally available TopSafe, device is shown in figure 4.

Fig.4. Testo 315-3

During the measurement, optical and audible signals shows immediately whether the variably adjustable limit values have been exceeded.

4.4 Field Measurements

The case study focused on one direction only. Two types of field measurements took place in this

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research, the first field measurement was targeting the number of vetches crossing Shuhada road as a data input for the statistical equation. Four monuments were collected from Shuhada road; each measurement presents the number of cars, motorcycle, big vehicles such as (bus and tracks) as shown in Table 6. While the second field measurement were made by the research team and it measures the amount of CO_2 in Shuhada road using Testo 315-3 measuring instrument as shown in Table 6.

Table 6. CO_2 emitted against various energy sources.

Duration	Vehicle type	Number of Vehicle	CO_2 Readings from Testo 315-3 measuring instrument
2:50–2:55 pm	Car	251	406-415 ppm
	Motorcycle	3	
	Truck	10	
	Bus	2	
	Microbus	2	
2:55–3:00 pm	Car	153	419 ppm
	Motorcycle	3	
	Truck	8	
	Bus	13	
	Microbus	8	
3:00-3:05 pm	Car	177	396 ppm
	Motorcycle	2	
	Truck	3	
	Bus	5	
	Microbus	3	
3:05-3:10 pm	Car	184	433 ppm
	Motorcycle	4	
	Truck	12	
	Bus	2	
	Microbus	8	

4.5 Calculating CO_2 in Shuhada Road Using Statistical Equation

In order to calculate the amount of CO_2 emissions in Shuhada roads, input data should be added to the equation to help the equation in calculating the CO_2 emissions. The data inputs are the different types of vehicles operating by gasoline or diesel, and the number of verticals passing through the road in 30 minutes. While the data outputs are the amounts of carbon emissions through four different periods of time on a certain day. The presented statistical equation is based on the multivariate linear regression method, the multivariate linear regression method is one of the statistical methods used for curve fitting and recently is considered as one of the Machine Learning methods.

An algorithm is implemented by Mathematica 12.1 software depending on the concept of the multivariate linear regression method to estimate the

magnitude of the carbon emissions. The expected results are going to be compared by the experimental results.

The following notations are used in the proposed algorithm:

L = 0.015; (* L in meters represents the range of the used instrument for measuring the amount of CO_2 (ppm)*) m = 4; (* No.of times for conducting the experiment *) Y = {410.5, 419, 396, 433}; (*real values registered by the instrument at four different periods of time.

5 Results and Discussion

According to the presented study, the presented statistical equation will help in estimate the amount of carbon produced in specific road.

This research conducted a comparative analysis to validate the presented statistical equation and to measure its efficiency and percentage of error.

As shown in Table 7, the results of CO_2 readings from Testo 315-3 measuring instrument compared to results from Statistical equation. As stated before the equation data input depended on field survey, were the researchers counted the number and types of vehicles passed through the road in specific date and time. However, the differences between both results are expected human errors, as shown in the following Table 7.

Table 7. Comparison between of CO_2 statistic equation and the reading of measuring device

Duration	Vehicle type	Number of Vehicle	CO_2 Readings from measuring device	Statistical equation results
2:50–2:55 pm	Car	251	406-415 ppm	415.583 ppm
	Motorcycle	3		
	Truck	10		
	Bus	2		
	Microbus	2		
2:55–3:00 pm	Car	153	419 ppm	436.776 ppm
	Motorcycle	3		
	Truck	8		
	Bus	13		
	Microbus	8		
3:00-3:05 pm	Car	177	396 ppm	313.828 ppm
	Motorcycle	2		
	Truck	3		
	Bus	5		
	Microbus	3		
3:05-3:10 pm	Car	184	433 ppm	487.065 ppm
	Motorcycle	4		
	Truck	12		
	Bus	2		
	Microbus	8		

As shown in table 7, the percentage of error has minimum of 2.3% and maximum error of 12.75% as comparing the results of CO_2 readings from Testo 315-3 measuring instrument and results from Statistical equation.

According to similar research's using similar variables (vehicles types and electricity consumption) to calculate the CO_2 emissions using statistical equations, the percentage of errors reach 20% [6]. Moreover pervious research indicates that the green space along the high traffic roads had affected positively the CO_2 absorption. Increasing the greenery around the high traffic density roads can mitigate the direct CO_2 emissions produced by the urban transportation [25] and [3].

6 Conclusion

In conclusion vehicles have huge effects on the amount of emissions produced in Egyptian roads. The proposed equation will help urban planners and designers to estimate the amount of CO_2 produced from roads during the design process in which it will help in designing better roads and decrease the traffic congestions. Traffic congestion causes the driver to start-stop the vehicle which causes the vehicle to produce more CO_2 Emissions than smoother driving.

The amount of CO_2 emissions produced from passenger vehicles, play a predominant role in the CO_2 emissions of urban on-road transportation, and more traffic CO_2 emissions are derived from the private transportation than those of the public transportation in urban roads.

Well-designed streets and maintain the street quality, decrease the traffic congestions which will lead to decrease the emissions emitted in the air from traffic congestion that reflects on human health through polluting the environment and causing sever health effects.

Acknowledgements

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Dr. Rania Rushdy Moussa, has implemented the empirical Study.
Dr. Mahmoud Mansour has created the equation and the statistical analysis
Eng. Naglaa has collected data and organized the manuscript.

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