Annual emissions of greenhouse gases of motor vehicles in the Academic Unit Valle de las Palmas UABC

Emisión anual de gases de efecto invernadero de vehículos motorizados en la Unidad Académica Valle de las Palmas UABC

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Abstract

The purpose of this research is to carry out a quantify motor vehicles that enter the Valle de las Palmas Academic Unit (UA) of the Autonomous University of Baja California, calculate the GHG Levels based on CO2 emissions and evaluate the environmental impact generated by transportation according to indicators of the Transportation category of the UI GreenMetrics 2023 Guide. A manual counting method is used to know the number and type of vehicles that travel to the UA and with based on these results, determine the emissions of GHG as well as the environmental impact generated by motor vehicles that travel to the UA. Its conclude that the type of motor vehicles that travel to the UA us heterogeneous, consisting of private cars, urban transport, and motorcycles and these generate 1884 metric tons of CO2 per year, so with these data there is a baseline of environmental impact generated by transport that travels to the UA, existing areas of opportunity for improvement for the benefit of air quality and the health of the university community.

GHG emissions, quantify motor vehicles, Higher Education

8 Introduction

The gauging is an essential tool for the study and analysis of the vehicular flow on a given road or highway to calculate the amount of CO_2 emitted in a Higher Education Institution (HEI). In a world in constant movement, vehicular traffic traveling to a HEI is a factor that directly affects the quality of life of students, faculty and administrative staff, as well as the air quality at the site. Motorized vehicles can generate a negative impact by using fossil fuels, effects such as air pollution (Mannering & Washburn, 2020) by emitting Greenhouse Gases (GHG) (Nava Carrasco, 2023) and negatively affect human health. In this context, some authors point out that transportation is the main cause of pollution in urban areas (Rehimi, Landolsi, & Kalboussi, 2017), in Europe, for example, it accounts for 71% of CO_2 emissions (Yongseng Qian, Xuting Wei, & Li, 2023), and for Mexico it contributes 40% (Hancevic, Núñez, & Rosellón, 2023). The collection of accurate and reliable data on vehicular traffic commuting to an HEI is essential for the quantification and implementation of GHG generation reduction policies related to motor vehicle emissions, as well as the optimization of HEI community travel times and alternatives in urban or shared means of transportation.

To estimate GHG pollution, it is necessary to know the vehicular traffic at peak hours and throughout the day by means of vehicle gauging to determine their quantity, composition and emission levels (Rehimi, Landolsi, & Kalboussi, 2017) of vehicles circulating on a road in a certain period of time, which allows obtaining relevant information on the volume of CO_2 emissions in the atmosphere. The application of vehicle gauging techniques can be carried out in various ways, including direct observation, the installation of electronic devices, the use of video surveillance systems and the analysis of GPS navigation data. Each of these techniques has advantages and limitations in terms of accuracy, cost and ease of implementation (Kineo Ingeniería del Tráfico, S. L., 2023).

The objective of this research work is to perform a gauging of motorized vehicles (urban transport, private vehicles, motorcycles) entering the Academic Unit (UA) of Valle de las Palmas of the Autonomous University of Baja California (UABC) and given that this traffic obeys the supply and demand of transport, perform measurements at peak hours at a certain time of day in the month of September 2022 and March 2023. With this experimental data and according to the UI GreenMetrics 2023 guide, calculate the GHG levels based on CO_2 emissions and compliance with the indicators that correspond to the Transportation category according to UI GreenMetrics 2023 (UI GreenMetric Secretariat, 2023) in order to have a baseline of the environmental impact generated by the transportation that travels to the UA.

8.1 Theoretical framework

Motorized traffic flow is the movement or circulation of motorized vehicles such as cars, buses, motorcycles, or cargo trucks that circulate on a roadway and the knowledge about the quantity and behavior of this traffic flow or vehicular gauging (Secretaría de Comunicaciones y Transporte, 2016) in a certain period of time. There are several methodologies to carry out a vehicle gauging and its selection will depend on the purpose of the study (Monetti, Contreras, & Sevillano, 2018) among which we can mention manual and automatic methods (Secretaría de Comunicaciones y Transporte, 2016):

Manual method: on-site gauging. corresponds to vehicle counting where the data collector is located at an intersection and through previously prepared logs observes and records the vehicle count (Monetti, Contreras, & Sevillano, 2018).

Automatic method: this is performed with automatic equipment designed to continuously record vehicular traffic through sensors or detectors. These devices can transmit data in real time and counting is performed through inductive loop detectors, sensors (magnetic, microwave radar, passive infrared, laser radar, ultrasonic) and video detection (Secretaría de Comunicaciones y Transporte, 2016).

Likewise, it is important to know what are the emissions generated by motor vehicles, Shiva, et al (Shiva Nagendra, Jaikumar, & Sivanandan, 2017) refer that the key pollutants from vehicle exhaust are nitrogen oxides (NOx), carbon monoxide (MO), hydrocarbons (HC), particulate matter (PM) and carbon dioxide (CO_2). The latter is generated by the combustion of fossil fuels such as gasoline and diesel and in 2021 the transportation sector contributed 29% of GHG emissions in the United States (Environmental Protection Agency, 2023).

On the other hand, research on environmental impact generated by transportation in the context of HEIs refers mainly to the implementation of strategies to reduce the generation of GHG emissions. According to the sustainability report of San Diego State University, policies are implemented such as reducing the percentage of employees and students who travel in single occupancy vehicles, as well as by the year 2025 the purchases of university vehicles should represent at least 50% (San Diego State University, 2021). Another example, is San Jose Sate University, where their goal is to promote the use of bicycles, urban transportation and carpooling with a 2018 impact on GHG reduction of 28, 000 Tons (San Jose Sate University, 2020).

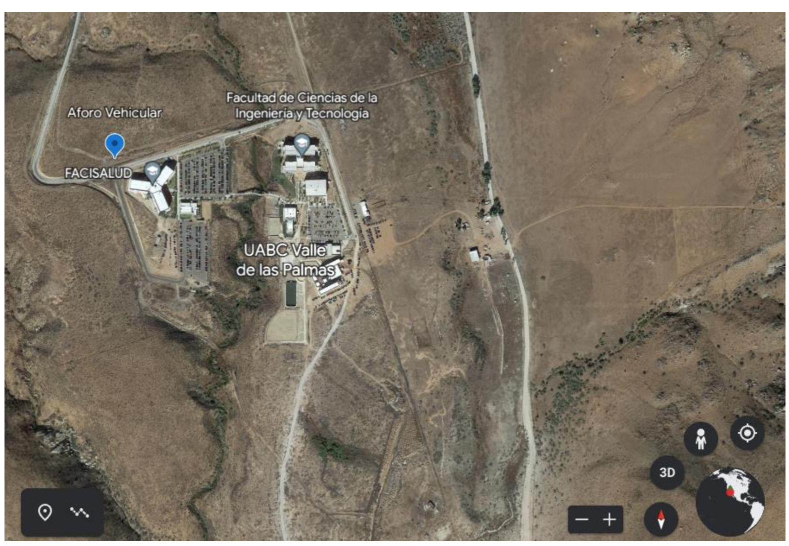
The lack of knowledge of the amount of GHG emitted in the IES, may create some uncertainty for not knowing the environmental impact that this has towards people and the natural environment, this due to the daily displacement of the university community to this area. This research is based on the results of an in situ vehicular gauging and based on the results, calculate the GHG emissions.

8.2 Methodology

8.2.1 Study area

The study site is the UA Valle de las Palmas of the UABC, located in the city of Tijuana, Baja California at the geographical coordinates 32°43'502" and 116°67'506" in an area of 50 hectares (Figure 8.1). This is an applied, descriptive and documentary research presented in three stages: vehicular gauging, GHG emissions calculation and evaluation of the environmental impact generated by transportation in the UA.

Figure 8.1 Study site: Valle de las Palmas UA



Source: (Google Earth, 2022)

8.2.2 Vehicle gauging

In order to know the number and type of motorized vehicles entering the UA, two vehicle counts are performed according to the manual method (Monetti, Contreras, & Sevillano, 2018): In September 2022, a pilot vehicle count was conducted in the UA and at peak hours, to anticipate the challenges that could be encountered when executing the definitive gauging and thus adhere to the UI GreenMetrics Guideline 2022 (UI GreenMetric Secretariat, 2022). Again in March 2023, on-site vehicle gauging is performed at the UA, where the motor vehicle count is observed and recorded in a logbook during peak hours. See annex BITACORA.

8.2.3 Calculation of GHG emissions

To calculate the GHG emissions generated by motor vehicles, the Carbon Footprint emission factor (Carbon Footprint Ltd, 2023) is used as a basis and in accordance with the UI GreenMetric Guideline 2023 (UI GreenMetric Secretariat, 2023), considering the number of vehicles entering the AU and also the distance in kilometers that a vehicle travels within the AU and considering the days worked per year in the AU to obtain the annual emissions in metric tons and generated by transportation.

8.2.4 Environmental impact generated by transportation in the AU

To evaluate the environmental impact of the AU and in accordance with the UI GreenMetric Guideline (UI GreenMetric Secretariat, 2023) in the transportation category, a self-assessment is made to the AU considering the following indicators:

- Number of vehicles used and managed.
- Number of vehicles entering daily.
- Number of motorcycles entering daily.
- Ratio of total motorized vehicles divided by the total population.
- Shuttle service within the UA.
- Number of shuttles operated by the UA.
- Average number of passengers per shuttle.
- Total trips by internal transportation services.
- Zero Emission Motor Vehicle (ZEV) Policy.
- Average daily number of ZEV motorized vehicles.
- The ratio of ZEV zero emission motorized vehicles divided by the total population of the UA.
- Total parking area (m^2).
- Ratio of parking area to total area.
- Transportation program to design or limit parking area over the past three years.
- Number of transportation initiatives to reduce motor vehicle ingress.
- Policy to reduce motor vehicle travel.
- Policies for pedestrian walkways.
- Daily motor vehicle travel distance within the UA.

8.3 Results

8.3.1 Vehicle capacity. September 2022

Tables 8.1, 8.2 and 8.3 show the results of the count in the month of September conducted between 8:00 and 9:00 a.m., which show that motor vehicles entering the UA are mainly private vehicles (PV), followed by urban transport vehicles (UTV) sedan type (ST) and in smaller quantities urban buses (UB), minivans with a capacity of 17 passengers (P) and motorcycles (M).

Table 8.1 Vehicle capacity on September 19

Time	PV	AU	UTV	MV	M
8:00	155	1	4	-	-
8:15	137	-	5	-	-
8:30	130		2	1	3
8:45	54	1	3	-	-
9:00	65	-	-	-	2
Total	**541**	**2**	**14**	**1**	**5**

Table 8.2 Vehicle capacity on September 21

Time	PV	AU	UTV	MV	M
8:00	125	2	5	1	3
8:15	165	-	3	-	-
8:30	123	-	1	-	5
8:45	96	1	2	-	-
9:00	47	-	-	-	3
Total	**556**	**3**	**11**	**1**	**11**

Table 8.3 Vehicle capacity on September 23

Time	PV	AU	UTV	MV	M
8:00	110	1	6	1	2
8:15	95	-	3	-	3
8:30	59	-	1	-	1
8:45	32	1	2	-	-
9:00	27	-	-	-	1
Total	**323**	**1**	**12**	**1**	**7**

In the gauging carried out in September 2022, it is observed that the motorized vehicle fleet entering the UA is heterogeneous, composed mainly of private vehicles (Table 8.4).

Table 8.4 Total motorized vehicles

PV	AU	UTV	MV	M
1,420	6	37	3	23

Vehicle capacity. March 2022

Tables 8.5, 8.6 and 8.7 show the results of the count in the month of March, carried out between 8:00 and 9:00 a.m., which show that the motorized vehicles entering the AU are mainly PV, followed by UTV and, to a lesser extent, AU and M.

Table 8.5 Vehicle capacity on March 13

Time	PV	AU	UTV	MV	M
8:00	100	5	2	8	1
8:15	120	-	2	3	-
8:30	128	-	5	-	-
8:45	40	1	6	-	-
9:00	37	1	4	-	-
Total	**425**	**7**	**19**	**11**	**1**

Table 8.6 Vehicle capacity on March 15

Time	PV	AU	UTV	MV	M
8:00	211	3	4	2	3
8:15	135	-	6	-	1
8:30	115	-	2	2	-
8:45	40	1	4	-	-
9:00	37	1	-	-	-
Total	**425**	**5**	**16**	**4**	**4**

Table 8.7 Vehicle capacity on March 17

Time	PV	AU	UTV	MV	M
8:00	159	1	6	-	-
8:15	133	-	7	-	1
8:30	159	-	2	2	-
8:45	64	1	3	-	-
9:00	32	-	-	-	-
Total	**547**	**2**	**18**	**2**	**1**

In the gauging carried out in March 2023, it was observed that the motorized vehicle fleet entering the UA is heterogeneous, composed mainly of private vehicles (Table 8.8).

Table 8.8 Total motorized vehicles

PV	AU	UTV	MV	M
1,597	14	53	17	6

In Table 8.9, a comparison is made of the gauging carried out and as can be seen, the vehicle fleet is heterogeneous, increasing in 2023 for all vehicles, except for motorcycles.

Table 8.9 Comparison of vehicle capacity between 2022 and 2023

Year	PV	AU	UTV	MV	M
2022	1,420	6	37	3	23
2023	1,567	14	53	17	3

8.3.2 Calculation of GHG emissions

To calculate the GHG emissions generated by motor vehicles, the emission factor of the Carbon Footprint (Carbon Footprint Ltd, 2023) is used as a basis and in accordance with the UI GreenMetric Guideline 2023 (UI GreenMetric Secretariat, 2023), obtaining the following results:

a) Transport emissions per year:

Description:

According to the 2023 school term of UABC there are 205 working days in the year.

0.01 is the coefficient to calculate the metric tons generated by vehicular transportation per km (UI GreenMetric Secretariat, 2023).

$$= \left(\frac{(No.transport\ entry)(Round\ the\ day)(Distance)(Days\ of\ work)}{100}\right)(0.01) \qquad (1)$$

Equation (1)

Result:

$$= \left(\frac{(84)(8)(2.9481\ km)(205)}{100}\right)(0.01)$$

$= 40.6130\ metric\ tons$

b) Automobile emissions per year:

Description:

205 are the working days in the year. 0.02 is the coefficient to calculate metric tons of automobiles per km (UI GreenMetric Secretariat, 2023).

$$= \left(\frac{(No.of\ cars\ entering)(2)(Distance)(Days\ of\ work)}{100}\right)(0.02) \tag{2}$$

Equation (2)

Result:

$$= \left(\frac{(1567)(2)(2.9481\ km)(205)}{100}\right)(0.02)$$

$= 378.8221\ metric\ tons$

c) Emissions generated by motorcycles per year:

Description:

205 are the working days in the year.

0.01 is the coefficient to calculate the metric tons of motorcycles per km (UI GreenMetric Secretariat, 2023).

$$\left(\frac{(No.of\ motorcycles\ entering)(2)(Distance)(Days\ of\ work)}{100}\right)(0.01) \tag{3}$$

Equation (3)

Result:

$$\left(\frac{(6)(2)(2.9481)(205)}{100}\right)(0.01)$$

$= 0.7252\ metric\ tons$

d) Annual emissions generated by transportation in metric tons:

Formula:

$$Electricity\ use\ per\ year\ +\ transportation\ +\ automobiles\ +\ motorcycles$$

Result:

$= 1495.0871 + 13.776 + 378.8221 + 0.7252$

$= 1888.4104\ metric\ tons\ per\ year$

8.3.3 Environmental impact generated by transportation in the AU.

The environmental impact of the AU was evaluated according to the criteria and indicators of the UI GreenMetric Guideline (UI GreenMetric Secretariat, 2023) in the transportation category, obtaining the results shown in Table 8.10.

Table 8.10 Results obtained from the self-assessment in the transportation category

	Criteria and indicators for the transportation category	Results
5.1.	Number of motor vehicles managed	There is only a record of three vehicles used by the Institution for students' field practices.
5.2.	Number of motorized vehicles managed daily	Through the data recorded during the vehicle registration, we obtained an average of 522 motorized vehicles per day.
5.3.	Number of motorcycles entering the UA daily	On average, at least one motorcycle enters each day.
5.4.	The ratio of total motorized vehicles divided by the total population in the UA.	The ratio corresponds to the sum of the 3 previous points divided by the population of the UA in general, which is about 5947, obtaining as a result 0.0884, and corresponds to Level 4.
5.5	Shuttle service within the AU	Not applicable
5.6.	Number of shuttles operated at your university	Not applicable
5.7.	Average ridership of each shuttle	Not applicable Not applicable
5.8.	Total trips per shuttle service each day	Not applicable Not applicable
5.9.	Zero Emission Vehicle (ZEV) Policy	In this weighting the University is in Level 1, which means that it does not have zero-emission vehicles available. To date, there is no record of a policy that promotes the use of zero-emission vehicles.
5.10	Average number of ZEV vehicles per day	There is a record of two ZEVs for private use.
5.11.	The ratio of ZEV zero-emission motor vehicles divided by the total population of the UA.	The AU has a record of only two ZEV vehicles, which divided by the general population of 5947, gives us a result of 0.0003, placing us in Level 1 in the GreenMetrics 2023 weighting table, corresponding to the section.
5.12.	Total parking area (m2)	It has a surface area of 32,702m2 (Google Earth, 2022).
5.13.	Ratio of parking area to total area of the AU	The total parking area is 32,702m2 between the total area of the AU is 60,471m2 multiplied by 100%, giving us a total of 54.07%.
5.14.	Transportation program designed to limit or decrease parking area on campus, during the last 3 years.	No records are available
5.15.	Number of transportation initiatives to reduce motorized vehicles.	There is no official initiative at the UA; however, unofficial carpooling is present, but the scale is unknown.
5.16.	Policies for pedestrian walkways	The UA has pedestrian paths, designed for the safety and comfort of pedestrians.
5.17.	Approximate daily travel distance of a motorized vehicle (in Kilometers)	Within the AU, a motor vehicle travels approximately 2.5 km from the entrance to the farthest parking lot.

Source of reference: (UI GreenMetric Secretariat, 2023)

8.4 Acknowledgements

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8.5 Conclusion

Through the vehicular gauging carried out we can observe the changes occurred in relation to the composition of the transportation in which the university community travels to the UA, composed mainly of private vehicles and urban bus, in lesser quantity the use of motorcycles. Also, in the 2023 gauging, an increase in the vehicle fleet accessing the UA was observed. Therefore, an opportunity for improvement will be to offer urban transportation alternatives that reduce travel time and vehicle use per occupant.

GHG emissions due to the displacement of motorized vehicles that travel to the UA is 1884 metric tons per year, which are the baseline to offer the university community alternatives in the use of transportation that contribute to the reduction of GHG emissions.

Based on the self-assessment in the transportation category, there are opportunities in terms of urban transportation, the implementation of policies that raise awareness of the use of zero-emission vehicles, as well as incentives for the use of carpooling and thus reduce the area allocated for parking.

This study aims to be a reference and generate knowledge from which measures can be proposed to reduce exposure to polluting gases and avoid health risks to the university community, as well as the development of mitigation strategies and mitigation of GHG emissions emitted into the atmosphere.

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