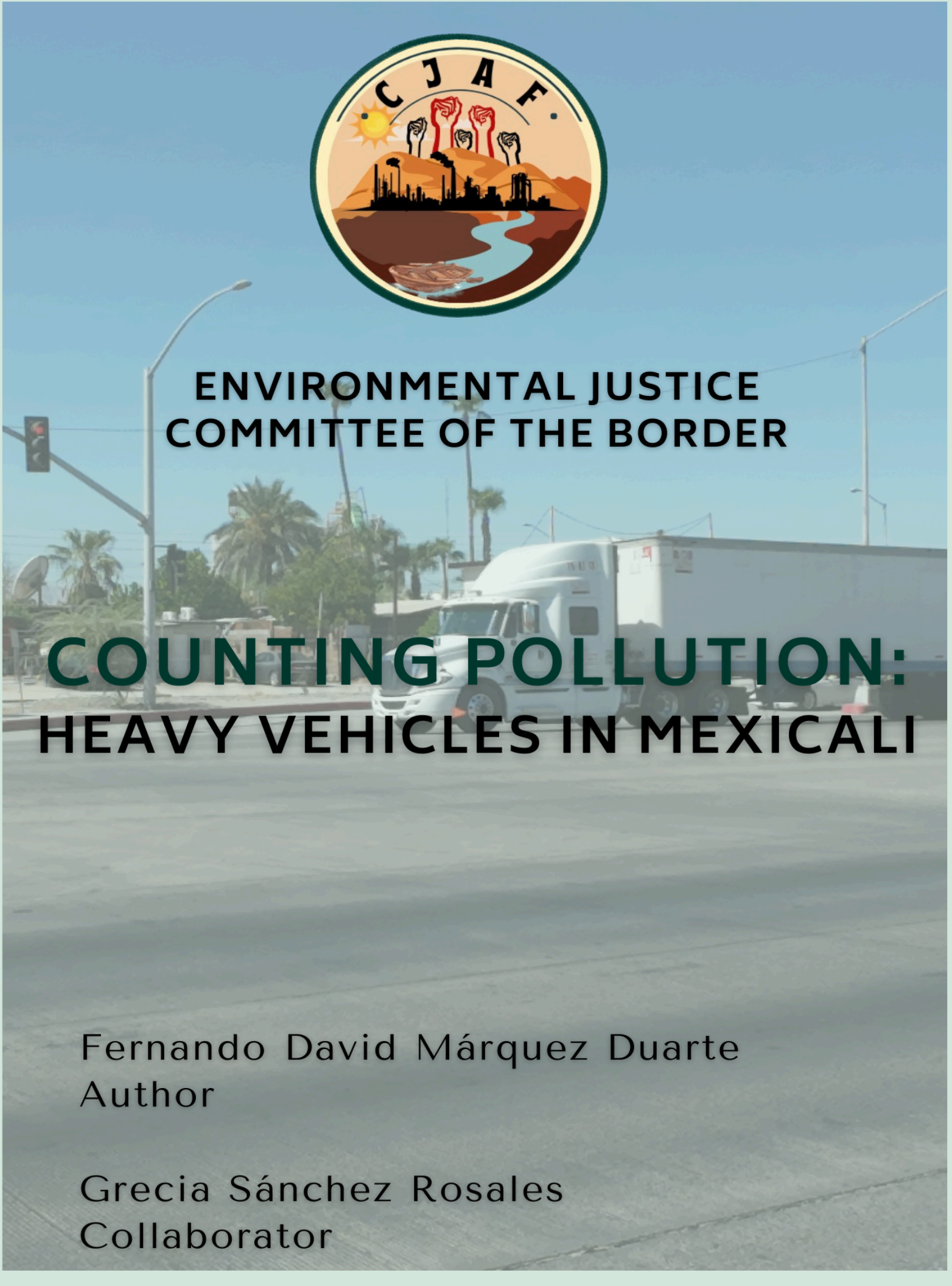


ENVIRONMENTAL JUSTICE
COMMITTEE OF THE BORDER

COUNTING POLLUTION:
HEAVY VEHICLES IN MEXICALI

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Heavy vehicles in Mexicali

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INTRODUCTION

The Environmental Justice Committee of the Border (CJAF) is a community group fighting for environmental justice in the border region: Mexicali, Baja California, Mexico, and Imperial County, California, USA. We are a group composed entirely of volunteers. We currently have 37 members.

We fight for healthier, fairer, and more equitable communities, with a focus on environmental justice in the region. We focus on air quality,as well as inwater quality and scarcity.

For the Committee, environmental justice (EJ) is a constant struggle. EJ means having the right to live in a healthy environment, to breathe clean air, and to have clean and sufficient water. Fighting pollution is fighting for environmental justice. It is based on the principle that all people, regardless of race, social class, where they live, their religion, or any other factor, must be protected from environmental pollution and its negative effects on health, quality of life, and life itself.

As part of the fight for environmental justice, we decided to conduct a truck count study at the Committee, due to the serious air pollution situation in the Mexicali and Imperial region. This study counted heavy vehicle traffic at four key points with significant traffic concentration in the city of Mexicali.

For context, Mexicali is the capital of the state of Baja California, in the far northwest of Mexico. According to CEMDI, the current population of the municipality of Mexicali is estimated at 1,100,000 inhabitants.[1]Mexicali is an industrial city due to its economic focus, particularly its maquiladora industry, with a large number of manufacturing plants for export. Mexicali shares a border to the north with Imperial County, California.

Due to the number of maquiladora plants in Mexicali, there is significant heavy vehicle traffic, primarily freight trucks. Furthermore, due to the climateextremeIn addition to the city's high temperatures (reaching over 50 degrees Celsius, or over 120 degrees Fahrenheit in the summer) and insufficient public transportation, the number of vehicles is also generally high. In this context, one of the main sources of air pollution in Mexicali is vehicle emissions, especially from heavy vehicles. According to Climate Trace, from 2023 to 2025, vehicles were the leading source of CO2 equivalent emissions in Mexicali, accounting for 28% of the city's emissions. Vehicles were even more the leading single source of CO2 emissions, representing over 32%. During this period, 1.6 million tons of CO2 were emitted annually. In Imperial County, over the same period, 43-44% of CO2 emissions were caused by vehicles. This represents approximately 1.2 million tons emitted each year.[2].

The pollution caused by CO2 and other polluting particles emitted by vehicles has serious consequences for the health of the community's residents, which will be analyzed in the following pages. In addition, these polluting emissions also damage the ozone layer, increasing global warming and climate change, thus creating

[1] CEMDI, “Indicadores de Baja California.”
[2] Climate Trace, "Emissions Summary.”

a vicious cycle of extreme heat, which leads to more people using cars, further increasing emissions that exacerbate the extreme heat.

The ultimate goal of this report is to present the study's findings so that affected communities can understand what is happening—as well as the seriousness of the problem—and become aware of the need to fight for environmental justice. Likewise, this report is generating local data to support advocacy efforts and propose legislative and legal changes to protect our communities from environmental injustice and racism, and to ensure we are never again treated as sacrifice zones, especially regarding the regulation of polluting emissions from heavy vehicles. Reducing these emissions is both viable and possible; zero-emission fuel technologies exist, such as electric vehicles, which do not release any pollutants into the air.

It is important to note that for us, the only current technology we consider zero-emission (ZE) for vehicles is electric, meaning battery-electric trucks. We do not consider other "alternative" fuels, such as natural gas, ammonia, hydrogen, and others, to be zero-emission because their generation process releases a significant amount of polluting emissions into the air and has extremely negative impacts on the water, soil, and air of the communities where their plants are located and the fuels are transported.[3].

[3] Márquez Duarte,*Driving the Just Transition: Perspectives by Truck Drivers and Community Members on the Trucking Just Transition*.

ACKNOWLEDGMENTS

This report is the result of nearly a year's work by members of The Environmental Justice Committee of the Border (CJAF) . Special thanks to *Clean Mobility Collective*(CMC), for its invaluable support in carrying out the project, as part of the*Fellowship* by Ms. Grecia Sánchez Rosales, co-founder of the Committee and co-coordinator of Research, who is *Fellow* of CMC.

A special thanks to everyone who participated in the counts, starting with the coordinators of the four locations: Grecia Sánchez Rosales, Lorenia Gutiérrez Moreto Cruz, Ezequiel Duarte Hernández, Valeria Ramos Sánchez, and myself, Fernando Márquez Duarte, who are co-founders of the Committee. Thanks also to the members who participated in any of the counting sessions: Dr. Edna, Dr. Angélica, Dr. Socorro, Raúl, Melissa, Shania, Mario, Osiel, Nur, Jasiel, Adel, Julio, Eder, and everyone else who joined in.

Special thanks are also due to Dr. Astrid Calderas for her feedback and data for this report, to Mr. Alejandro Castillo for his recommendations, to Mr. Jasiel Zamora for his support with geographic information systems, and finally, to all of you who are reading this report. We hope this report motivates you to fight for environmental justice in your community and to believe that cleaner air and a better quality of life are possible if we unite and fight for our rights, our community, and our environment.

CONCEPTUAL/THEORETICAL FRAMEWORK

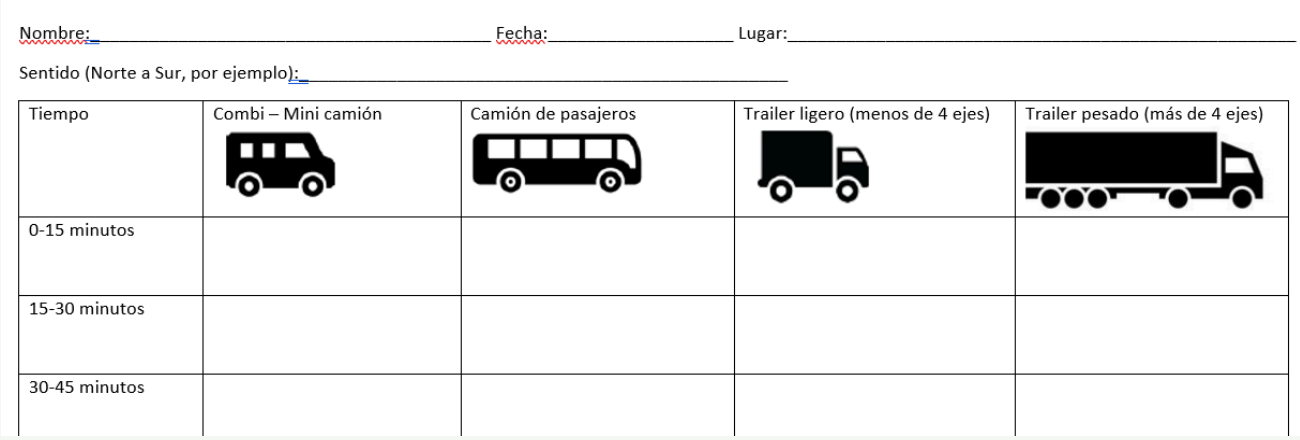
- **Air Quality Index (AQI):** A universal indicator created by the Environmental Protection Agency (EPA) to report on air quality and its potential health risks using a numerical scale that is easy for the public to interpret.[4].
- **Fine particulate matter (PM2.5 and PM10):** A mixture of solid particles and liquid droplets found in the air. PM2.5 and PM10 particles can only be detected with an electron microscope; these are inhalable and, as their name indicates, can be 10 micrometers or smaller in diameter and 2.5 micrometers or smaller in diameter.younger [5].
- **CO2:** Carbon dioxide (CO2) is one of the main greenhouse gases present in the air naturally as part of the carbon cycle and mostly as a result of anthropogenic activities [6]
- **NO2:** Nitrogen dioxide is a highly reactive gas that is present in the air from the combustion of fuels.[7].
- **NOX:** Nitrogen monoxide gas is the sum total of gases formed by the combination of nitrogen and oxygen during combustion at high temperatures and pressures. Both NOx and NO2 have effects on human health and the environment.[7]
- **Diesel combustion process (Black carbon):** It is a type of soot, ultrafine carbon dust (nanometric size) that is formed by the incomplete combustion of fuel due to a lack of sufficient oxygen[8].
- **Thermal inversion:** A meteorological feature in which air temperature increases with altitude instead of decreasing, reversing the usual behavior of the atmosphere. This creates a layer of warm air above a denser, cooler layer of air trapped at the surface, blocking vertical air circulation and acting as a "lid" that prevents the dispersion of pollutants.[9].
- **Shared Atmospheric Basin:** Continuous geographical area delimited by topographic, meteorological and population settlement characteristics that share the same air mass (emissions, concentrations and reactions of polluting gases and particles)[10].

[4] *AirNow, "AQI (Air Quality Index) Basics," U.S. Environmental Protection Agency*
[5] *U.S. Environmental Protection Agency, "Particulate Matter (PM) Basic"*
[6] *Agencia de Protección Ambiental de los Estados Unidos, "Emisiones de dióxido de carbono"*
[7] *Environmental Protection Agency, "Basic Information about NO2"*
[8] *Takamura, "Chemistry, Electrochemistry, and Electrochemical Applications | Carbon"*
[9] *Pérez "El origen de la inversión térmica y su relación con la contaminación del aire"*
[10] *Secretaría de Medio Ambiente y Recursos Naturales, "Cuencas atmosféricas que integran la Megalópolis"*

METHODOLOGY

This report presents the main results of the truck count study in Mexicali. Fieldwork for the study began in late January and concluded in the first week of March 2026. The work consisted of counting heavy vehicles at four strategic, high-traffic locations in the city of Mexicali. Four counting sessions were conducted at each of the four locations. Each counting session lasted two hours, and one count was performed per week.

To conduct the heavy vehicle count, an exploratory investigation was carried out, examining truck counts previously conducted in different countries. This was done to determine what types of heavy vehicles were counted and for what purpose, taking into account the context of each region where studies had been conducted to identify vehicle types that exist and/or are common but not in Mexicali. As a result of this phase of the study, a format was created for this study, which includes four types of heavy vehicles: vans/mini-trucks, passenger trucks, light and heavy trucks.



Nombre:_____ Fecha:_____ Lugar:_____

Sentido (Norte a Sur, por ejemplo):_____

Tiempo	Combi – Mini camión	Camión de pasajeros	Trailer ligero (menos de 4 ejes)	Trailer pesado (más de 4 ejes)
0-15 minutos				
15-30 minutos				
30-45 minutos				

Figure 1. Image of the truck counting format. Source: Author's own work.

For the study, we decided to include these four vehicle categories, as they are all considered heavy vehicles. We chose only these categories to simplify the counting process while still capturing a relevant variety of vehicles for emissions estimation. To differentiate between the "light trucks" and "heavy trucks" categories, we specified the axle configuration for each. Each axle has one tire on each side, so a vehicle with three tires on each side was counted as a light truck, while a vehicle with five tires on each side was counted as a heavy truck. The form includes an illustration showing what the vehicle in each category might look like.

Likewise, the person filling out the form had to include their name, the date of the count, the location (counting station), and the direction of the roadway where they were counting. Each count involved at least two people to ensure a more accurate count of all vehicles passing in all

directions. In some counts, one person counted North-South and another East-West, if there were only two people present. In other counts with more people, one person counted North-South, another South-North, another East-West, and another West-East, for example.

Each counting station had a coordinator. This person had a mobile air pollution monitor, which measured the following data during the counting sessions: PM 2.5 and PM10, Air Quality Index (AQI), as well as temperature and humidity. The coordinator was also responsible for bringing the forms, chairs and tables, high-visibility vests (like those worn by construction workers), water, and snack bars (or other refreshments) to each counting session for the volunteers who participated.

To allow sufficient space for completing the tally sheet and to avoid mental fatigue during the count, the vehicles were counted in 15-minute intervals, as shown in the image of the form. Count marks were grouped in sets of five. At the end of the count, each participant handed their completed form to the coordinator, who then tallied the marks and recorded the total numerically, adding up the counts for each column.

Each coordinator uploaded photos or scans of the completed forms from each count to a shared project folder, from where the data was transferred to a shared spreadsheet. Additionally, each coordinator transferred the data from their air particle monitor to a shared folder for analysis.

Finally, to ensure data comparability and avoid counting bias, the counting sessions at each location were held on different days and times. Specifically, at one location, the counting session took place on a Monday from 4 to 6 p.m one week, and on a Friday from 12 to 2 p.m another week. This eliminated time-related bias. In other words, methodological strategies were implemented to guarantee the accuracy of the collected data. This allowed us to average the data and obtain valid information with minimal bias.

CONSEQUENCES OF POLLUTION IN THE REGION

Most vehicle emissions are caused by medium and heavy-duty vehicles (MHDVs). Mexico lacks a robust inventory of pollutant emissions by type and source; however, data from the United States are relevant to this study, as the region is a border area.

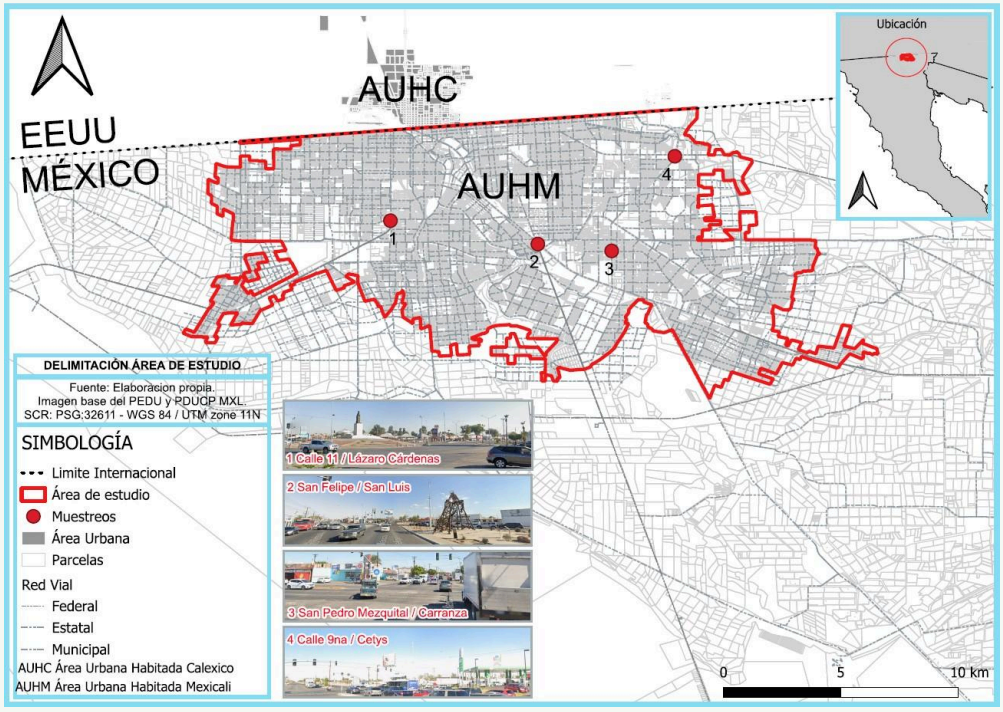
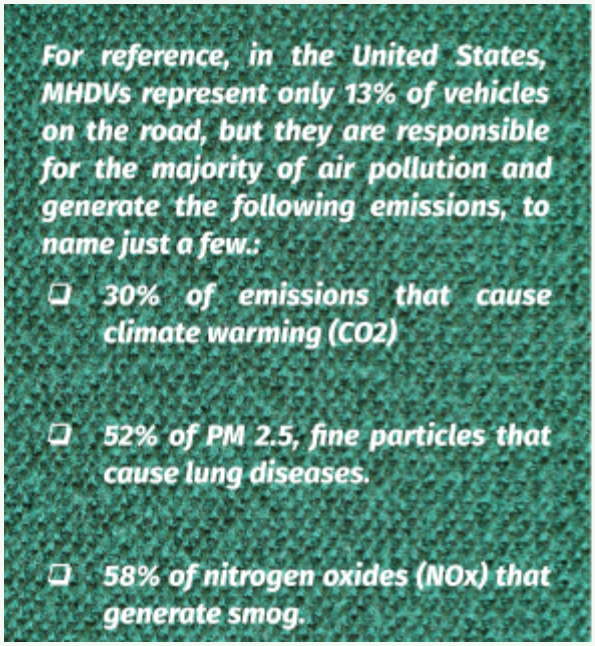


Figure 2. Map of Mexicali with the 4 counting points marked. Source: Author's own work.



The impact of emissions from heavy-duty fossil fuel vehicles primarily affects residents near roads with high traffic concentration, loading centers, ports, rail terminals, and warehouses, disproportionately impacting marginalized racialized communities.[11].

For example, pFor the state of California, although only 12% of all medium and heavy-duty trucks (MHDVs) are Class 7 or Class 8 tractor-trailer trucks, these heavy-duty trucks alone are responsible for generating 35% of the state's total nitrogen oxide (NOx) emissions and more than 70% of vehicle NOx emissions.[12].

As mentioned earlier, heavy vehicles release different polluting emissions into the air that have serious negative impacts on health, such as NOx, NO2, PM10 and PM2.5:

- **Nitrogen oxides (NOx)** can irritate the eyes, nose, throat, and lungs, potentially causing coughing, shortness of breath, fatigue, and nausea. It is estimated that 4,401 tons of NOx are produced annually.
- **Nitrogen dioxide ($NO_2)_2$)** can cause asthma, COPD, loss of consciousness, cardiovascular disease, and even death. Prolonged exposure can lead to infertility.
- **Particles of 10 micrometers or less (PM10)** are inhalable through the lungs and can cause cardiovascular effects such as cardiac arrhythmias and heart attacks, and respiratory effects such as asthma attacks and bronchitis.
- **PM (particulate matter) of 2.5 micrometers or less** are associated with premature mortality, increased patients with heart or lung conditions, acute and chronic bronchitis, asthma attacks, urgent medical care, respiratory symptoms, and restricted activities for those affected. They are also associated with heart disease, stroke, influenza, and pneumonia. Researchers also found a similar association between exposure to PM pollution and an increased risk of death from lung cancer in nonsmokers.[13].

Vehicle emissions are a major cause of overall air pollution, which not only has harmful consequences for the health and quality of life of communities where these pollution sources are located, but also damages the ozone layer and contributes to global warming and climate change. Traffic-related pollution continues to rise,

[11] Torres et al.,*Warehouses, Pollution, and Social Disparities: An Analytical View of the Logistics Industry's Impacts on Environmental Justice Communities across Southern California*.
[12] SB-372 Medium- and Heavy-Duty Fleet Purchasing Assistance Program: Zero-Emission Vehicles.

[13] American Lung Association, State of the Air 2024.

especially due to the expansion of the industrial and logistics complex, land-use policies, and zoning that prioritize logistics infrastructure over community health and well-being, disproportionately impacting marginalized communities. In Mexicali, the concentration of industrial parks, and therefore heavy truck traffic, is in the eastern and southeastern parts of the city. It is no coincidence that most of the neighborhoods and housing developments in this area are low-income families and marginalized communities.

On the other hand, a 2024 NASA study shows that areas near warehouses (and in the case of Mexicali, maquiladoras) experience, on average, a 20% increase in NO_2 levels. It is also important to consider that in low-income and people of color communities in the United States, and in low-income communities in Mexicali, the health impacts of pollution are compounded by other factors such as poverty, inadequate access to healthcare, and other social stressors, exacerbating health effects and mortality rates.[14].

In Mexicali, there are high levels of illnesses that are increased and aggravated by air pollution.

A 2022 study on rhinitis prevalence in 18 cities across 9 countries found that Mexicali experienced the greatest increase in childhood rhinitis prevalence over a 10-year period, even surpassing cities with severe air pollution such as New Delhi, India, and Mexico City.

[15]Another study published in 2021, comparing 27 cities in different countries, shows that Mexicali is the city where the prevalence of asthma in children and adolescents (up to 14 years old) increased the most between 2003 and 2018, surpassing highly polluted cities such as Latakia (in Syria), Taipei (in Taiwan), or Mexico City.[16]Likewise, at the state level in Baja California, lung cancer has ranked 2nd and 3rd among the cancers that cause the most deaths, as well as among the most common cancers in the state in recent years.[17].

Furthermore, neither Mexicali nor Baja California has enough functional monitoring stations to obtain accurate and up-to-date data on air pollution levels for the entire city of Mexicali, or for all cities in the state. There are only seven monitoring stations in the entire state, and only three of them are operational in Mexicali. These stations only measure PM2.5 and

[14] American Lung Association, *Nitrogen Dioxide and Community Health*.

[15] Strachan et al., "Worldwide Time Trends in Prevalence of Symptoms of Rhinoconjunctivitis in Children."
[16] Asher et al., "Worldwide Trends in the Burden of Asthma Symptoms in School-Aged Children."
[17] Baylon, "Mata cáncer de pulmón a 222 en un año."

PM10.[18]This lack of air quality monitoring is compounded by the lack of interest and ignorance of the Baja California government's environmental secretariat, which has repeatedly made unfounded statements generating misinformation about the sources of air pollution. They have declared that the sources of pollution in Mexicali are natural and therefore nothing can be done about it, and that the pollution is not so serious.[19].

The health consequences of pollution unfortunately mostly affect communities in countries of the Global South.

According to a study published in 2022, pollution causes 9 million deaths globally, with 90% occurring in countries of the Global South or developing countries.

[20]This is not a coincidence and is a result of injustice and environmental racism, where marginalized communities in the Global South are deliberately used as sacrifice zones for profit by projects and companies.

Likewise, it is important to point out that Mexicali's transformation into an industrial zone of export-oriented assembly plants is not accidental. It is a process deliberately fostered in the city to facilitate the capitalist logistics complex in the Mexico-United States border region. As a border city with California, a land transit point between Baja California and the rest of the country, and close to the ports of Los Angeles and Ensenada, and possessing an existing rail network, Mexicali was given this "industrial vocation," beginning in the 1980s. Added to this is its proximity to the Inland Empire region of Southern California, through which most of the products and goods transported in the United States pass, and where the highest concentration of warehouses, freight terminals, and freight traffic is found.[21]A large number of these trucks cross into Mexico through Mexicali, carrying products and parts to and from the maquiladora plants in Mexicali.

Following this logic, both the municipal government of Mexicali and the state government of Baja California have encouraged the attraction of more and more transnational maquiladora plants, offering tax breaks and water fee waivers, among other incentives. Likewise, both the municipal and state governments have ignored the pollution caused by these industries, citing the jobs they generate and the “economic benefits” they bring to the region. However, the majority of the jobs created by this industry are for workers without higher education or specialized training. According to data from INEGI (National Institute of Statistics and Geography), more than 80% of the jobs in the export-oriented manufacturing sector (maquiladoras) are held by blue-collar workers.[22]These jobs are poorly paid and there are constant cutbacks, resulting in the dismissal of thousands of employees and creating high job turnover.

[18] Villa, “Mexicali, ciudad contaminada los 12 meses del año.”
[19] Martínez, “La movilidad, principal causa de la contaminación al aire”; RadarBC, “Justifica secretaria de Medio Ambiente mala calidad del aire en Mexicali.”
[20] Fuller et al., “Pollution and Health.”

[21] Márquez Duarte,*Driving the Just Transition: Perspectives by Truck Drivers and Community Members on the Trucking Just Transition*.
[22] INEGI, “Ocupación.”

These plants are highly polluting, not only because of the emissions they release as static sources, i.e., the emissions from the maquiladora plant, but also because they are indirect sources of air emissions, due to the number of cargo vehicles that enter and leave these facilities, a situation similar to the Inland Empire warehouses.

[23]Neither at the state nor municipal level is there regulation of indirect sources, so heavy vehicles can pollute with total impunity and without consequences, affecting the health and lives of communities in both Mexicali and Imperial.

[23] Márquez Duarte,*Driving the Just Transition: Perspectives by Truck Drivers and Community Members on the Trucking Just Transition*.

RELATIONSHIP BETWEEN POLLUTION AND HEALTH INDICATORS AND SOCIAL INDICATORS

Although the count study was conducted in Mexicali, it is relevant to briefly show the context of Imperial County, since a large number of the cargo vehicles that travel through Mexicali cross the border into the United States through Imperial. To illustrate the context of Imperial, there is a tool in the state of California called CalEnviro Screen, launched by CARB (California Air Resources Board), which is the state government agency.

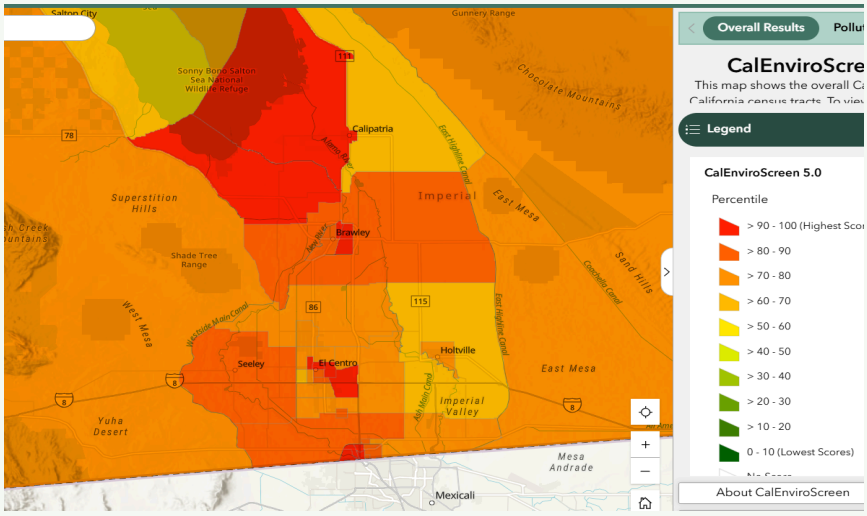


Figure 3: Map of cumulative environmental impacts in Imperial County. Source: Author's own work using Cal Enviro Screen 5.

California that addresses air pollution. The new version of this tool was released in mid-2026, so for this section we used version 5.0 of Cal Enviro Screen.[24]This diagnostic tool helps to identify communities with a disproportionate burden from multiple sources of pollution and with population characteristics that make them more sensitive to the effects of pollution.

This first map from CalEnviro Screen shows all the accumulated environmental impacts. The redder the color, the more environmental impacts the area has, and the greener it is, the fewer environmental impacts it has. As you can see, the area of Calexico where the Mexicali border crossings are located (both the downtown and east crossings) shows a high accumulation of environmental impacts, between 80 and 90%, as does the area of El Centro where Interstate 8 and Highway

[24] CARB, "CalEnviroScreen 5.0."

111 intersect, as well as Brawley and the entire southern part of the Salton Sea.

This means that these areas suffer more from the consequences of various types of accumulated pollution. This visually illustrates environmental injustice and racism. Although we don't have this mapping for Mexicali, the fact that the Calexico area with the border crossings has a high accumulation of environmental impacts indicates that Mexicali does as well, because air, water, and soil pollution knows no borders; it doesn't need a visa or passport to cross the border, but rather spreads freely. Furthermore, it is through these areas that heavy vehicles, and that is where the impacts generated by them are shown.

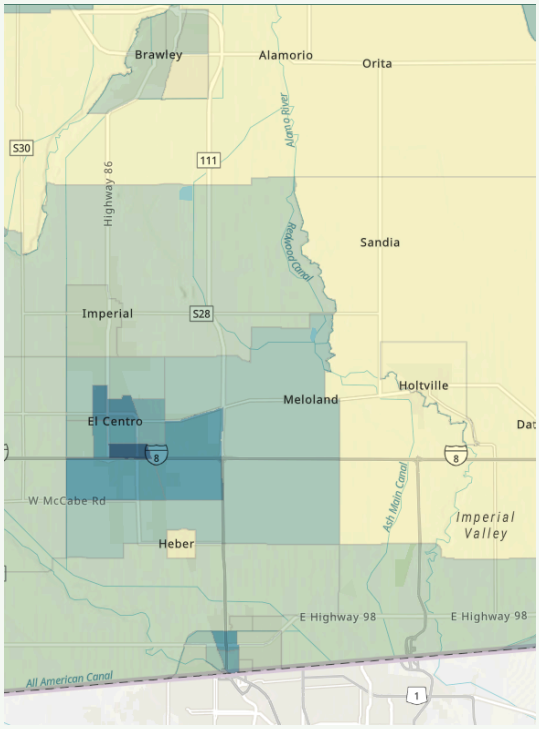


Figure 4: Traffic density map of Imperial County. Source: Created by the author using Cal Enviro Screen 5.0

This map shows traffic density in Imperial. The darker the shade of blue, the higher the traffic density in the area. As you can see, traffic is concentrated at the Calexico border crossings and at the intersection of Interstate 8 and Highway 111, which is the route taken by a large number of freight trucks crossing the border.

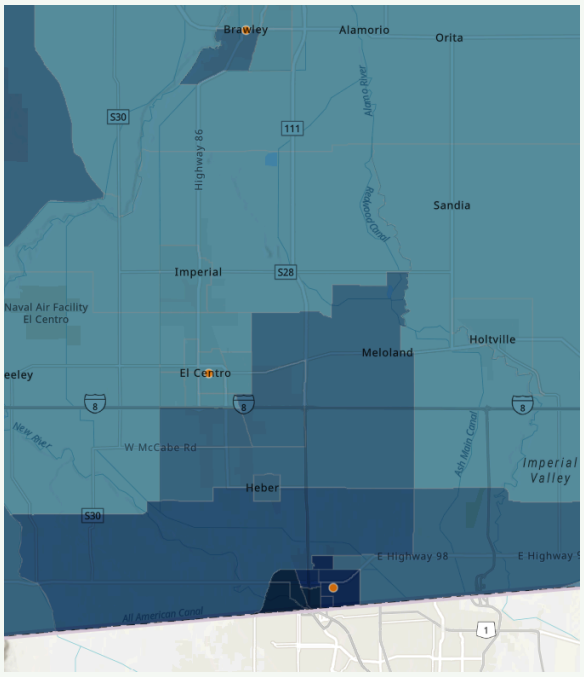


Figure 5: PM 2.5 concentration map for Imperial County. Source: Created by the author using Cal Enviro Screen 5.0

This map shows the concentration of PM2.5 in the area. The darker the shade of blue, the higher the PM2.5 concentration. The darkest area on the map is the international border crossing in Calexico, significantly higher than other areas in the county. The PM2.5 monitoring stations are

shown as orange dots: one in Calexico, one in El Centro, and one in Brawley. Comparing this map with the previous one, it's clear that the border crossing, with its high traffic density, also shows a high concentration of PM2.5. To better illustrate the causal relationship between vehicle traffic and PM2.5 emissions, see the following map:

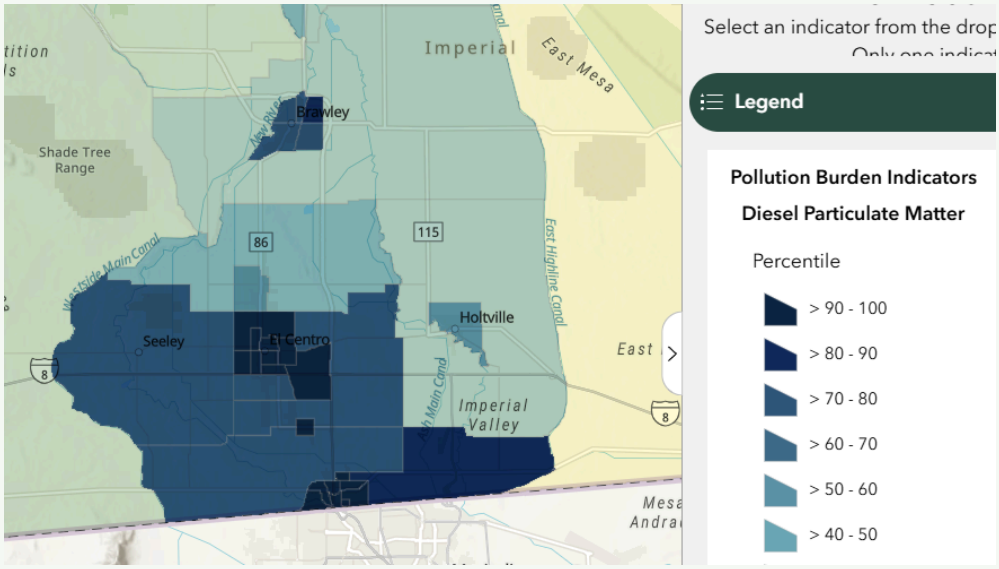


Figure 6:PM concentration map by diesel in Imperial County. Source: Author's own work using Cal Enviro Screen 5.0

This map directly shows the concentration of particulate matter (PM) caused by the use ofdieselAlthough this map shares general similarities with PM 2.5, it shows not only the border crossing area with its extremely high concentration of PM, but also the El Centro area near Interstate 8, as well as a small portion of Brawley. These areas experience heavy vehicle traffic, including a significant amount of heavy truck traffic. The three points represent the three main freight truck routes, as trucks enter through the border crossing and then head either to San Diego via Interstate 8 or north to the Inland Empire via Interstate 111 and subsequently Interstate 86.

These four maps highlight two highly relevant aspects for this study: firstly, they provide context for air pollution in the binational area of Mexicali-Imperial. As previously discussed, this area suffers from a high concentration of air pollutants. Secondly, they demonstrate the clear relationship between heavy vehicle traffic and air pollution in the binational region.

TRUCK COUNT ANALYSIS

The main objective of this study has been to record the number of heavy vehicles (trucks) at four points in the city of Mexicali, as well as to measure pollutant emissions at those same points in order to influence public policy on air pollutant emissions regulations.

This study is the first of its kind in Mexicali, as it counted four different types of heavy vehicles, as specified in the methodology section. The total number of vehicles counted by vehicle type and location is shown in the following table:

Table 1

Total count by vehicle type and by counting position

Counting point	Type of heavy vehicle				
	Combi-mini truck	Passenger truck	Light trailer (4 axles or less)	Heavy trailer (5 axles or more)	
Carranza x SP Mezquital	241	139	457	596	
Carr SF x Carr SL	573	302	722	436	
11th Street x Lazarus	563	482	683	502	
9th x Cetys	201	60	375	1953	
Total	1578	983	2237	3487	8285

Source: Own elaboration

There are several points to analyze regarding this table. The first point is that this number of vehicles was recorded in only 8 hours (4 sessions of 2 hours each).

In 8 hours, a total of 8,285 heavy vehicles were recorded at the four counting points. Of these, the most frequently recorded type of heavy vehicle was the heavy truck, that is, trucks with 5 or more wheel axles

These figures are extremely alarming because the impacts on health and road conditions are quite serious. As explained in previous sections of this report, heavy vehicles generate the most air pollution, cause the most damage to roads, and produce the most noise pollution. The heavier a vehicle is, the more negative impacts it generates, so the fact that the majority of the vehicles counted were the heaviest type of semi-trailer truck is even more concerning.

Another key finding from the counts is that passenger buses were the least frequently counted type of heavy vehicle. This illustrates the reality in the city: public

transportation is scarce and insufficient. This is especially concerning in a city with very high levels of air pollution, as the lack of adequate public transportation leaves people with no alternative but to use private vehicles. Another factor regarding public transportation observed during the counts, particularly along Avenida Carranza and Carretera San Luis, is that a large proportion of the passenger buses counted were not public transportation but rather company vehicles used by employees of specific maquiladoras (assembly plants). In other words, if 200 passenger buses were counted, it's possible that around half were company vehicles, not public transportation.

Additionally, during the counts, emissions generated by heavy vehicles produced a very unpleasant odor, and by the end of the two-hour counting sessions, it became almost unbearable. Several people who participated in the counts reported headaches, nasal irritation, burning eyes, and coughing during the sessions. On the other hand, as heavy trucks passed, the heavy vehicles shook the ground with a sensation similar to a perceptible earthquake, and the detachment of aggregates could be seen, that is, the wear of the pavement by the passage of these vehicles.

Conducting a heavy vehicle count allowed us to calculate averages to estimate how many heavy vehicles pass through these four points in the city at different times. The following table shows the results of these estimates based on the data collected during the counts:

Table 2

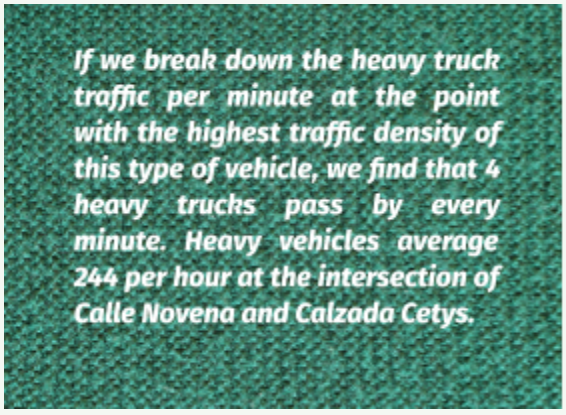
Estimates of heavy vehicles based on data collected in counts by time ranges

Average by time range	Combi	Passengers	Light trailer	Heavy trailer	ADDITION
Average per hour SF	71,625	37,75	90,25	54,5	254,125
Carranza hourly average	30,125	17,375	57,125	74,5	179,125
Average per hour Lazarus	70,375	60,25	85,375	62,75	278,75
Hourly average 9th	25,125	7,5	46,875	244,125	323,625
Average per day SF	1719	906	2166	1308	6099
Average per day Carranza	723	417	1371	1788	4299
Average per day Lazarus	1689	1446	2049	1506	6690
Average per day 9th	603	180	1125	5859	7767
Average per week SF	12033	6342	15162	9156	42693
Average per week	5061	2919	9597	12516	30093

Carranza					
Average per week Lazarus	11823	10122	14343	10542	46830
Average per week 9th	4221	1260	7875	41013	54369
Average per month SF	52360,74	27596,76	65976,36	39841,68	185775,54
Average per month Carranza	22022,58	12701,82	41760,66	54462,48	130947,54
Average per month Lazarus	51446,94	44045,16	62412,54	45872,76	203777,4
Average per month 9th	18367,38	5482,8	34267,5	178465,14	236582,82
Annual SF	628328,88	331161,12	791716,32	478100,16	2229306,48
Annual Carranza	264270,96	152421,84	501127,92	653549,76	1571370,48
Annual Lazarus	617363,28	528541,92	748950,48	550473,12	2445328,8
Annual 9th	220408,56	65793,6	411210	2141581,68	2838993,84

Source: Own elaboration

The table above shows the averages for each of the four counting sites by type of heavy vehicle, as well as the total for all four sites. As can be seen, the heavy trailer is the type of heavy vehicle that travels the most per hour at two of the counting sites, and also the most frequently. The passenger bus travels the least.



At that same intersection, an average of 7.5 passenger buses pass per hour, meaning one bus passes every 9 minutes. Furthermore, it's important to consider that many of these buses are not public transportation, and that more than one bus route passes through that intersection. This means that passengers on the public transportation routes that pass through there have to wait more than half an hour for a bus. This represents a very serious flaw in the city's public transportation system.

Another point that stands out when looking at the table is the amount oftrailersEstimated heavy truck traffic at the intersection of Calle Novena and Calzada Cetys. This location experiences the heaviest traffic of these vehicles, as it is the primary route to the commercial border crossing into the United States. This

crossing is for commercial vehicles only (trucks with cargo).

Based on the average calculated from the traffic counts, it is estimated that more than 2,140,000 heavy trucks of this type cross annually. This situation is extremely alarming due to the impacts of these vehicles, which, as mentioned previously, generate 30% of the emissions that cause global warming (CO2), 52% of PM2.5, and 58% of the nitrogen oxides (NOx) that contribute to smog.

Likewise, the heavier a truck is, the greater the negative impacts it generates, both in terms of emissions and its impact on the streets. More than 2 million trucks that generate these impacts pass through that point in Mexicali each year, and more than 3.8 million across all four counting points combined. This is just a fraction of the number of heavy trucks that travel the streets of Mexicali every year and affect our health.

On the other hand, we must not lose sight of the other three types of heavy vehicles registered. The type of vehicle we call a "light truck," which refers to trucks with four or fewer axles, also contributes to the emissions impacts described in the previous paragraph. The point of highest traffic of these vehicles is the intersection of Carretera San Luis and San Felipe, with an estimated 800,000 crossings of this type of vehicle per year. This is because these two roads are well-known industrial corridors with a high concentration of industrial parks, maquiladoras, and other industries where these vehicles are constantly loading and unloading.trailersIf we add up the annual estimates of this type of vehicle from the four counting points, we have almost 2.5 million crossings per year.

In addition, the following table shows the sum of the averages for all types of heavy vehicles at the four counting points, broken down by time range, from hourly to annually. As can be seen, on average, more than 1,000 heavy vehicles pass through these four counting points in Mexicali. This does not represent the total number of heavy vehicles per hour in Mexicali; it only shows the heavy vehicles passing through the four selected points. Therefore, the actual number is much higher than 1,000 heavy vehicles per hour.

It is estimated that more than 24,000 heavy vehicles pass through these four points daily, more than 170,000 weekly, more than 750,000 monthly, and more than 9 million annually.

These figures show the seriousness of heavy vehicle traffic and its negative impacts on the health of Mexicali residents, especially those who live near one of the counting points.

Table 3

Sum of averages by time ranges of the four counting points

	Hourly average	Average per day	Average per week	Average per month	Average per year
Amount	1035.6	24855	173985	757083.3	9084999.6

Source: Own elaboration

ANALYSIS OF MONITORED POLLUTANT EMISSIONS

During the truck counting sessions, the coordinators at each counting point measured air pollutant emissions of PM2.5, PM10, and AQI (Air Quality Index). It is important to specify that the mobile monitors used only record emissions data every 10 minutes while the monitor is powered on. In other words, the data generated by the monitors does not record the maximum and minimum emissions during the measurement period; it only records the average, minimum, and maximum values recorded exactly every 10 minutes. However, when the monitors registered spikes in AQI or PM, the coordinators documented them by taking photographs during some counting sessions.

Before showing the analysis, it is necessary to show the different categories and ranges of emissions measured by the mobile monitors used in the counts:

Table 4

Categories of different pollutant emissions according to their health risk

Category	Well	Moderate	Dangerous for sensitive groups	Dangerous	Very dangerous	Extremely dangerous
Mexico according to NOM 172 standards for 2026						
ICA	0-50	50-100	100-150	150-200	200-300	300-500
PM 2.5	0-14.9	15-24.9	25-78.9		79-129.9	>130
PM 10	0-44.9	45-49.9	50-131.9		132-212.9	>213
United States according to EPA standards since 2024						
ICA	0-50	50-100	100-150	150-200	200-300	300-500
PM 2.5	0-9	9.1-35.4	35.5-55.4	55.5-125.4	125.5-225.4	>225.5
PM 10	0-54.9	55-154.9	155-254.9	255-354.9	355-424.9	>425
European Union according to EEA standards since 2017						
ICA	There is no unified index; the index for each type of issue is used.					
PM 2.5	0-10.9	11-20.9	21-25.9	26-50.9	51-75.9	>76
PM 10	0-20.9	21-40.9	41-50.9	51-100.9	101-150.9	>150

Source: Prepared by the author using data from the Official Standard of the Federation (NOM) 172 of Mexico, the Environmental Protection Agency (EPA) of the United States, and the European Environment Agency

The table presented contains several points worth analyzing. As can be seen, pollutant emission standards vary from country to country. It is important to clarify that only the pollutant emissions measured by the monitors in this study, and for which established measurement ranges and standards exist, are shown.

1 In Mexico, there are five levels instead of six, because for specific emissions, such as PM 2.5, PM 10, etc., the category of "hazardous for sensitive groups" does not exist. Therefore, the "moderate" category is automatically elevated to "hazardous." This is considered a positive change, as it more clearly informs the public that if any of the air pollutants fall into this third category, it is hazardous, and the community as a whole should take precautions to protect their health, such as avoiding outdoor physical activity, among other measures.

2. The rating scales in Mexico are stricter than in the United States. This is a measure that Mexico strengthened following the reform of NOM 172, as the scores for each rating scale were modified in 2024, and other changes were established.even stricterThe ratings will be updated starting in 2026. For example, the "Moderate" category for PM 2.5 was previously defined as 15 to 35, but this has been changed to a range of 15 to 25. Before this modification to NOM 172, a monitor reading of 30 micrograms of PM 2.5 was considered "moderate," while after the modification, it is considered "hazardous." This measure is positive and significant, as it focuses on public health and reducing pollutant emissions. Knowing the air quality rating not only raises public awareness of health risks but also allows local governments to activate environmental protocols and/or contingencies with stricter measures, as is done in Mexico City. Unfortunately, these types of environmental contingencies are not implemented in Mexicali.

3. The United States has the most lenient and permissive air pollution regulations. This is a result of higher overall pollution levels than in Mexico, as well as prioritizing the business sector and economic measures over public health.

4. Undoubtedly, the strictest ranges are those of the European Union (EU). The EU has decades of ambitious and valuable strategies for reducing polluting emissions, which are reflected in the ranges established by the European Environment Agency in 2017. The EU is the region that has made the most progress in the energy transition to zero-emission technologies.and also featuresStricter environmental regulations exist. However, it cannot be denied that several European companies have polluting plants and projects in countries of the Global South, such as Mexico. It is important that EU member states also enforce environmental standards for their companies in the Global South.

To begin the analysis from the data collectedThrough the mobile air quality monitors used in the counting sessions, we have the highest recorded values in terms ofIndexAir Quality Index (AQI). The maximum score detected was 187, which corresponds to a **dangerous** air quality, according to Mexican standards.



Figure 7.AQI (ICA) photograph of the mobile air quality monitor, taken during the second counting session at the Boulevard Carranza corner of Avenida San Pedro Mezquital. Source: Gutiérrez Moreto Cruz, Lorenia, 2026.

The highest PM 2.5 score recorded was 30.7, also registered at the same counting point (Boulevard Carranza at the corner of Avenida San Pedro Mezquital), as shown in the following graph. According to Mexican standards, this score equates to an air quality rating of [unclear - possibly "unsafe" or "unsafe"].**dangerous**Likewise, it can be seen in the following graph that at two other counting pointsrecorda maximum score of almost 30 (29.6 and 29.9), which also fall within the hazardous air quality range.

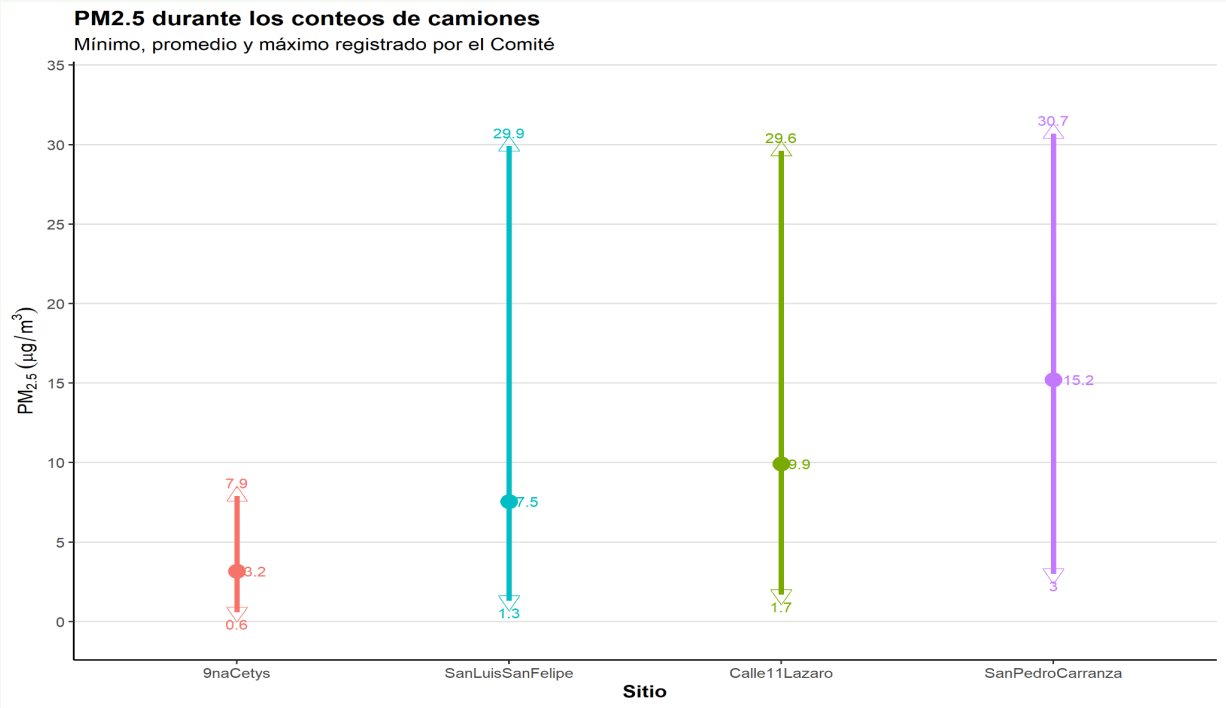


Figure 8. Minimum, maximum, and average PM 2.5 scores recorded during truck counting sessions. Source: Author's own elaboration

Additionally, the highest PM10 score recorded by the monitors was 53.4, at the counting point at the intersection of San Luis and San Felipe highways, during the

first counting session. This score also falls within the air quality category.**dangerous**The highest PM 10 scores from two other counting points were also quite high (50.5 and 51.6, respectively) andalsoThey entered the hazardous air quality category.

Additionally, the following graph showsThey appreciate the maximum, minimum, and average AQI (ICA) scores recorded by the mobile monitors during the truck counting sessions. As mentioned previously, higher maximum scores were recorded during the sessionsthrough photographs of the monitor screen, but they are not recorded in the exported monitor data, because only the data recorded every 10 minutes is saved.

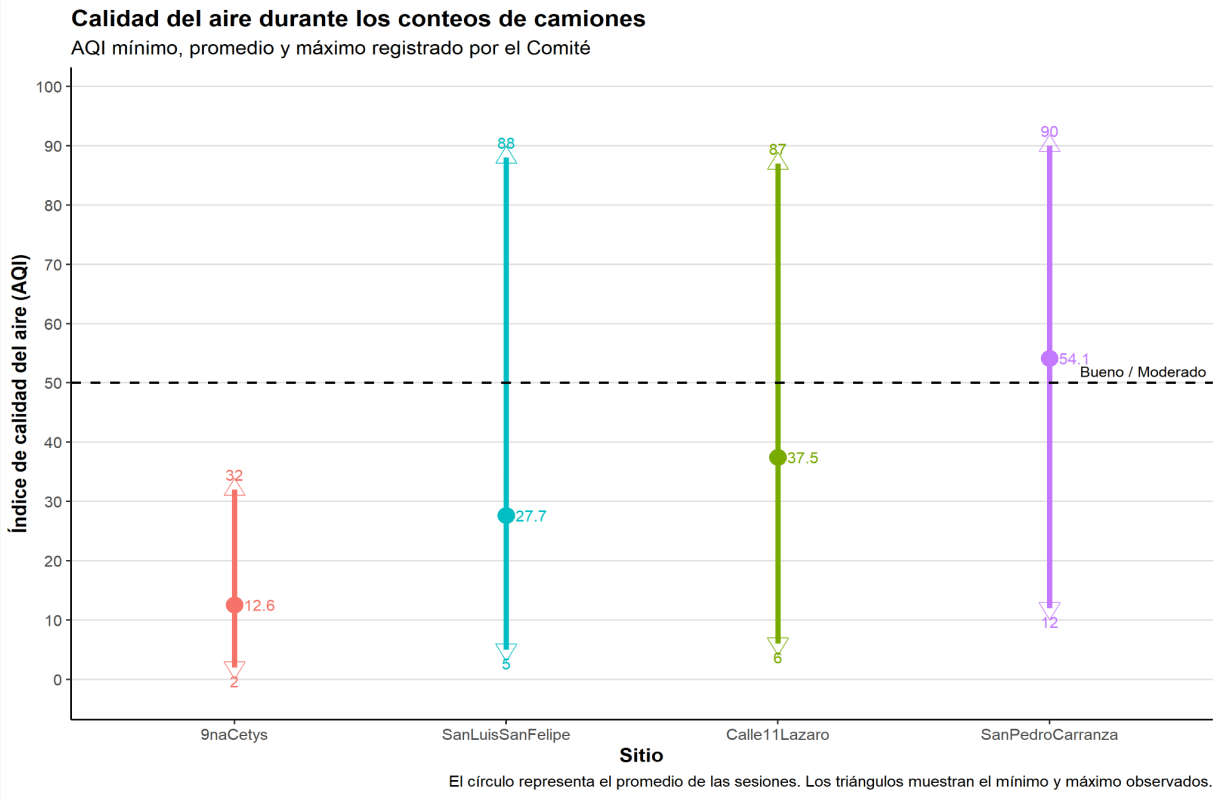


Figure 9. Minimum, maximum, and average AQI (ICA) scores recorded during truck counting sessions. Source: Author's own elaboration

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

This report presents the results of a truck (heavy vehicle) count study conducted at four strategic locations in the city of Mexicali. Through the analysis of data generated during the counting sessions, data on the environmental consequences of heavy vehicles, and the harmful health effects on communities affected by air pollution, the situation in Mexicali due to high heavy vehicle traffic has been highlighted. It is also important to emphasize that this is an exploratory community study with inherent limitations. Specifically, the heavy vehicle traffic estimates are based solely on the days, times, and counting points measured. Furthermore, the emissions measurements are limited by their reliance on portable monitors and short timeframes. Finally, it is important to note that while heavy vehicles are a major contributor to the measured pollutant emissions, they are not the only source. The data and recommendations generated in this report are exploratory, so further research is needed to obtain more robust estimates.

The main conclusions are as follows:

- Heavy vehicle traffic in Mexicali is extremely high. At just the four counting points, it is estimated that more than 1,000 heavy vehicles pass through each hour (the sum of the estimates for all four types of heavy vehicles counted), and an estimated 9 million per year. This is equivalent to almost nine times the current population of Mexicali.
- The heaviest semi-trailer (with five or more axles) is the most common heavy vehicle at the four counting points. Based on collected data, it is estimated that over 2 million trucks pass through one of the counting points each year, and over 3.8 million across all four points combined. This represents only a fraction of the number of these heavy trucks that travel the streets of Mexicali annually and negatively impact our health.
- Heavy vehicles have extremely harmful effects on health, generating the majority of PM2.5 and NOx emissions, a large percentage of CO2, and other pollutants. These emissions cause respiratory illnesses such as asthma, rhinitis, COPD, and lung cancer, as well as cardiovascular and neurological diseases, among others, leading to a tangible decrease in quality of life and premature death. The high level of pollutant emissions was confirmed during counting sessions using data from mobile air quality monitors, where PM2.5, PM10, and the Air Quality Index (AQI) showed air quality levels considered hazardous.
- In Mexicali, heavy vehicles travel along roads that are literally in residential areas. People living near these and other high-traffic intersections suffer the most from the health consequences of the pollution generated by these trucks.
- The trucks counteduseFossil fuels, the most polluting fuel technology in existence, were the primary source of pollution. The effects were immediate for those who participated in the surveys: eye, throat, and nose irritation,

headaches, and other ailments. Cumulative exposure to these polluting emissions exacerbates the aforementioned illnesses. This situation poses a serious public health risk.

Based on the conclusions presented in this report, we offer the following legislative and public policy recommendations to reduce polluting emissions from heavy vehicles, as well as to reduce the harmful effects on public health in the community:

A key recommendation is the enactment of a State Environmental Responsibility Law in Baja California, as one currently does not exist. This law would serve as a guiding framework for compliance regarding licenses and operating permits for heavy and semi-heavy freight transport in its various classifications. Emissions from heavy vehicles must comply with the maximum limits established by Mexican official standards; unfortunately, many lack the necessary documentation or certificate proving compliance. When violations are detected, they are only subject to administrative fines. The proposed law would harmonize the municipal environmental protection regulations of Mexicali, prohibiting and penalizing air pollution from stationary and mobile sources, as well as noise pollution in populated areas. Therefore, it is crucial to create this law to improve access to environmental justice. With it, individuals can enforce their environmental rights before specialized environmental courts, compelling polluting companies to repair the damage, not just pay a paltry administrative fine.

A key public policy initiative to reduce emissions from heavy goods vehicles is the Indirect Source Regulation (ISR). This proposal establishes binding regulations mandating a reduction in emissions from heavy goods vehicles entering and leaving companies, production plants, and other industrial facilities by a specified percentage, for example, 30%. This proposal provides sufficient flexibility for each company to choose one or more of the proposed methods for reducing vehicle emissions, such as reducing the number of fossil fuel trucks and increasing the number of zero-emission (ZE) (electric) trucks, establishing charging infrastructure for ZE trucks, and streamlining the logistics system to prevent trucks emitting emissions into the air from remaining running for a long time, companies must implement additional measures in their processes and facilities to reduce overall company emissions, among other measures.

Another recommendation, in addition to the previous ones, is to establish designated truck routes. These routes should be developed in consultation with the local population to define routes where trucks can travel without significantly impacting people's health—that is, trucks that don't pass directly by people's homes. While this would not reduce emissions, it would prevent people from breathing these emissions so close to where they live and reduce the negative public health effects of truck emissions. These routes have been established in several cities around the world and have proven successful in mitigating some of the harmful effects of vehicle air pollution on people's health.

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