Idling Action London

Idling and Particulate Matter Inside Vehicles

Citizen Science Experiment

Aim

We aimed to build on the research conducted by King's College London for Idling Action that looked into what impact vehicle engine idling has on outdoor pollution levels. We used real-time Particulate Matter personal exposure monitors to look at what happens to pollution levels inside your vehicle when:

- You idle your own vehicle, and
- The car in front is parked and idling.

We replicated this across a number of locations, including busier and quieter roads, to evaluate if there are potential differences. We also compared these with following a bus at bus stops and a traffic queue caused by a broken down vehicle. This was 'citizen science' and not robust research findings conducted by an academic organisation.

Experiment Setup

We used an AirBeam 3 Particulate Monitor which measured PM2.5 and PM10 inside the vehicle. We have concentrated on the PM2.5 results as they are the fraction of particulate matter that cause most health concern.

The set up for the offroad/driveway option is shown in the below photo. The Air Casting App showing data recording from AirBeam 3 Particulate Monitor are both located close to the vehicles' air vent.

COOLWORLD CONSULTING

Whilst driving, the monitoring equipment was on the front passenger seat so as not to impact the driver.

Experiment Scenarios

The monitoring was taken in early December 2021 during a period where no air quality alerts had been issued. The same petrol vehicle with the same fan/ventilation setting, drawing in outside air, was used to record all monitoring scenarios.

The scenarios under which the monitoring was undertaken are described below, indicating the type of road, weather conditions, the type of vehicle or vehicles idling.

- Scenario 1: Still day (low wind), driveway, own Petrol car idling (and recording).
- Scenario 2: Slight wind, driveway, Petrol car in front idling, own Petrol car recording also idling.
- Scenario 3: Windy day, quiet road, own Petrol car idling.
- Scenario 4: Still day (low wind), quiet road, Petrol car in front idling, own car off with fan on.
- Scenario 5: Still day, busy road, side of road, own car idling.
- Scenario 6: Still day, busy road, side of road, car in front idling, own car idling.
- Scenario 7: Slight wind, busy road at normal times. Driving and hitting a traffic jam caused by a broken down vehicle, long queue of idling vehicles.
- Scenario 8: Still day, busy road. Following and driving behind a (diesel) bus, pulling in behind it as it idled at bus stops, own car idling.

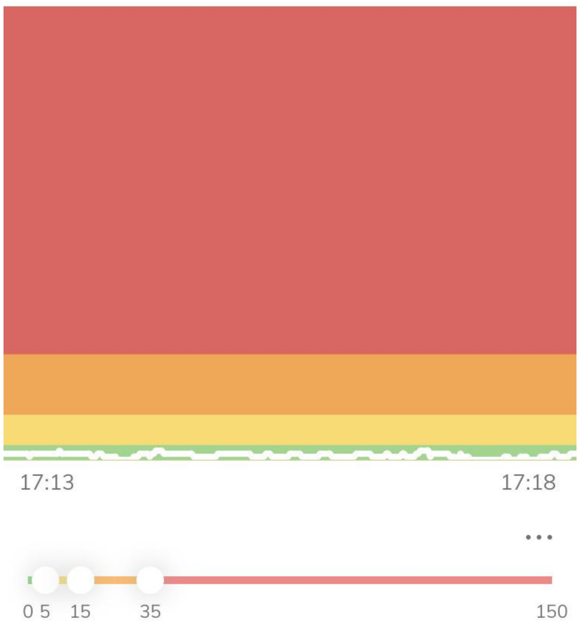
We used the following coloured bands, from lowest to highest concentrations ($\mu g/m^3$), for the indicative ranges of PM2.5 in the graphs recording the results:

- Green range: 0-5 (5, corresponding to WHO annual mean Air Quality Guideline)
- Yellow range: 5-15 (15, WHO 24-hr mean Air Quality Guideline)

- Orange range: 15-35 (35, Boundary of Low to Moderate PM2.5 in DEFRA's Daily Air Quality Index)
- Red range: 35 to 150 (150, Maximum concentration detected by device).

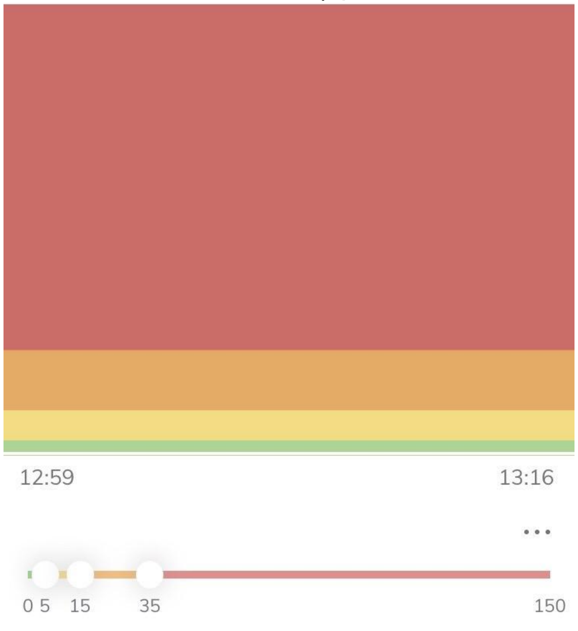
Results

<u>Scenario 1</u>: Still day (low wind), driveway, own Petrol car idling
Background: PM2.5 = 1 $\mu g/m^3$
Peak: PM2.5 = 4 $\mu g/m^3$



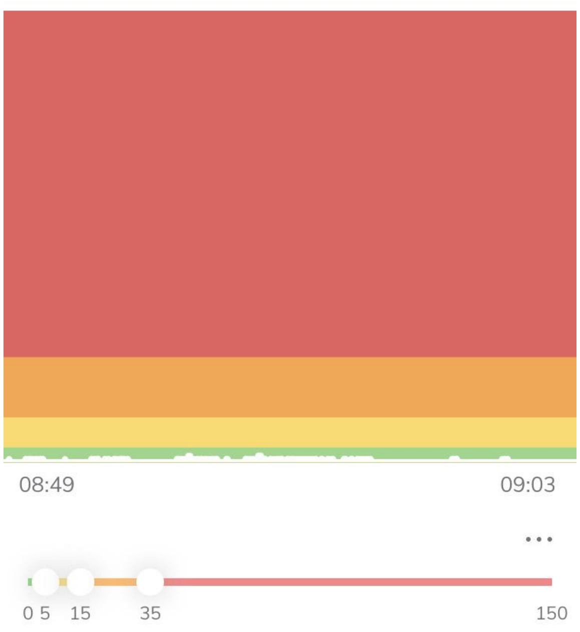
In Scenario 1, the background concentration was 1$\mu g/m^3$ which quickly increased to a peak reading of 4$\mu g/m^3$ and continued to fluctuate over 2 and a half minutes within a narrow range to another peak of 4$\mu g/m^3$, before dropping quickly to background levels as the idling stopped.

Scenario 2: Slight wind, driveway, Petrol car in front idling, own Petrol car recording also idling
Background: PM2.5 = 0 $\mu g/m^3$
Peak: PM2.5 = 0 $\mu g/m^3$



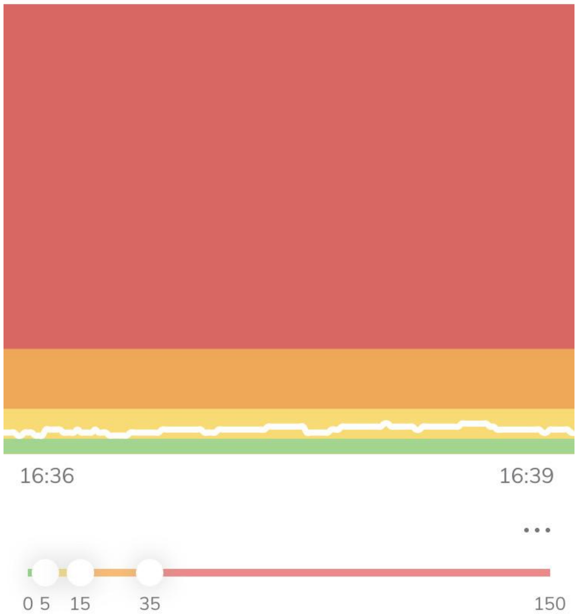
In Scenarios 2, the background and peak monitoring levels were not recorded above the minimum level of detection (i.e. 0 $\mu g/m^3$) throughout the time of idling.

Scenario 3: Windy day, quiet road, own Petrol car idling:
Background: PM2.5 = 0 $\mu g/m^3$
Peak: PM2.5 = 1 $\mu g/m^3$



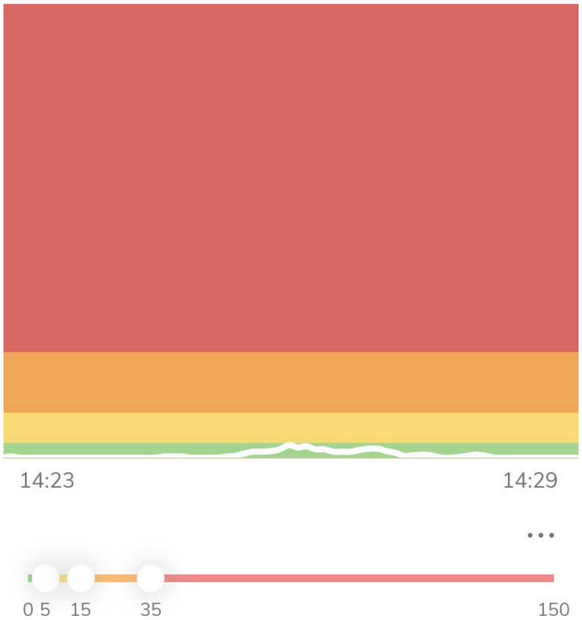
In Scenarios 3, the background was 0$\mu g/m^3$ and gradually reached peak of 1$\mu g/m^3$ in the middle of the idling before returning to 0$\mu g/m^3$.

<u>Scenario 4</u>: Still day (low wind), quiet road, petrol car in front idling, own car off with fan on:
Background: PM2.5 = 5 μg/m^3
Peak: PM2.5 = 7 μg/m^3



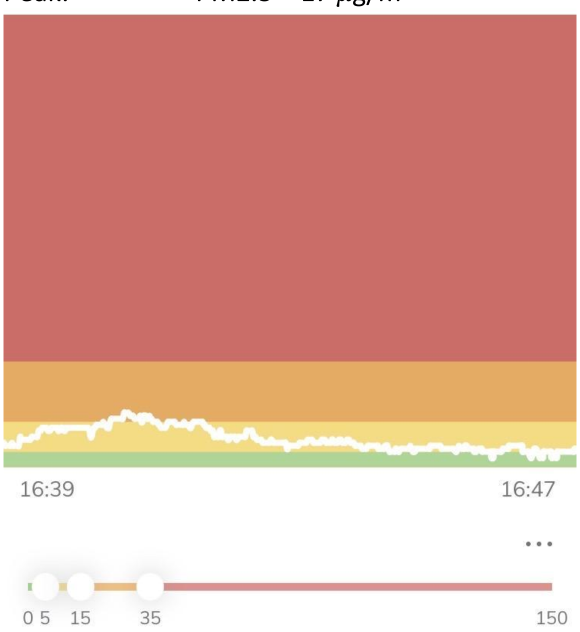
In Scenario 4, the background concentration was 5μg/m^3 with two periods of approximately 1 minute each with slightly higher readings, both reaching a peak of 7μg/m^3. The readings dropped quickly back to background levels when the idling finished.

Scenario 5: Still day, busy road, side of road, own car idling.
Background: PM2.5 = 1 $\mu g/m^3$
Peak: PM2.5 = 5 $\mu g/m^3$



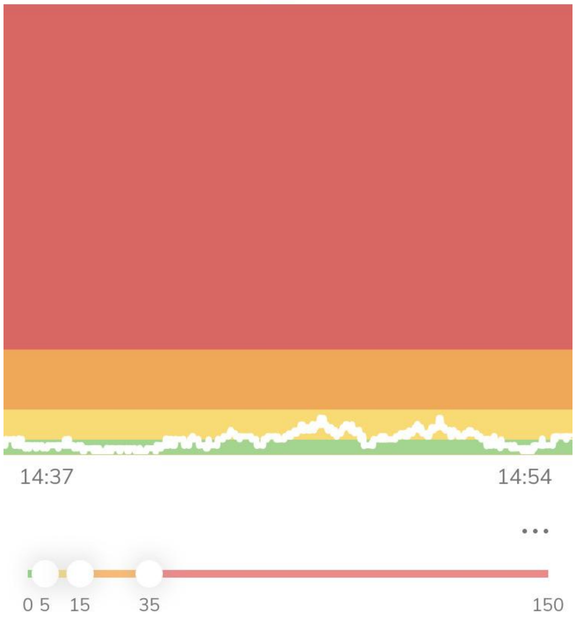
In Scenario 5, the background concentration was 1$\mu g/m^3$ prior to idling with a relatively short but steady increase to a peak of 5$\mu g/m^3$, some oscillation during the idling of 2-3 minutes, and a quick decrease to background levels, when the idling stopped.

Scenario 6: Still day, busy road, side of road, car in front idling, own car idling
Background: PM2.5 = 5 $\mu g/m^3$
Peak: PM2.5 = 17 $\mu g/m^3$



In Scenario 6, the background concentration was 5μg/m^3 prior to idling with a relatively short but steady increase to a peak of 17μg/m^3 during the idling of approximately 3 minutes, before a long steady decrease back to background levels.

Scenario 7: Slight wind. Busy road at normal times. Driving and hitting a traffic jam caused by a broken down vehicle, long queue of idling vehicles.
Background: PM2.5 = 3 μg/m^3
Peak: PM2.5 = 13 μg/m^3

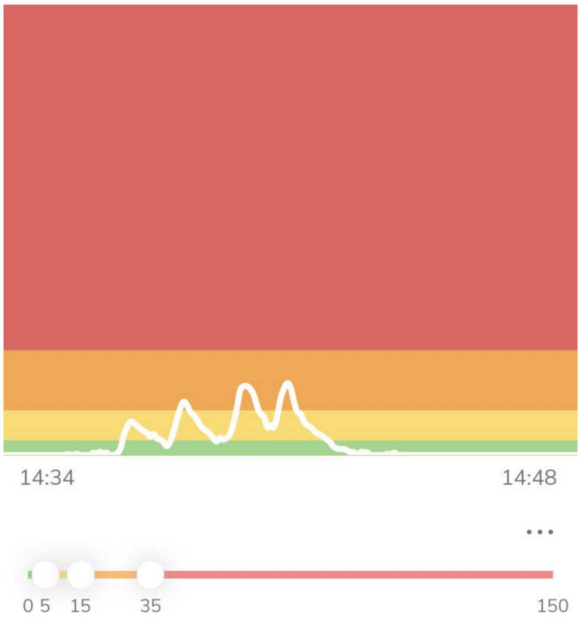


In Scenario 7, the monitoring was undertaken whilst driving in traffic. The background PM2.5 concentration was 3μg/m^3, which can be seen for approximately the first 5 minutes of monitoring. Then we encountered a long queue of idling vehicles in a traffic jam up a steep hill, caused by a broken down vehicle. The PM2.5 concentrations built up over the next few minutes to a peak reading of 13μg/m^3. As we continued in the traffic jam, there were several peaks recorded above 10μg/m^3, and the troughs had raised concentrations above background levels. The concentrations only returned to the background levels after the broken down vehicle had been passed. (There is a slight increase at the end of the graph, after 14:54, where further traffic was encountered).

Scenario 8: Still day, busy road. Following and driving behind a (diesel) bus, pulling in behind it as it idled at bus stops, own car idling.

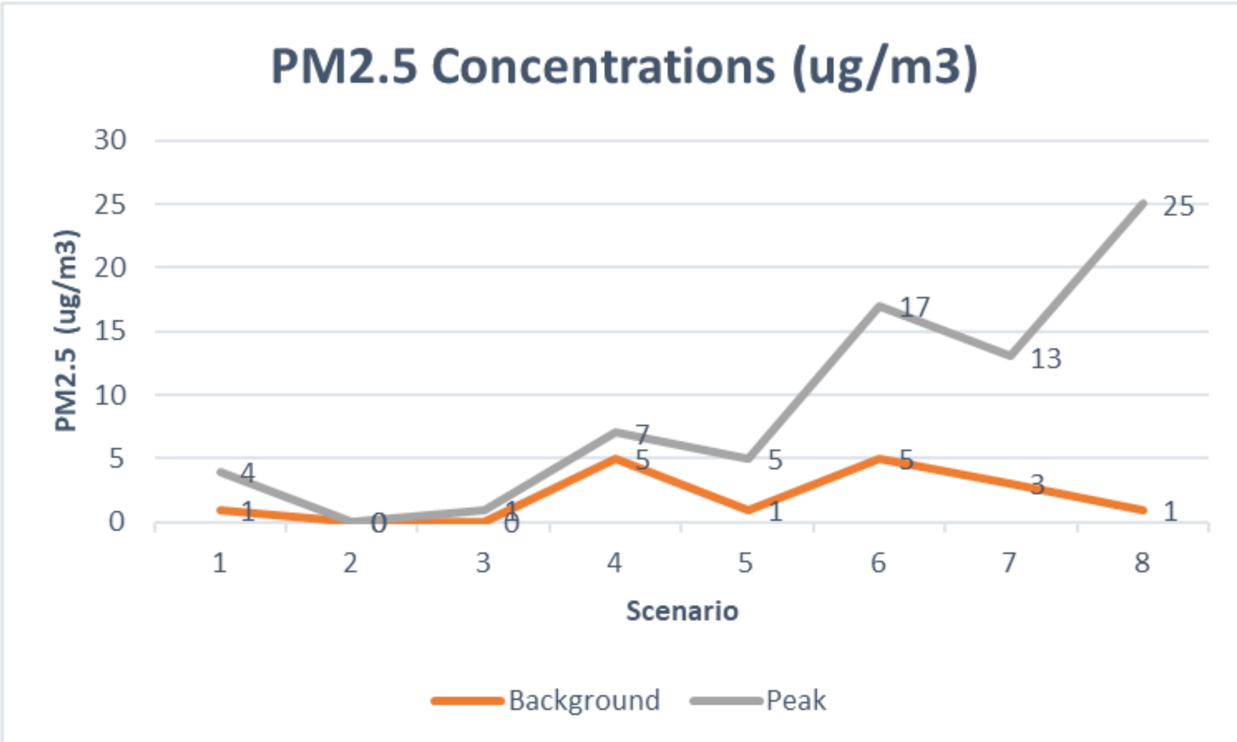
Background: PM2.5 = 1 μg/m^3

Peak: PM2.5 = 25 μg/m^3



In Scenario 8, the monitoring was undertaken whilst following a bus in traffic on a busy road. The background PM2.5 concentration was 1 μg/m^3 with a peak reading of 25 μg/m^3. We followed the bus and waited behind it at successive bus stops. The highest peak concentrations recorded in the experiment were in this scenario. The concentrations can be seen to oscillate from low whilst driving to high whilst idling at the bus stops, with increasing peaks and troughs, indicating the PM2.5 is accumulating to some extent. The initial background reading quickly rises from 1μg/m^3 to 12μg/m^3 as we stop behind the bus at the first bus stop, before dropping slowly to 4μg/m^3 as we drive to the next bus stop, rising quickly again at the next bus stop to 17μg/m^3, falling back to 5μg/m^3 whilst driving, rising again to 25μg/m^3 whilst at the bus stop, dropping to 10μg/m^3, before quickly rising to 25μg/m^3 again at the last bus stop. The concentrations then fall to background levels as we stop following the bus.

Discussion



The graph above shows the background and peak concentrations of PM2.5 (vertical axis) recorded inside the vehicle in all eight scenarios (numbered 1-8 on the horizontal axis) of the experiment.

The background PM2.5 concentrations were $5\mu g/m^3$ or below across all scenarios. The highest background concentrations of $5\mu g/m^3$ were recorded in Scenario 4 (still day, quiet road) and Scenario 6 (still day, busy road), with the lowest, $0\mu g/m^3$, in Scenario 2 (windy day, driveway) and Scenario 3 (windy day, quiet road).

Scenario 2 (windy day, driveway) and Scenario 3 (windy day, quiet road) had the lowest peak PM2.5 concentrations (0 and $1\mu g/m^3$, respectively). The highest peak concentration of $25\mu g/m^3$, was recorded in Scenario 8 (still day, busy road) followed by Scenario 6 (still day, busy road) with $17\mu g/m^3$.

In Scenarios 1 and 2, located on the driveway, and Scenarios 3 and 4, located on a quiet road, there was also only a small difference ($3\mu g/m^3$ or less) between background concentrations and the peak readings. In these scenarios where wind was noted, there were the smallest difference or no difference between background and peak readings.

In Scenarios 5 to 8, located on the busy roads, the difference between the background and the peak readings were larger, with the biggest difference of $24\mu g/m^3$, being in Scenario 8, whilst following the bus. Additionally in these scenarios, the increases in PM2.5 concentrations that occurred during the periods of idling were most obvious (see peaks on the graphs), before falling when the idling stopped/we drove away.

In Scenarios 1 (driveway), 3 (quiet road), and 5 (busy road) only the vehicle recording the PM2.5 concentrations was idling. The recorded concentrations were low. The corresponding scenarios, 2 (driveway), 4 (quiet road), and 6 (busy road), where there was a vehicle in front also idling, had relatively low PM2.5 concentrations within the recording vehicle, except for Scenario 6 which recorded 17$\mu g/m^3$. In the quiet traffic situations, it appears the wind level had a greater bearing on the level of in-vehicle peak PM2.5 concentrations, with higher concentrations noted in the still weather. However, when comparing the concentrations in the busy road situations, the in-vehicle concentrations were much higher when there was a vehicle in front also idling, rather than when only the monitoring vehicle was idling.

Scenarios 7 and 8, also on busy roads but in traffic rather than on the side of the road, further illustrated the point that the in-vehicle concentrations were much higher when there was a vehicle in front also idling.

Conclusions

Lower peak PM2.5 concentrations were detected in scenarios located on the driveway and quiet roads with higher concentrations noted in the busy road scenarios. Within the same road category scenarios, windier days had lower readings than still days. The two highest peak readings were noted on still days and on busy roads. The highest peak reading was from the scenario where we followed a diesel bus as it idled at several bus stops on a busy road.

In all scenarios where only the vehicle recording the PM2.5 concentrations was idling, the recorded concentrations were low. In the quiet traffic situations where there was a vehicle in front also idling, relatively low PM2.5 concentrations were recorded within the monitoring vehicle as well. In the quiet traffic situations, it appears the wind level had a greater bearing on the level of in-vehicle peak PM2.5 concentrations than whether there were one or two vehicles idling, with higher concentrations noted in the still weather.

When comparing the concentrations in the busy road situations, the in-vehicle concentrations were much higher when there was a vehicle in front also idling, rather than when only the monitoring vehicle was idling. The scenarios in traffic on busy roads, rather than on the roadside, further illustrated the point that the in-vehicle concentrations were much higher when there were vehicles in front also idling.

From these results, the amount of traffic, the weather, and where you are idling in the road (roadside or main carriageway) have a bearing on the PM2.5 concentrations inside a vehicle. Cleaner (non-diesel) buses or buses with stop-start engine technology may facilitate a significant reduction in PM2.5 concentrations whilst at bus stops.

These results would suggest that in-vehicle pollution levels can be very high when in stationary traffic.

The greatest opportunity to significantly reduce drivers' (and passengers') exposure to air pollution due to idling would be to encourage drivers to switch off their engines when stopped in traffic, such as at junctions or traffic lights.