UNIVERSIDAD NACIONAL DE COLOMBIA
SEDE MEDELLÍN
FACULTAD DE MINAS

Bus passengers and drivers' exposure to Particle Matter: the case of National University of Colombia at Medellin Campus

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GLOBAL CENTRE FOR CLEAN AIR RESEARCH
UNIVERSITY OF SURREY

GCRF
Global Challenges Research Fund

UNIVERSITY OF SURREY

CArE-Cities: Clean Air Engineering for Cities

Project running from 2019 to 2020

Principal Investigator

Professor Prashant Kumar (Professor and Chair in Air Quality & Health / Director, Global Centre for Clean Air Research, GCARE; Department of Civil & Environmental Engineering; FEPS).

- CArE-Cities aspires to bring cleaner air to cities by building a knowledge exchange platform.
- To establish a multidisciplinary team for understanding emissions, penetrating low-cost pollution monitoring technology and exposure reduction strategies in selected ODA cities.
- To assess the commuters' exposure through collecting primary concentration data and evaluating different control scenarios

CArE-Cities

GCRF
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Collaborating partners from 11 DAC listed Countries

Latin America:

- **Professor Maria de Fatima Andrade** (University of Sao Paulo, Brazil) 
- **Professor Pedro Jose Perez Martinez** (University of Sao Paulo, Brazil)
- **Professor Yris Olaya** (Universidad Nacional de Colombia, Colombia) 

Middle-East:

- **Profesor Ahmed El-Gendy** (The American University in Cairo, Egypt) 
- **Dr Kosar Hama Aziz** (University of Sulaimani, Kurdistan region, Iraq)
- **Dr Khalid Omer** (University of Sulaimani, Kurdistan region, Iraq) 

South-East Asia:

- **Professor Mukesh Khare** (Indian Institute of Technology Delhi, India) 
- **Professor Shiva Nagendra** (Indian Institute of Technology Madras, India)
- **Professor Abdus Salam** (University of Dhaka, Bangladesh) 
- **Professor Shi-jie Cao** (Guangzhou University, China) 

Africa:

- **Dr Philip Osano** (Stockholm Environment Institute Nairobi, Kenya) 
- **Dr Vera Ngowi** (Muhimbili University of Health and Allied Services, Dar-es-Salam, Tanzania) 
- **Professor Adamson S. Muula** (University of Malawi, Malawi) 
- **Professor Araya Asfaw** (Addis Ababa University, Ethiopia 

Plan for car exposure trial studies

Time of the day	Setting 1 (runs)	Setting 2 (runs)	Setting 3 (runs)
Morning peak (MP; 7-9 am)	Window closed, Fan on (10)	Window closed, Recirculation (10)	Windows OPEN, Fan/recirculation off (10)
Off-peak (OP; 1-3 pm)	Window closed, Fan on (10)	Window closed, Recirculation (10)	Windows OPEN, Fan/recirculation off (10)
Evening peak (EP; 5-7 pm)	Window closed, Fan on (10)	Window closed, Recirculation (10)	Windows OPEN, Fan/recirculation off (10)

Motivation


Esumer
Clínica Cardio VID
Calle 78b
Carrera 72A
Avenida 80
Clínica Universitaria
Universidad Pontificia...
CORDOBA
Carrera 65
Fundación Casa
Museo Maestro Pedro...
Caribe
MORAVIA
Calle 75
School of Mines -
National University of...
BOSQUES DE
SAN PABLO
Carrera 67
Carrera 64c
Casino El Bosque
Calle 78
MIRAND
PILARICA
EL PROGRESO
Colegio Mayor
de Antioquia
ITM
EVERFIT
J. Emilio Valderrama
North Park
Secretaria de
Movilidad de Medellin
Urbanización Perlato
Vf Tierra Firme
CARIBE
Parque Explora
Universidad
de Antioquia
Universidad
SAN GERMAN
OTRA BANDA
ALAMOS
Calle 71
LOS ANGELES
Parque
Natural Cerro
El Volador
Calle 67a
Calle 67
Hospital
Carrera 56
Carrera 65
Politécnico
Grancolombiano...
Universidad Nacional de
Colombia Sede Medellín
Encicla National
Calle 61a
Google

Recurrent red alert episodes in March and October in Medellin

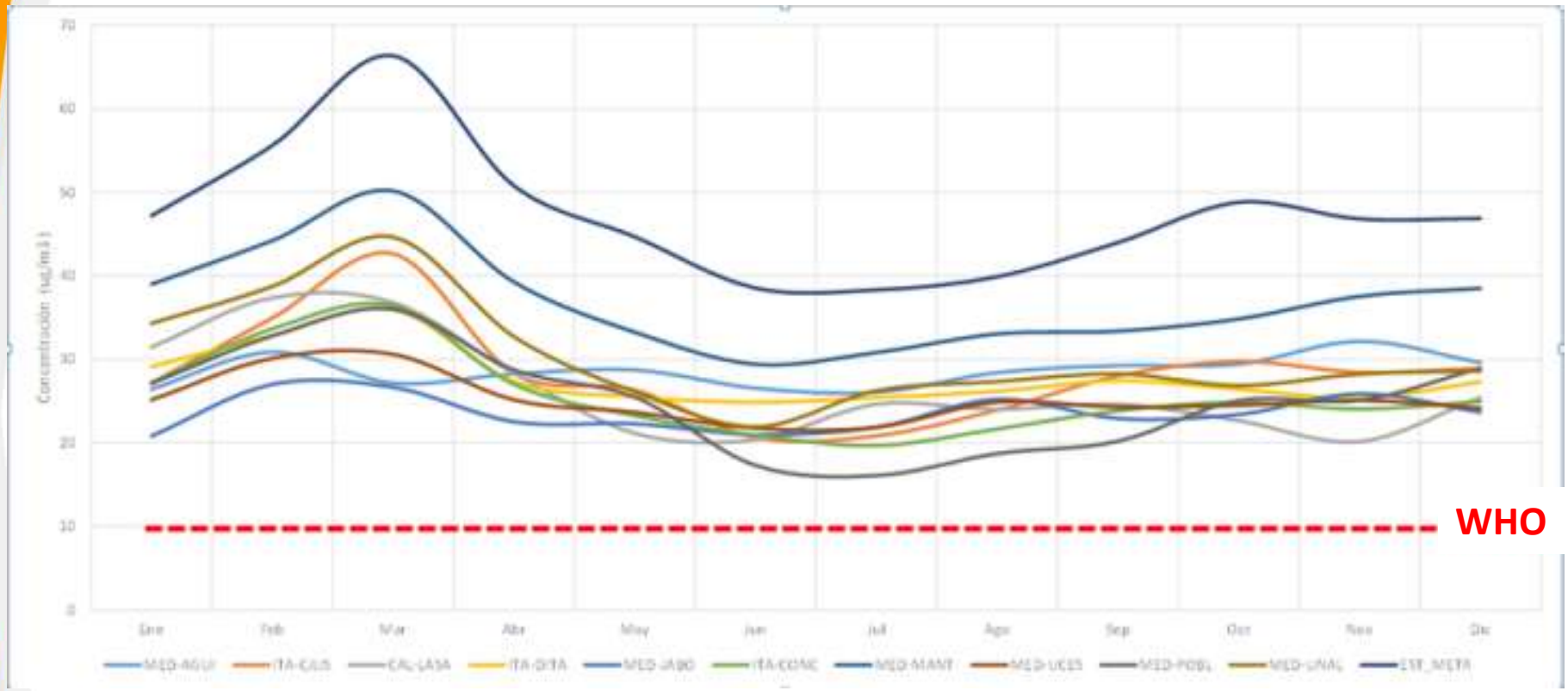


Figure 4. Average $PM_{2.5}$ concentrations (µg . m^{-3}) during the period 2008-2015

https://www.medellincuenta.com/irj/go/km/docs/pccdesign/informativo/MedioAmbiente/Shared%20Content/Documentos/Pacto%20por%20el%20Aire.pdf

More than 80% of CO, NOx, VOC and PM2.5 from mobile sources in Medellín

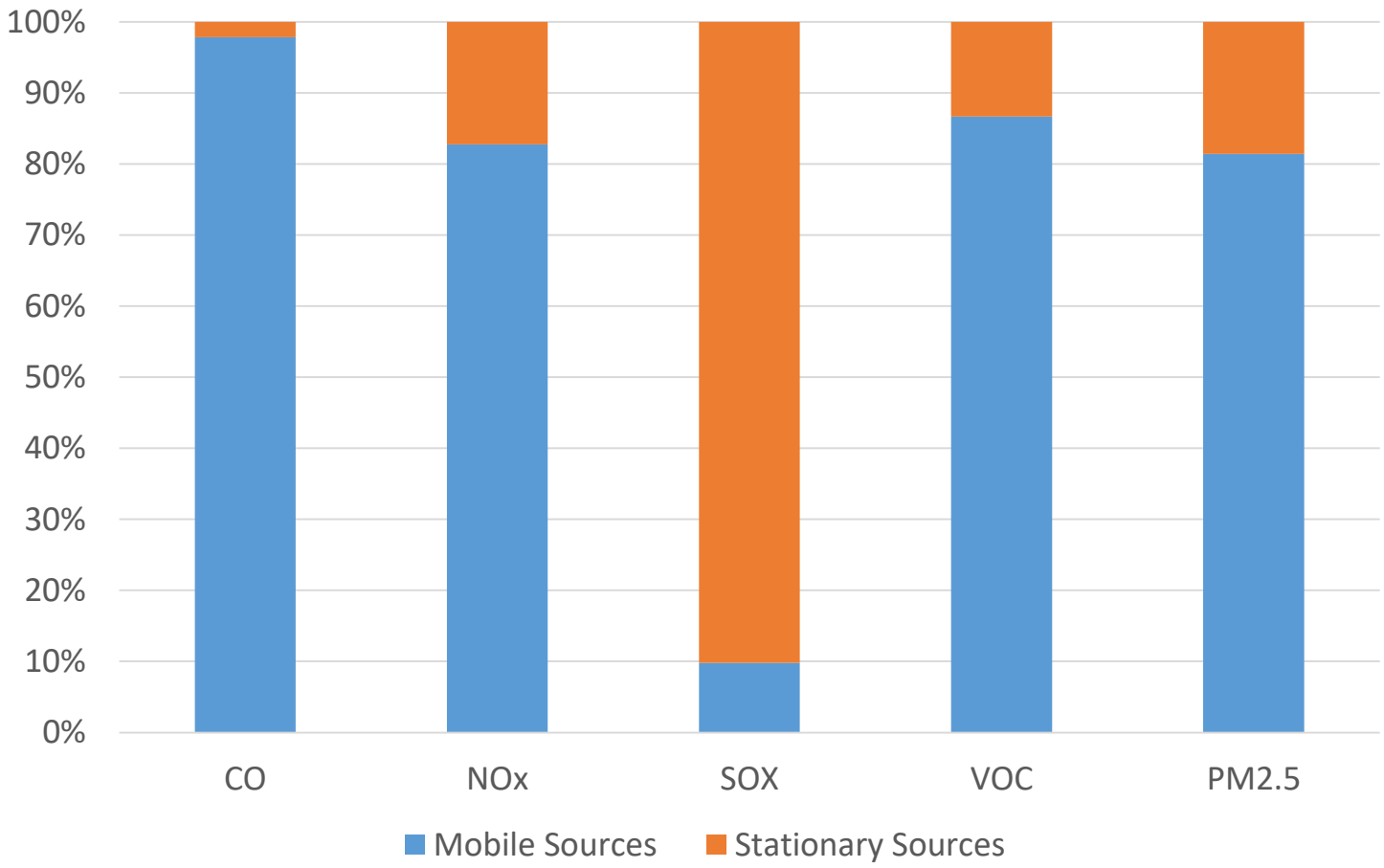


Figure 2. Distribution of total emissions by source at AMVA, 2016

https://www.metropol.gov.co/ambiental/calidad-del-aire/Documents/Inventario-de-emisiones/Inventario_FuentesFijas2016_FuentesM%C3%B3viles2015.pdf

Main sources of PM2.5 in Medellín

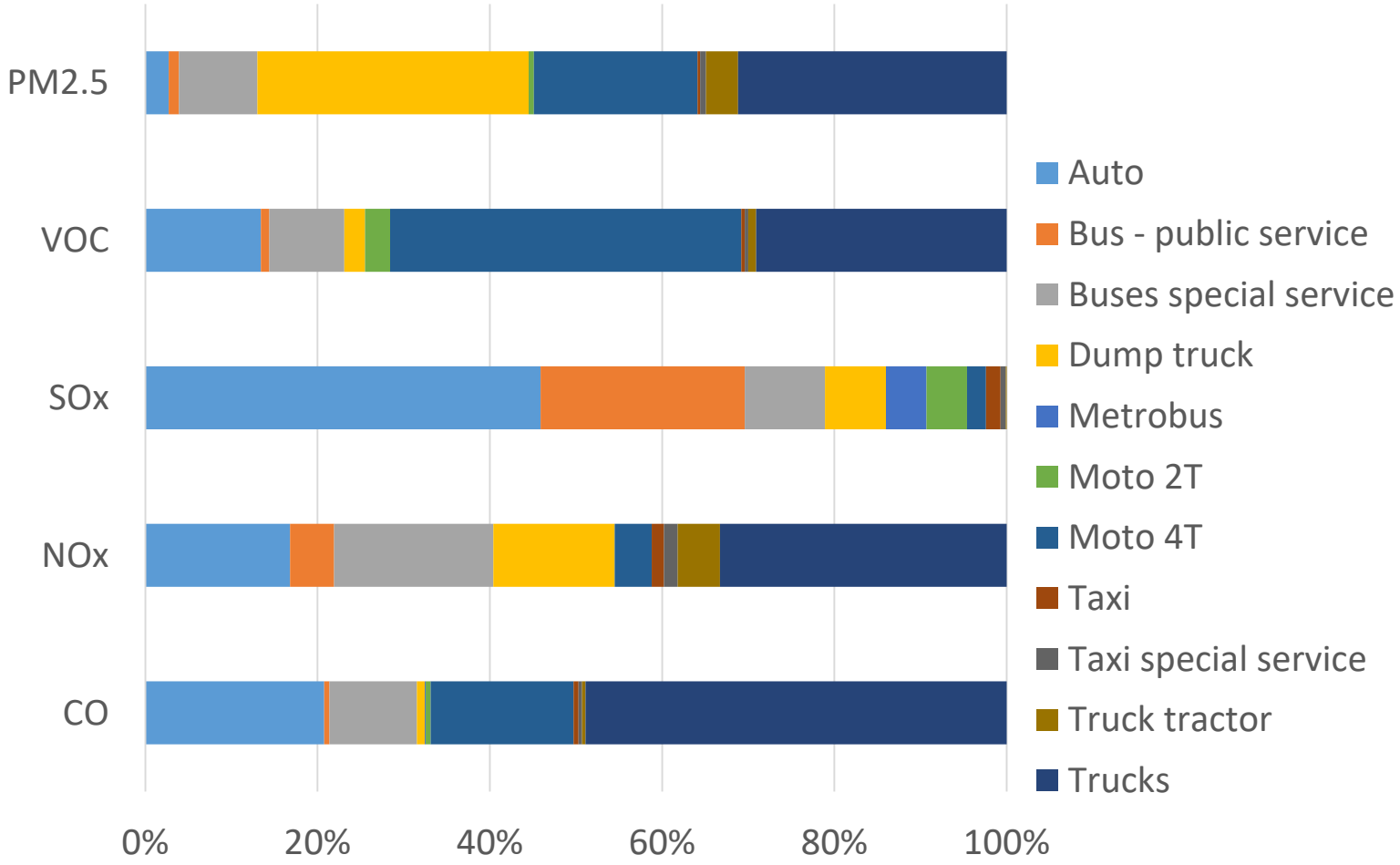


Figure 3. Emissions distribution by vehicle type, 2016

https://www.metropol.gov.co/ambiental/calidad-del-aire/Documents/Inventario-de-emisiones/Inventario_FuentesM%C3%B3viles2016.pdf

PM concentration in a route bus in Medellin

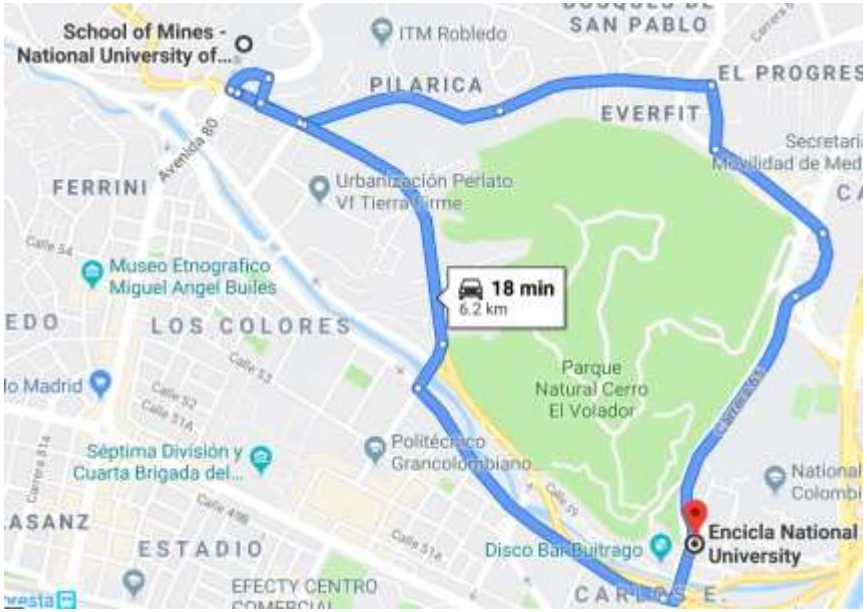
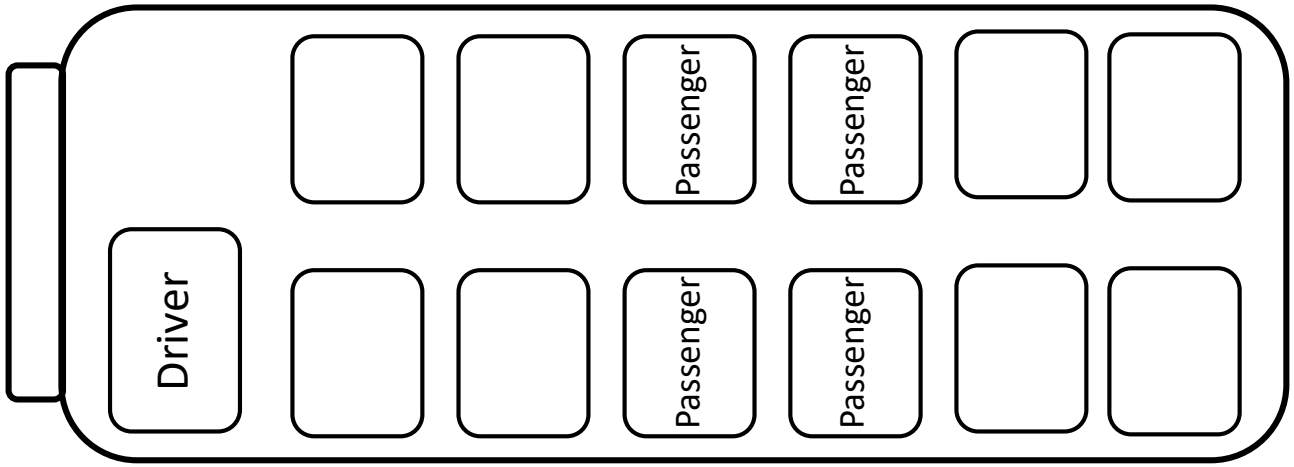


Figure 5. Route between Main campus and Faculty of Mines, Medellin.

	Ruta Main campus-Minas		Ruta Minas-Main campus	
	Peak hours	**Off-peak hours**	**Peak hours**	**Off-peak hours**
Measurement time	9-10 a.m.	5-6 p.m.	9-10 a.m.	5-6 p.m.
Route Average time	21 min 31 sec	9 min 43 sec	11 min 26 sec	10 min 37 sec
Number of measurements	14	13	13	12

Figure 6. Buses for student transport at National University of Colombia in Medellín

Total number of buses: 11
Number of buses with closed Windows and AC: 2
Type of fuel: diesel



Portable Instrument used

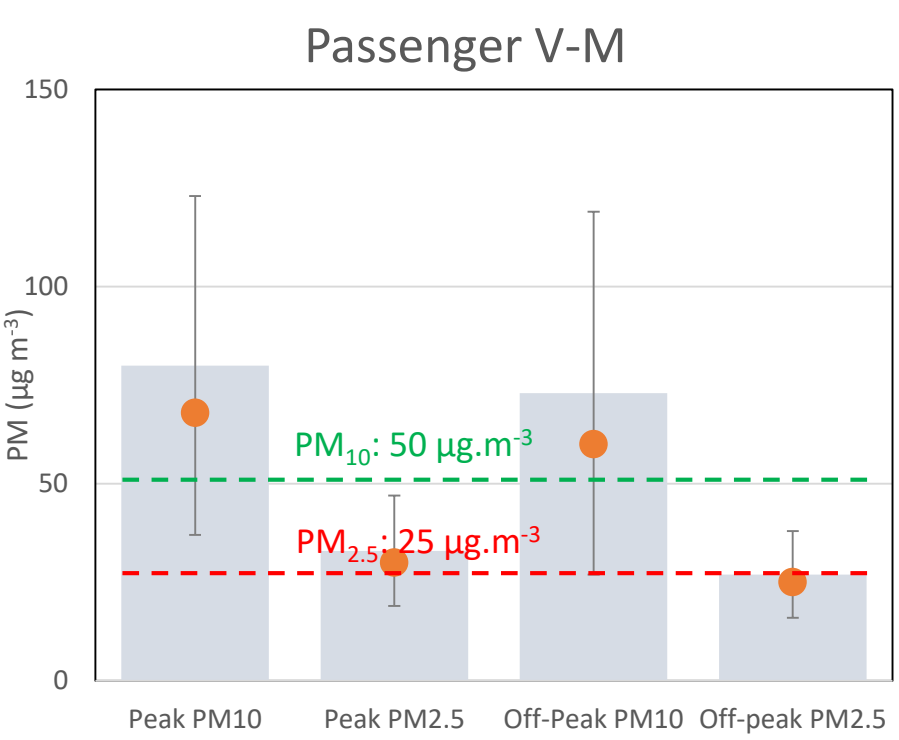
Figure 7. Portable monitor Dylos DC1700-PM

- Dylos DC 1700-PM
- Measurement of PM2.5 and PM10
- 1-minute resolution

Recent studies using Dylos monitor:

- ✓ Kumar et al., 2018
- ✓ Marowaska est al., 2018
- ✓ Torkmahalleh et al., 2018
- ✓ Lim et al., 2018
- ✓ Yuchi et al., 2019

Is there an impact of passenger and driver location in PM concentration?



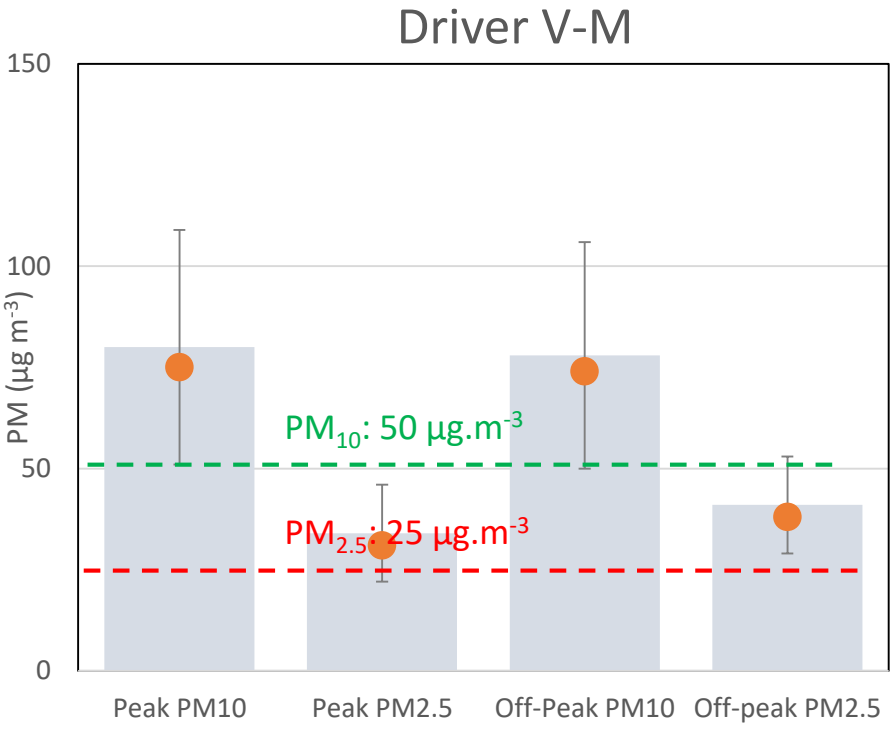
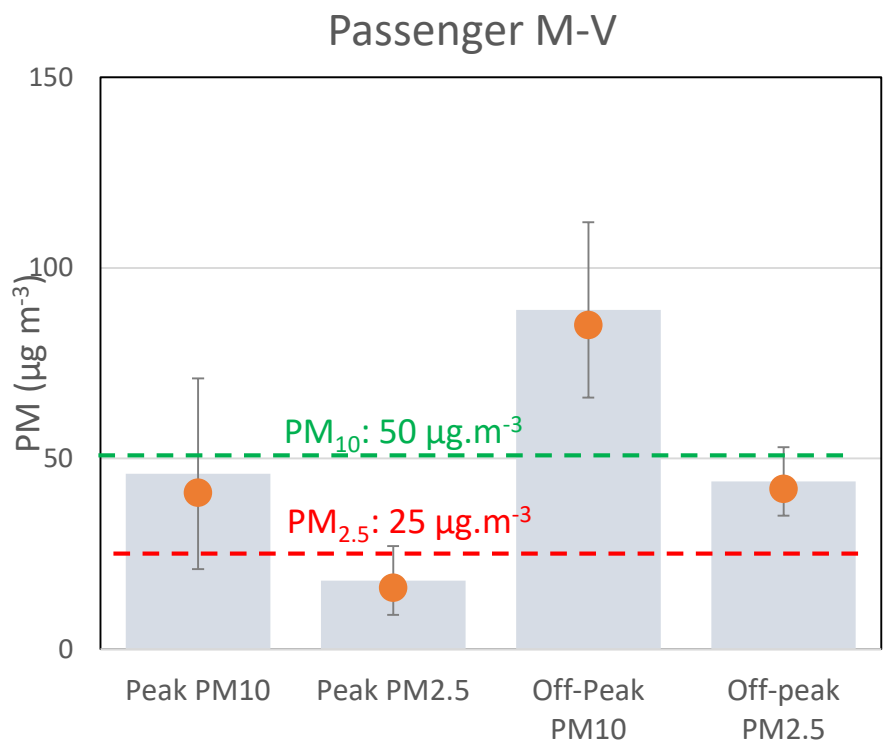


Figure 8. In-cabin concentration levels of PM for passenger and driver in the route Main campus (Volador) –Faculty of Mines

Is there an impact of passenger and driver location in PM concentration?



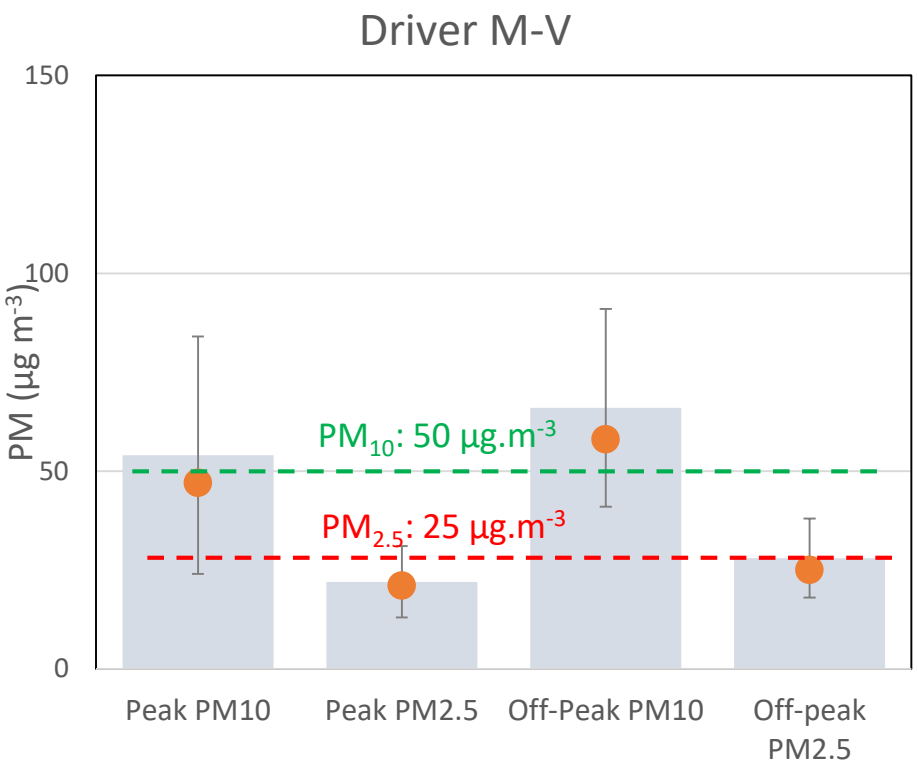


Figure 9. In-cabin concentration levels of PM for passenger and driver in the routeFaculty of Mines- Main campus (Volador)

Conclusions and future work

- To include measurements of Carbon Monocide for inside vehicle cabins
- Compare results with the Integrate transport system from de Aburrá Valley and other transport modes
- Include another routes in the city of Medellin.

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