UNIVERSIDAD NACIONAL DE COLOMBIA

ESTIMATION OF $PM_{2.5}$ AND BLACK CARBON EMISSIONS FROM ON ROAD VEHICULAR SOURCES IN MANIZALES, COLOMBIA

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SUBDIRECTION OF NATURAL RESOURCES

AIR RESOURCE

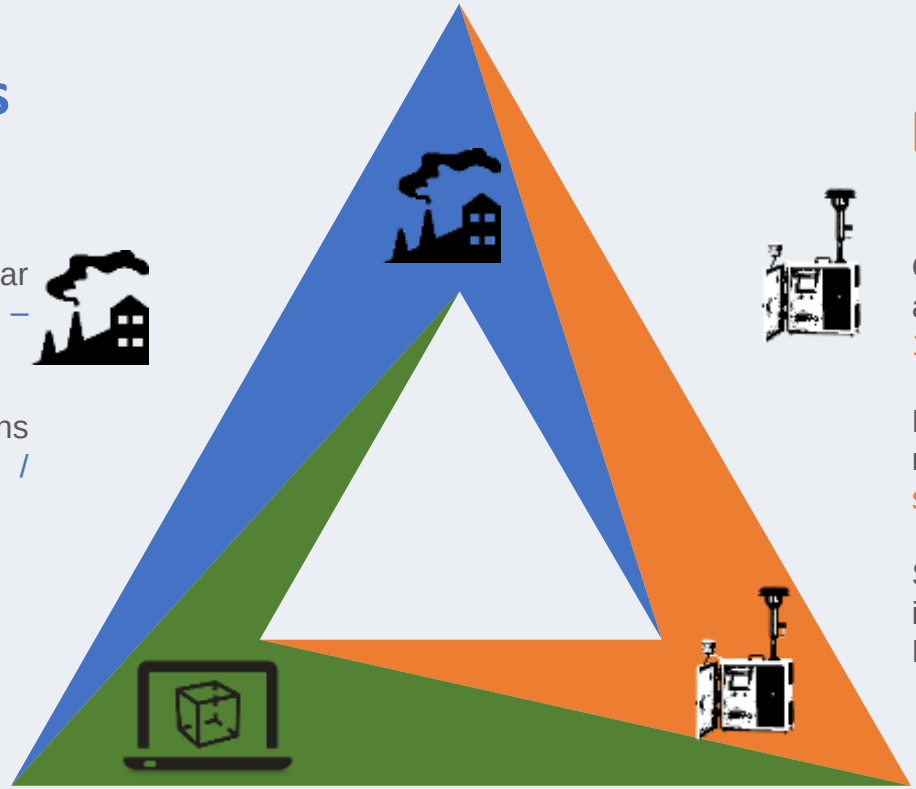
CORPOCALDAS
Corporación Autónoma Regional de Caldas
Gestión Ambiental para el Desarrollo Sostenible

AIR QUALITY

Emission sources

Update of the atmospheric emission inventory – year 2017 (Auditorium / Thursday, August 15 / 16:00 – 16:15)

Estimation of $PM_{2.5}$ and Black Carbon emissions from on-road vehicular sources (Auditorium / Thursday, August 15 / 16:30 – 16:45)



Monitoring

Concentrations and gas-particle partition of polycyclic aromatic hydrocarbons. (GEC G2 / Thursday, August 15 / 10:15 – 10:30)

Exposure to particulate matter in microenvironments related to transportation in Manizales (Poster session)

Study of the historical behavior of particulate matter in Manizales and analysis of the relationship $PM_{2.5}/PM_{10}$ (Poster session)

Modeling

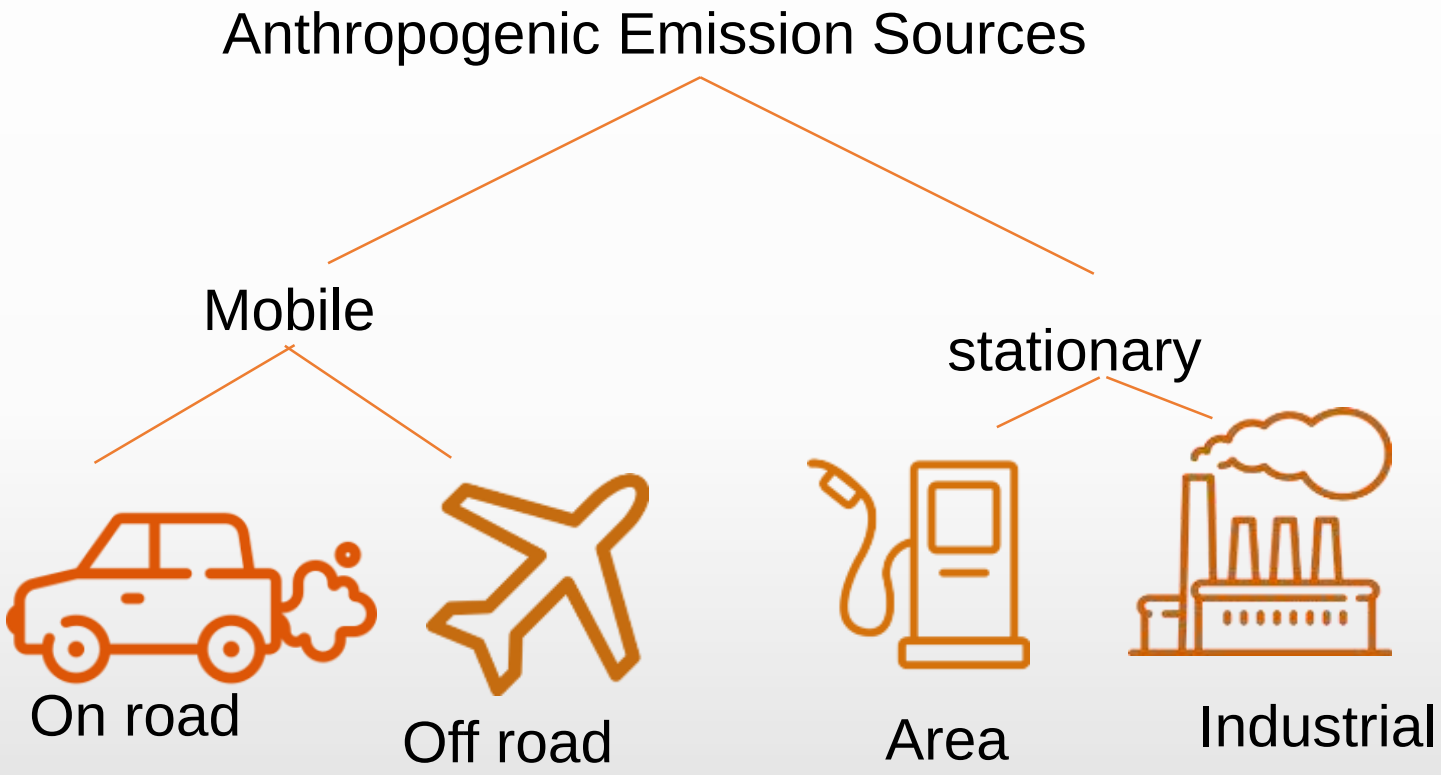
HIgh-resolution air quality modelling of a trace gas (CO) in Manizales, Colombia. Analysis of differences between two Chemical mechanisms (Poster session)

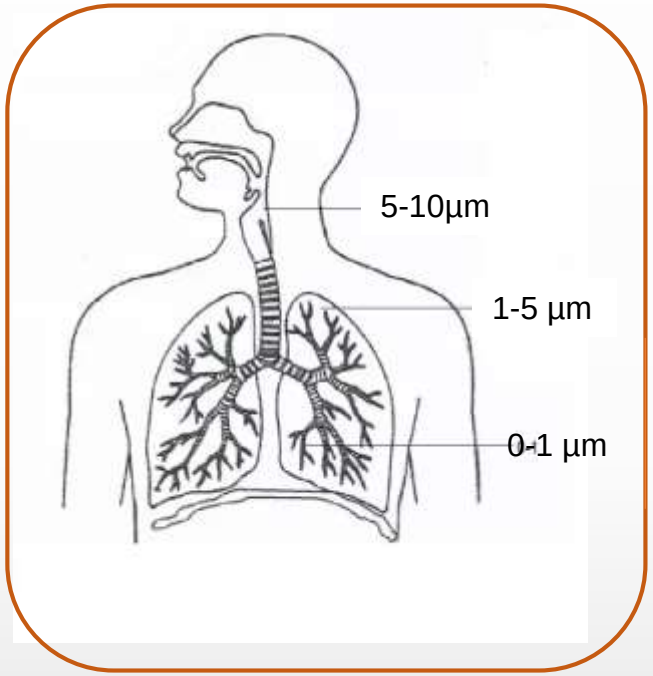
Biogenic volatile organic compounds in Colombia: First specialized model and determining emission factors (GEC G2 / Thursday, August 15 / 11:30 – 11:45)

PRESENTATION ESTRUCTURE

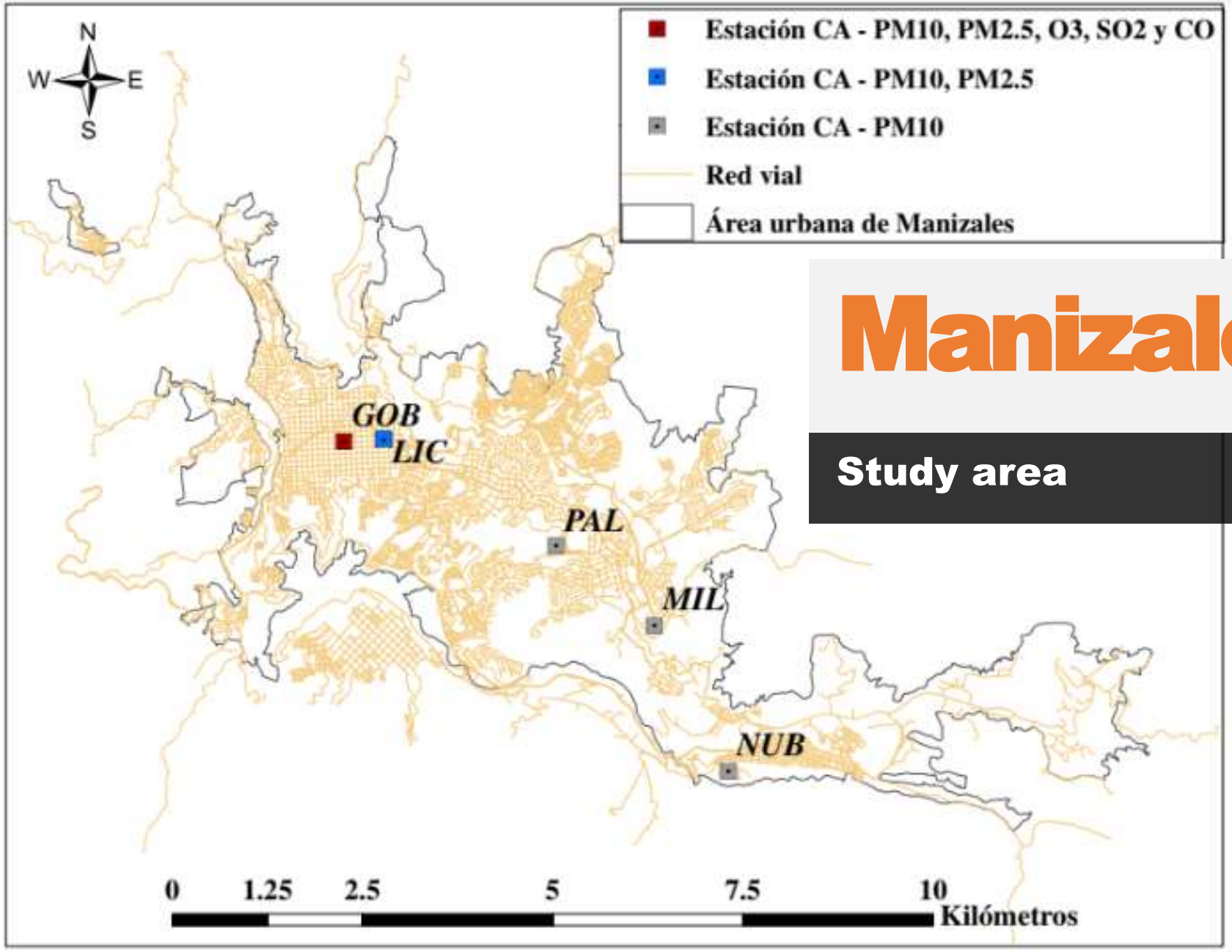
1. Theorical Framework
2. Introduction
3. Methodology
4. Results
5. Conclusions

THEORICAL FRAMEWORK





IMPORTANCE OF $PM_{2.5}$ AND BLACK CARBON POLLUTANTS



Manizales, Caldas

Study area

General aspects:

- Altitude (a.m.s.l) 2150
- 54 km^2 urban area
- 400436 inhab.

INTRODUCTION

$PM_{2.5}$ is estimated to contribute to 7 million premature deaths every year

(World Health Organization)

Black Carbon is the second leading cause of Global Warming

(Climate and Clean Air Coalition)

Few studies of $PM_{2.5}$ and Black Carbon emissions from mobile sources are presented

1 in 3 citizen mobilize in a particular vehicle

Motorization rate per 1000 inhabitants in 2017	Participation of prollutants by mobile source
424.8	**90%**

Resource: National Road Safety Agency

INTRODUCTION

International Vehicle Emissions (IVE) Model

Manizales, Caldas. Urban Zone

FIVE VEHICLE CATEGORY

Passengers Cars PC

Motorcycles 2W

Buses

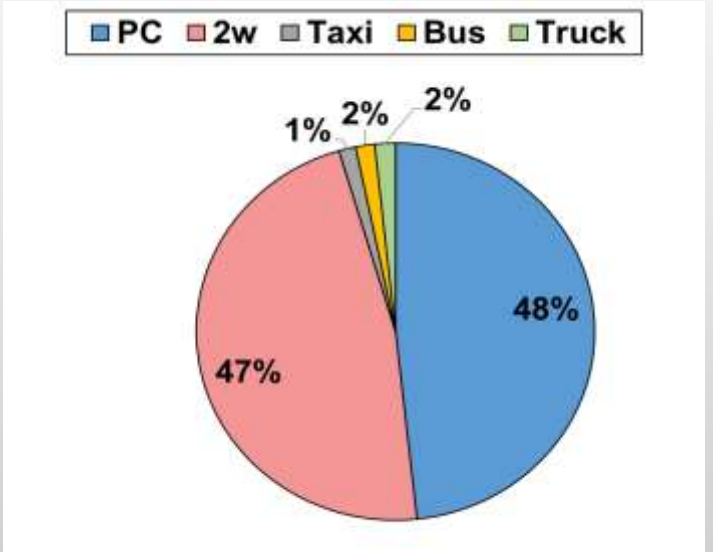
Trucks

Taxis

Automotive Park

169142

Vehicles in 2017



PROBLEM

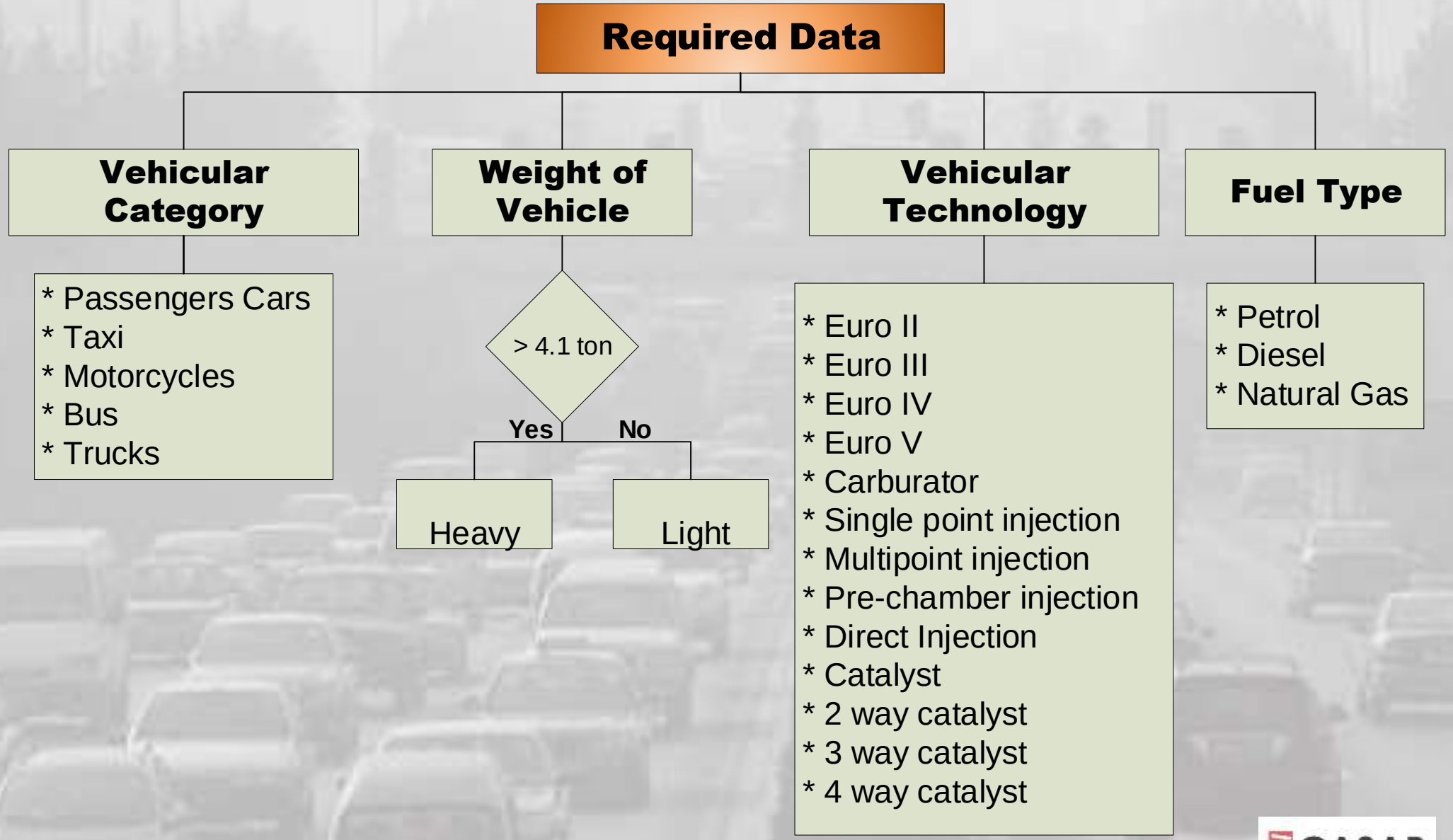
In the estimation of on-road mobile emissions inventory carried out in Manizales, the application of the methodology and IVE model allowed to obtain the fraction of particulate material PM_{10}; however, IVE does not have emission factors to obtain fluxes of $PM_{2.5}$ and BC.

OBJECTIVES

Evaluate $PM_{2.5}$ and Black Carbon emissions emitted from vehicular activity with reference of emissions inventory.

Evaluate incidence of $PM_{2.5}$ and Black Carbon emissions respect vehicular activity from technology, vehicle type and fuel type

METHODOLOGY



METHODOLOGY FOR $PM_{2.5}$

General Equation

$$E_{PM2.5} = \frac{E_{PM10}}{R}$$

$E_{PM2.5}$: Emisión $PM_{2.5}$ [Ton/year]
E_{PM10} : Emisión PM_{10} [Ton/year]

Alternative 1 (A1)	Alternative 2 (A2)	Alternative 3 (A3)	Alternative 4 (A4)
National Emissions Inventory: EPA, Environment Protection Agency 2018	*Pollutant Emissions Inventory: Environment and Climate Change Canada ECCC ,2019*	*Article: On-Road Particulate Matter $PM_{2.5}$ and PM_{10} Gillies et al 1996*	*Appendix $PM_{2.5}$ Speciation Report: MOVES 2014 Dollmeyer, SAE 2007-014170, Kalayci, 2011*
* Diesel Light duty vehicles * Diesel Heavy duty vehicles * non Diesel Light duty vehicles * non Diesel Heavy duty vehicles	* Diesel Light duty vehicles * Diesel Heavy duty vehicles * Petrol Light duty vehicles * Petrol Heavy duty vehicles * Motorcycles * GLP /GN Light duty vehicles * GLP /GN Heavy duty vehicles	Global factor emission	* Petrol and Natural gas * Diesel

METHODOLOGY FOR BLACK CARBON

Method 1 (B1)

Asociated to fuel consumed

*Diesel
*Petrol
*Natural Gas

$E_{BC} = Q_i \times FE_{i,BC}$

E_{BC}= Black Carbon Emission [ton/year]
i= Fuel Type
Q_i= Amount of fuel type "i"[gal/year]
$FE_{i,BC}$= Factor Emission of Black Carbon [gBC/gal]

Resource: SOLDICOM

Method 2 (B2)

Speciation factor $PM_{2.5}$

$E_{BC} = E_{PM2.5} \times FE_{i,j}$

E_{BC}=Black Carbon Emission [ton/year]
i=Fuel type
j= Vehicular category
$FE_{i,,j}$ = Factor emission $PM_{2.5}$ [gBC/g$PM_{2.5}$]
$E_{PM2.5}$ = $PM_{2.5}$ emission[ton/year]

Fuel Type — Diesel, Petrol,Natural Gas

Vehicular Category — Passenger Car, Motorcycle, Bus, Truck, Taxi.

Vehicular Weight — Light (>4.1 ton) Heavy (<4.1 ton)

Vehicular Technology — Euro II, Euro III, Euro IV, without control

Method 3 (B3)

Black Carbon, $PM_{2.5}$ ratio

$E_{BC} = E_{PM2.5} \times R_{i,BC}$

E_{BC}= Black Carbon Emission [ton/year]
i=Fuel Type
$R_{I,BC}$ =Black Carbon, $PM_{2.5}$ Ratio [gBC/g$PM_{2.5}$]
$E_{PM2.5}$ =$PM_{2.5}$ emission[ton/year]

Fuel Type

*Petrol
*Diesel
*Natural Gas

METHODOLOGY FOR $PM_{2.5}$

$PM_{10}/PM_{2.5}$ ratio	Diesel	Petrol	Natural Gas
A1	1.380 -1.390	2.524 - 2.629	2.524 - 2.630
A2	1.095 -1.083	1.134 -1.083	1.132
A3	1.095	1.095	1.095
A4	1.087	1.13	1.13

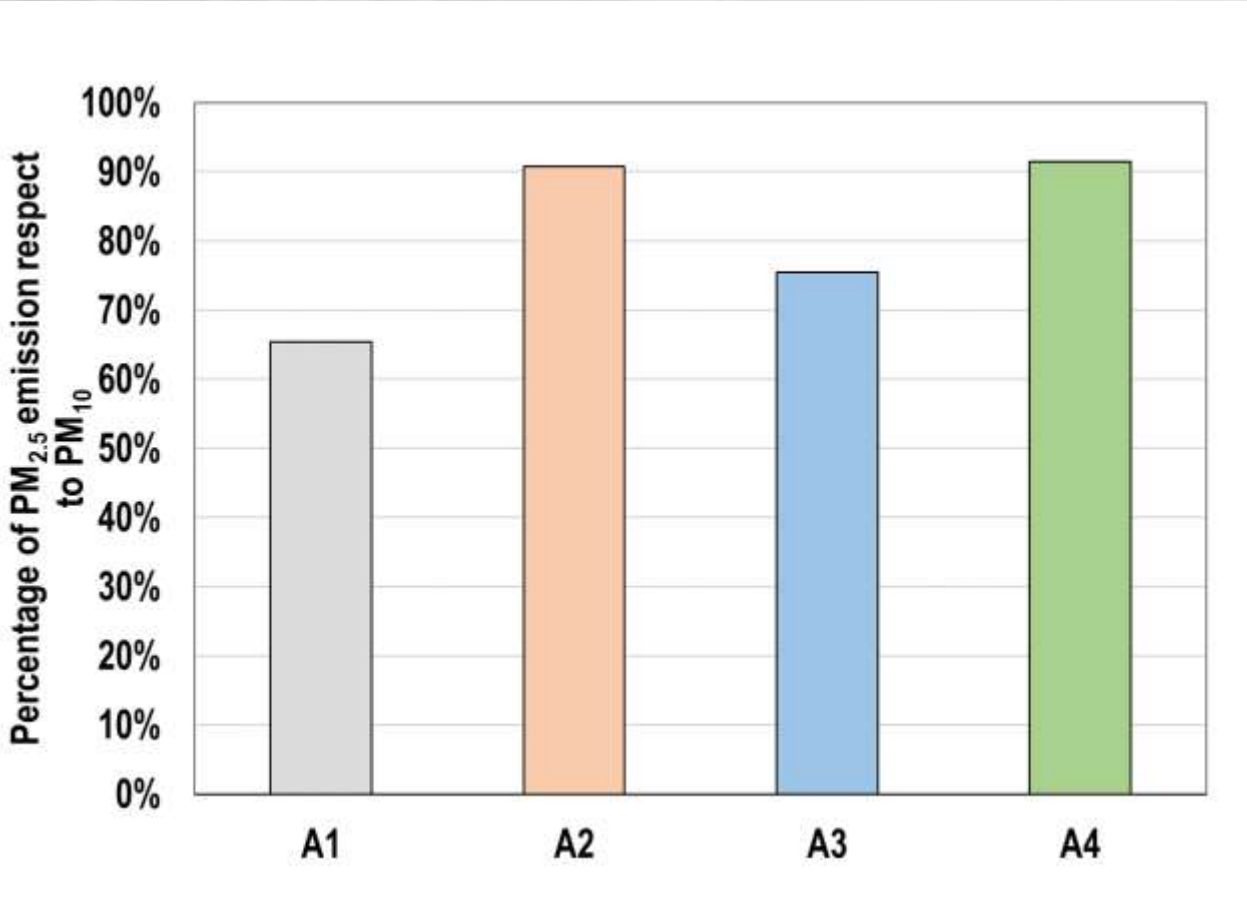
PM_{10} respect to $PM_{2.5}$ ratio estimation

METHODOLOGY FOR BLACK CARBON

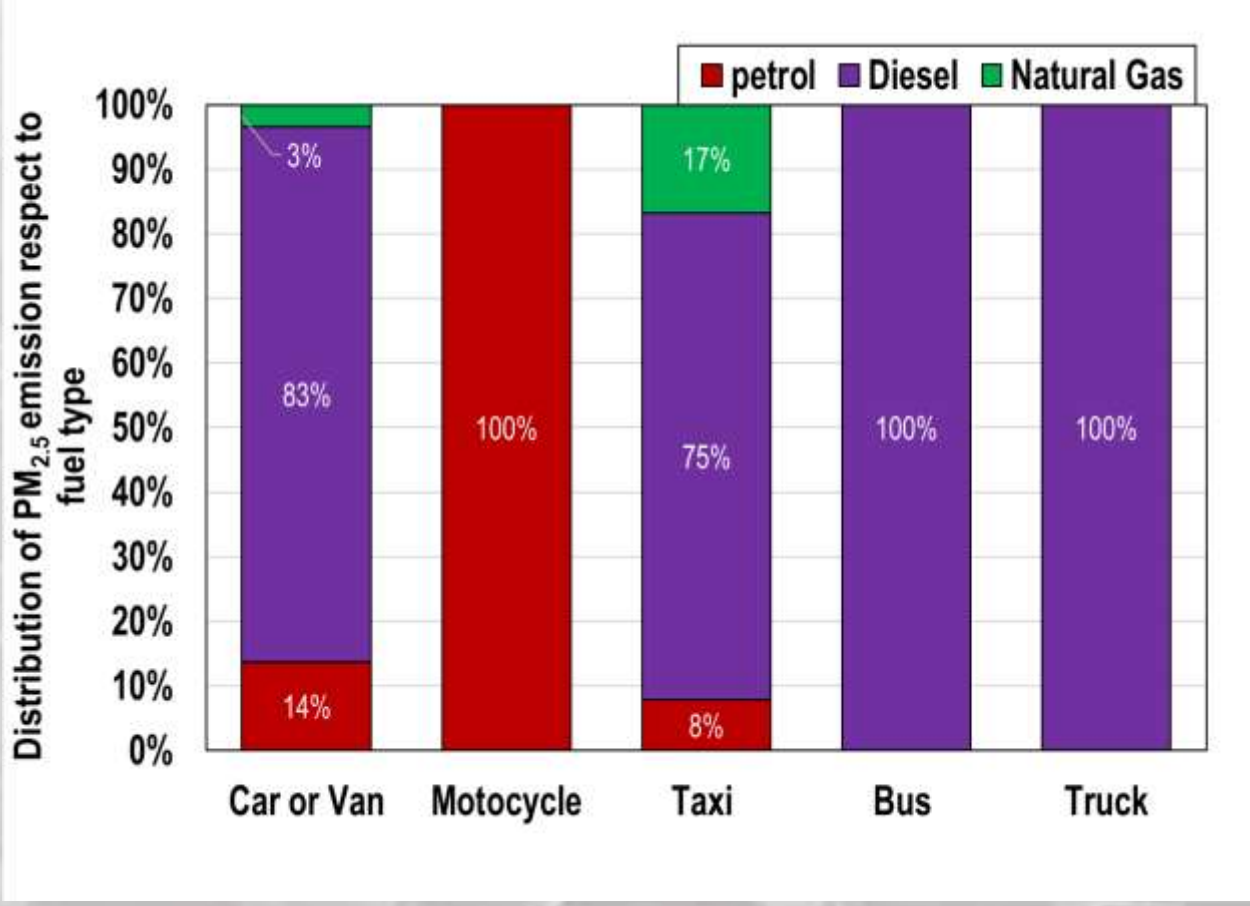
Ratio for Black Carbon estimation

Method	Ratio	Diesel	Petrol	Natural Gas
B1	[gBC/gallon]	3.185	0.073	0.036
B2	[gBC/$PM_{2.5}$]	0.8-0.69	0.25-0.15	0.2
B3	[BC/$PM_{2.5}$]	0.636	0.234	0.203

RESULTS $PM_{2.5}$

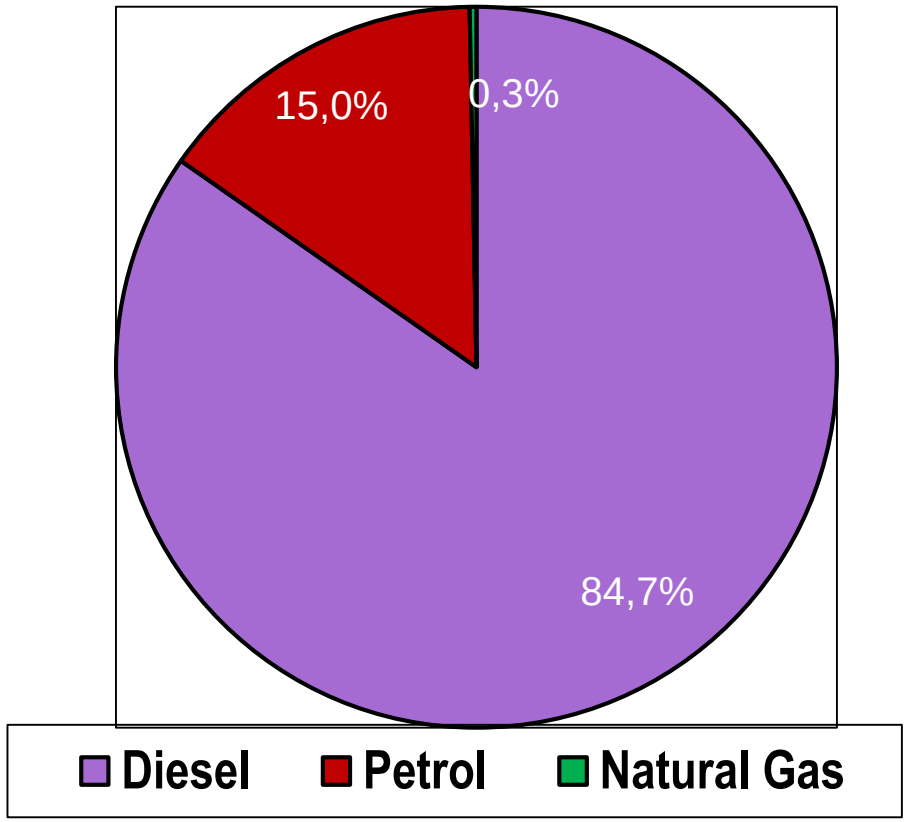


Percentage of $PM_{2.5}$ emission respect to PM_{10} for the alternatives evaluated.

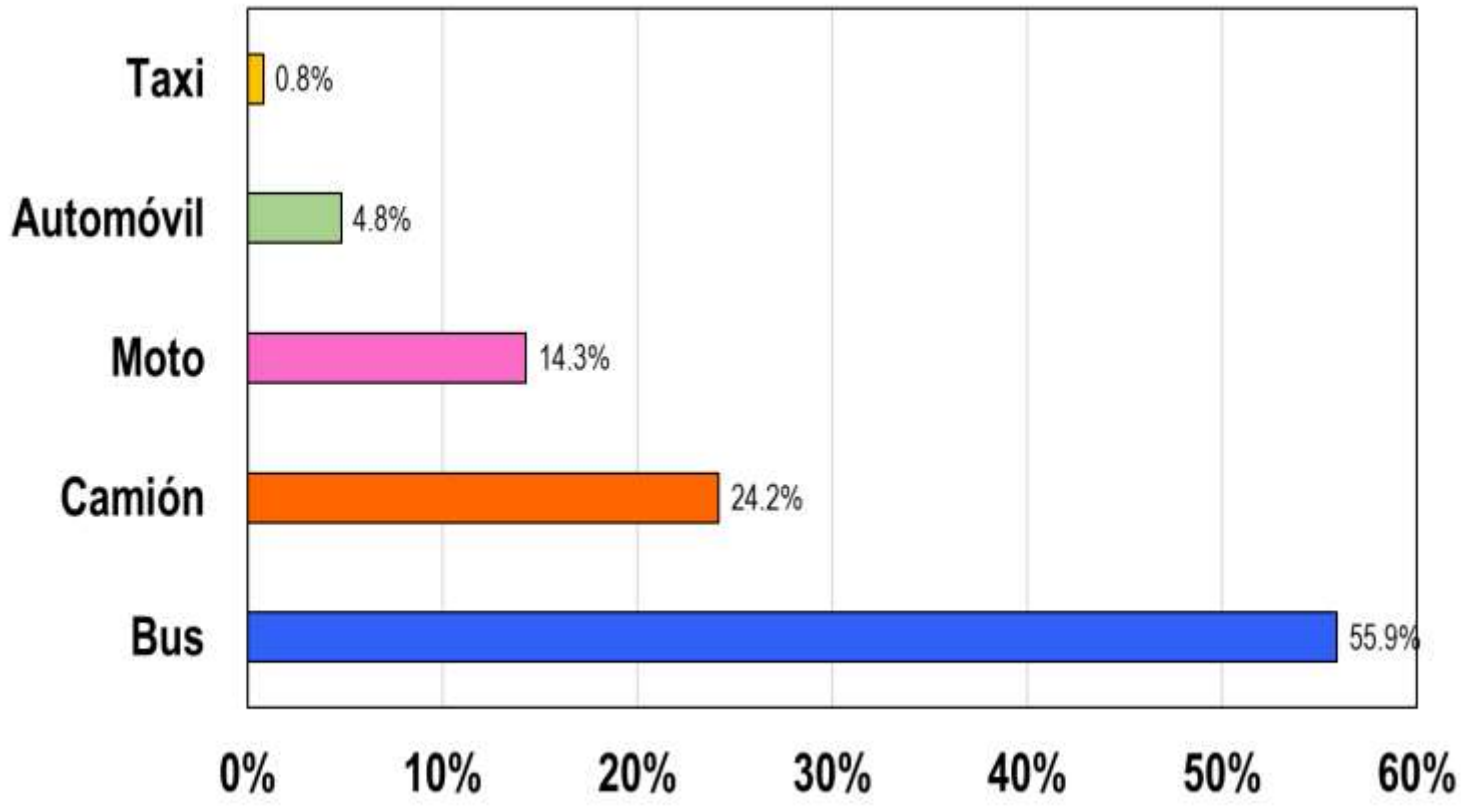


Distribution of $PM_{2.5}$ Emission respect to fuel type.

RESULTS $PM_{2.5}$

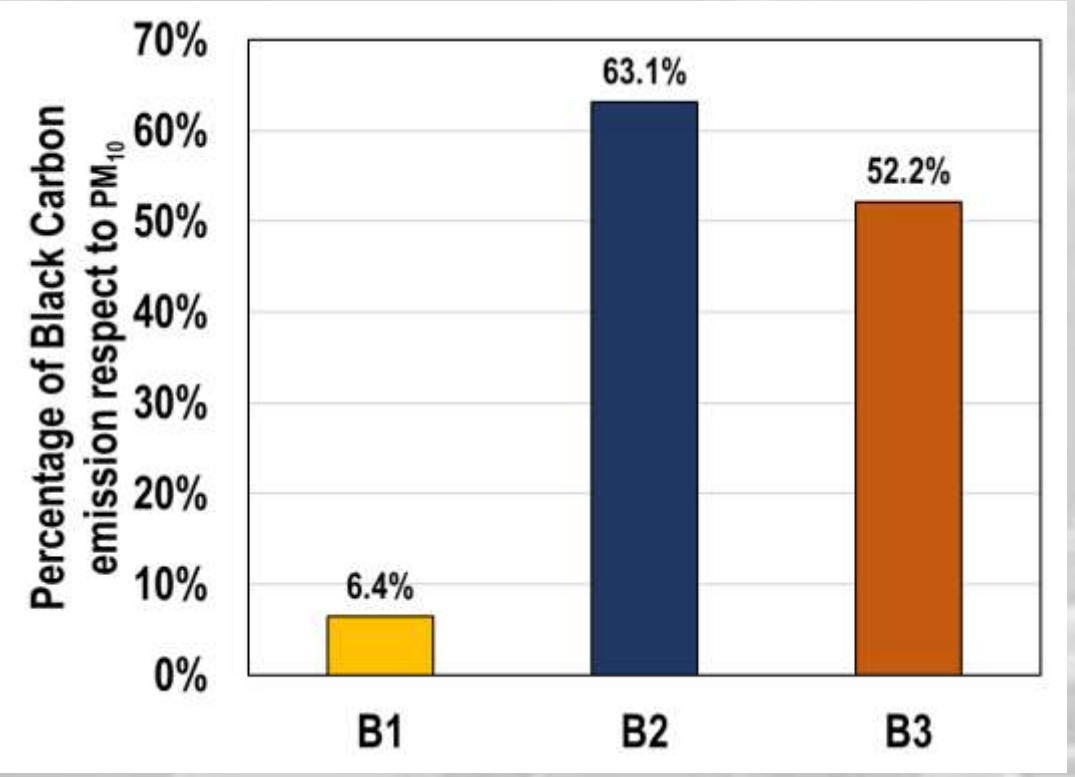


Percentage of $PM_{2.5}$ emission respect to fuel type

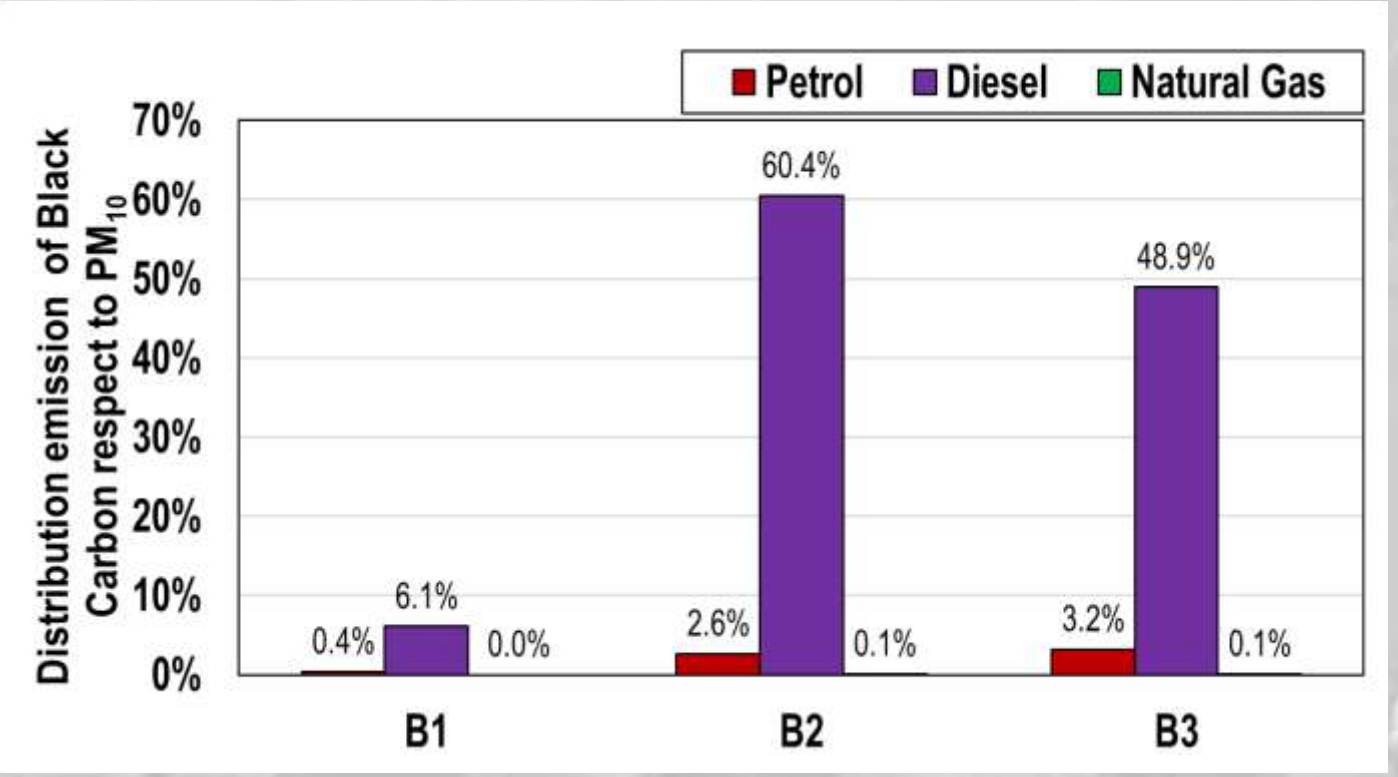


Percentage of $PM_{2.5}$ emission respect to vehicular category

RESULTS BLACK CARBON

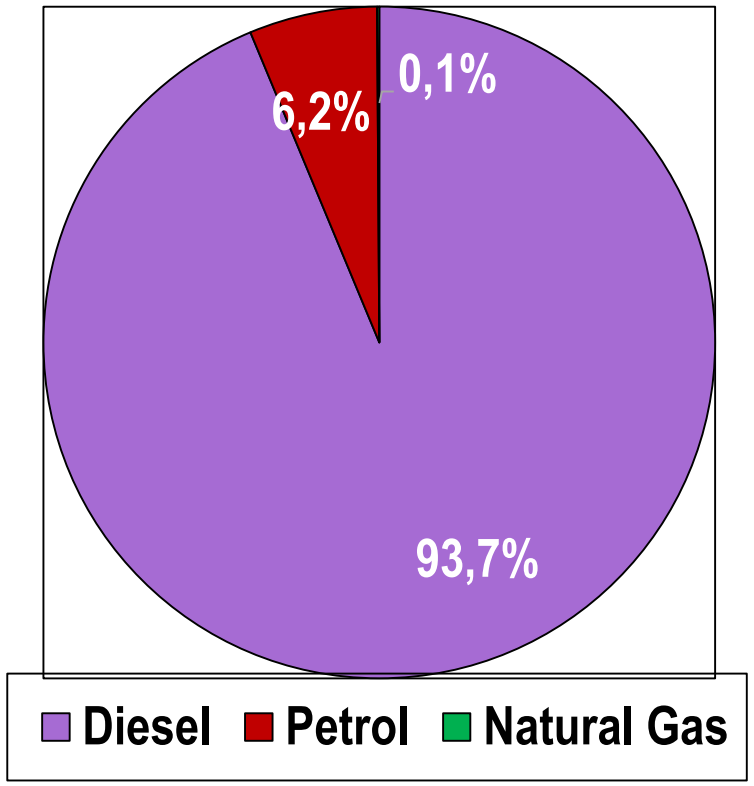


Percentage of Black Carbon content in PM_{10}

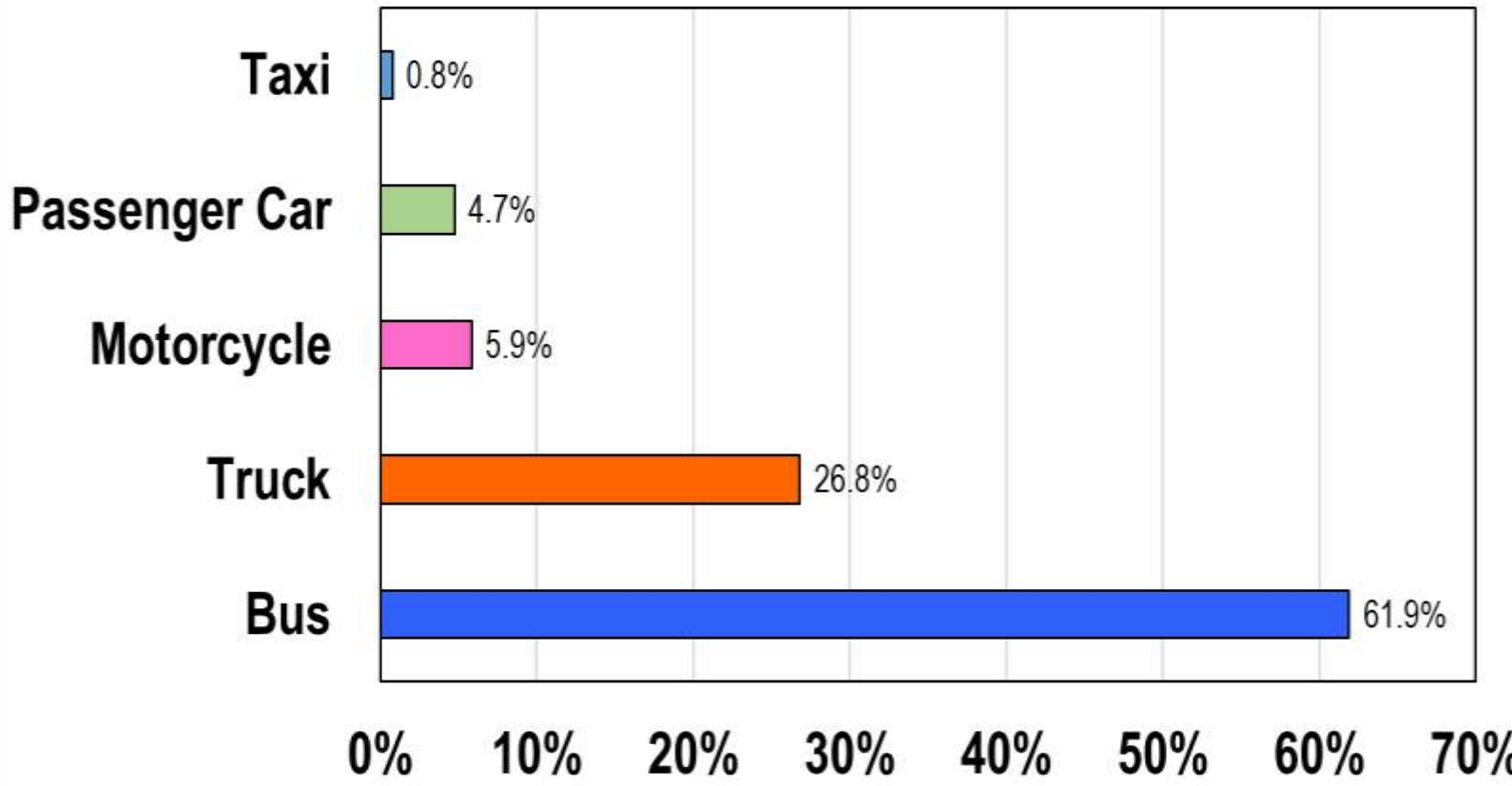


Distribution emission of Black Carbon respect PM_{10} considering fuel type

RESULTS BLACK CARBON



Percentage of Black Carbon emission with respect to fuel type



Percentage of Black Carbon respect to vehicular category

CONCLUSIONS

Percentage of contribution were in order of 90% for $PM_{2.5}$ emissions with respect to PM_{10} and 58% for Black Carbon emissions with respect to PM_{10}.

The greatest contribution of Black Carbon and $PM_{2.5}$ emissions was associated with the use of diesel as fuel with percentages of 93.7% and 84.7% respectively of total emissions estimated for these pollutants.

Bus category emitted the highest amount of $PM_{2.5}$ and BC comprising 56% and 62% respectively of total on-road vehicular emissions in Manizales.

ACKNOWLEDGMENTS

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Gestión Ambiental para el Desarrollo Sostenible

VII CASAP

RESOLUTION

107-2018 CORPOCALDAS UNAL

Thank You

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