Design and Implementation of Ambient Temperature and Carbon Monoxide Measuring Tools in the Car Cabin: A Case Study of Parking Area in the Universitas Negeri Padang

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Abstract **– Cars parked in sunny locations are frequently exposed to direct sunlight, which increases cabin temperature. This study developed a prototype measuring tool to investigate increases in carbon monoxide (CO) concentration and ambient temperature inside car cabins, with case implementation in parked cars in the Universitas Negeri Padang area. Temperature sensors and CO detectors were installed to record in cabin temperature and CO levels at various time intervals during the parking period. The results showed that the prototype identified a relationship between longer sun exposure and higher cabin temperature and CO concentration. In-cabin temperatures exceeded 61.17°C and CO concentrations reached 18.67 ppm, both potentially harmful to health. The study highlights the need to raise awareness of these health risks and to apply mitigation measures such as using sun visors or parking in shaded areas.**

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1. Introduction

Cars parked in sunny locations without shade at Universitas Negeri Padang are frequently exposed to direct sunshine, increasing the temperature inside the cabin. According to [1] and [2], this condition not only causes discomfort for motorists returning to their vehicles, but it also poses major health hazards. Furthermore, [3] and [4] discovered that one factor that is frequently disregarded is the accumulation of harmful gases, particularly carbon monoxide (CO), in the cabin of an automobile parked in a confined environment.

CO is one of the gases that damage the atmosphere. Carbon monoxide is commonly found on highways because it is created by the incomplete combustion of air and automobile gasoline. Imperfect combustion produces carbon monoxide gas, which enters the cabin through a leak in the air conditioner [5], [6], [7]. Carbon monoxide is a colorless, odorless, and tasteless gas made up of one carbon atom covalently bonded to one oxygen atom (O_2) [8]. In the other side, [9] and [10] stated that when motorists or passengers in motorized vehicles are exposed to carbon monoxide gas, they typically experience shortness of breath and headaches if ingested in a short period of time. Furthermore, [11], [12] and [13] claim that if a driver or passenger inhales for an extended period, they can be poisoned, lose consciousness and die. The Occupational Safety and Health Administration (OSHA) defines the allowable exposure limit at 35 ppm [14].

Solar radiation is a major contributor to the rise in the ambient temperature in a car cabin. According to [11] mention solar radiation entering the car cabin through the window can produce a considerable greenhouse effect, raising the temperature in the cabin considerably above that of the surrounding environment. According to their findings, high-intensity solar radiation can raise the temperature inside the cabin by 30-50% above the outside temperature. The study also discovered that car color and interior materials have a substantial impact on increasing the temperature rise. Dark shades and heat-absorbing materials raise temperatures faster than light colors and reflecting materials [15]. The issue of increased temperatures and CO concentrations in the cabs of parked cars has gotten little attention at Padang State University. Many drivers are unaware of the health concerns associated with these illnesses. According to [16] research, most parking lots on campus lack appropriate shade, resulting in a considerable increase in car cabin temperature.

Numerous investigations have been undertaken, including [17], which used a transient thermal model to evaluate the soak temperature heat distribution in the passenger compartment in different orientations. The results suggest that the driver and baby endure the least amount of heat while the car is parked outside. Furthermore, [1], [18] investigated the effect of window openings on the vehicle's thermal environment. Under high temperatures and intense sun radiation, open windows cool the cabin air to a maximum of 6.70°C. Considering previous studies, this study departs from the notion that high temperatures within a parked car's interior might raise the quantity of harmful gases such as CO. By analyzing temperature and CO concentration data at different time intervals, the relationship between the duration of sun exposure, temperature increase, and CO accumulation in the automobile cabin. This information is critical for identifying the major causes of the ailment and developing relevant remedies.

The purpose of this study is to investigate the increase in CO content and ambient temperature in the cabins of parked cars at Universitas Negeri Padang. The primary goal is to discover factors that influence the rise in temperature and CO concentrations and make recommendations to lessen health risks for car drivers and passengers. The temperature and CO content in the car cabin will be measured at various time intervals throughout the parking duration. The data will be analyzed to discover the relationship between the period of solar exposure, temperature increase, and CO concentration.

The study will also investigate mitigation methods that can be used to lessen the harmful impact of these conditions, such as the usage of sunshades and improved ventilation.

The primary result of this study is greater understanding of the health concerns caused by high temperatures and CO concentrations in car cabins. Furthermore, this study will make practical recommendations for vehicle owners and campus managers to reduce these hazards through preventive measures such as the usage of sun visors, greater ventilation, and the choosing of shadier parking lots. The importance of this study stems from the potential for serious health consequences from CO exposure and high temperatures within car cabins. Given the huge number of vehicles parked on the Universitas Negeri Padang campus daily, it is critical to rapidly detect and address this issue to preserve the health and safety of drivers and passengers. It is intended that this study would provide detailed insight into the dynamics of rising temperatures and CO concentrations in the cabins of cars parked at Padang State University. The findings of this study suggest that effective mitigation measures can be applied to lower health hazards. Furthermore, this research is aimed to raise awareness about the need of providing a secure and comfortable parking environment for all car users on campus.

This study develops and implements a device that detects ambient air temperature and the concentration of carbon monoxide levels within the car's cabin. This tool is anticipated to be beneficial in monitoring the rise of carbon monoxide levels in the vehicle cabin relative to increasing temperature. To enhance passenger awareness of the cabin temperature conditions. This is implemented to mitigate the danger of mortality resulting from elevated concentrations of carbon monoxide in the cabin. This study not only helps to improve safety and comfort, but it also provides valuable insights for the establishment of improved environmental rules in campus parking lots.

2. Methodology

This research utilizes a strategy that is experimental. The author [19] defines the experimental research method as a study approach used to determine the effect of specific treatments on others in a controlled setting. Experimental research is conducted to test a treatment by comparing test results from both treatments. Figure 1, Figure 2, and Figure 3 depict the vehicle parking area at Padang State University where this research was done.

a)

b)

Figure 1. Temperature measuring at the UNP auditorium car park:
a) measuring location; b) measuring process

a)

b)

Figure 2. Temperature measuring at the UNP Dormitory car park:
a) measuring location; b) measuring process

a)

b)

Figure 3. Temperature measuring at the UNP FMIPA car park:
a) measuring location; b) measuring process

The study was carried out across numerous days at precise time intervals, ranging from 09.00 to 15.00 WIB. Data was collected in three Padang State University car parks, which were chosen to represent the condition of cars exposed to direct sunshine. The selected locations include the UNP Auditorium parking area (Figure 1), the UNP dormitory parking area (Figure 2), and the UNP FMIPA parking area (Figure 3).

This study uses one Innova Type G 2.0 (M/T) vehicle. Special equipment is necessary to conduct the temperature and CO rise test in the cabin of a parked vehicle.

This equipment must be capable of measuring and recording temperature and CO data correctly and constantly. The temperature and carbon monoxide measurement apparatus in the vehicle cabin, as depicted in Figure 4, comprises an Arduino Uno microcontroller, a 16x2 LCD module, a MQ-7 sensor module, four DHT 11 sensors, a Real-Time Clock (RTC) module, an active buzzer, and a Micro SD card slot.

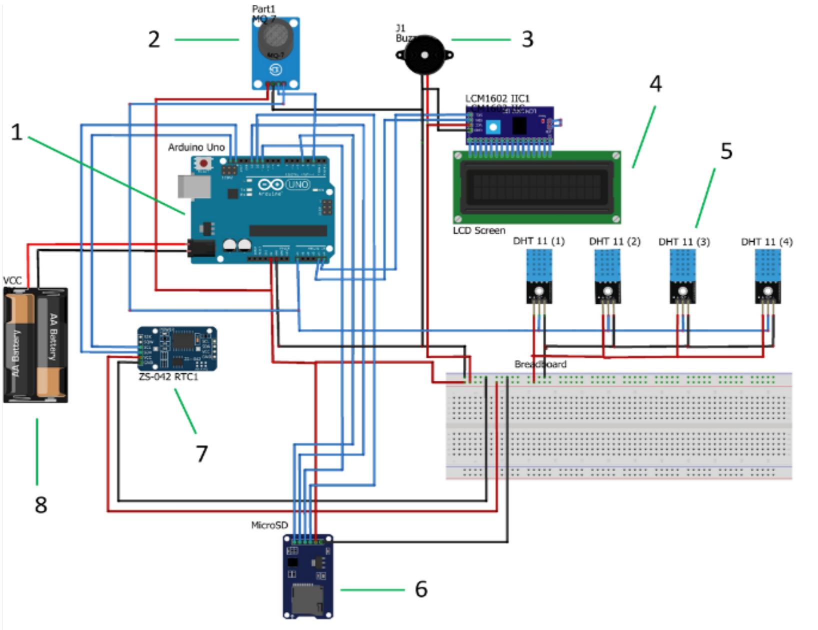

Figure 4. Co and temperature cabin measuring tools, 1) Arduino control, 2) Sensor MQ-7, 3) Buzzer, 4) LCD, 5) Sensor DHT 11, 6) Modul microSD, 7) Modul RTC, 8) Voltage battery

The MQ-7 sensor will detect carbon monoxide concentration levels in the vehicle cabin, while the DHT 11 sensor will measure cabin temperature at various locations.

The 16x2 LCD will be positioned adjacent to the rearview mirror for enhanced visibility to passengers in the vehicle.

This instrument is equipped with an RTC module that enables real-time storage of readings from the MQ-7 and DHT11 sensors onto the SD Card, facilitating data extraction for subsequent processing. This measuring equipment operates efficiently and its production adheres to the current datasheet, enabling car owners and passengers to be more cognizant of elevated temperature and carbon monoxide gas concentration levels within the vehicle interior.

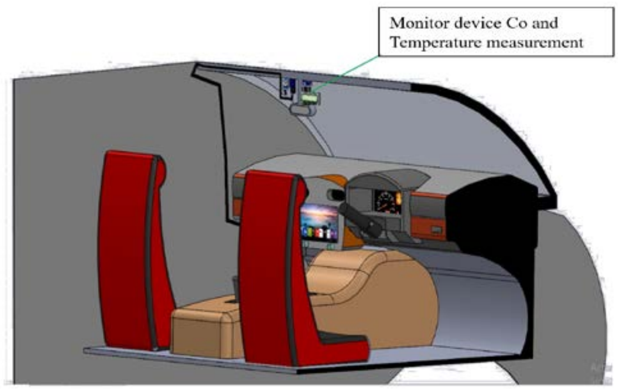

Figure 5. Device visual guide in car cabin measurement

The measurement process was to position the test equipment while the car was parked as shown in Figure 5. Measuring tools and data logger automatically captured cabin temperature and carbon monoxide elevation information. Before capturing temperature measurements, the data logger's parameters must be adjusted on a laptop or PC. In this scenario, the data logger clock is set to match the time on the computer, and the data capture time interval is set to one hour, implying that the data logger will record and store the current temperature data every hour. This research was conducted in several test scenarios of increasing temperature and carbon monoxide in the cabin of a parked vehicle.

The scenarios carried out can be seen from Table 1, and the Table 2 is the time for measuring cases. To analyze the entire data gathered and determine the results of monitoring CO levels, the temperature in the cabin during parking in the sun is calculated using the test's average results. Furthermore, create a plot graph to see the difference in the findings obtained during the test. To end the research outcomes, look at the growth in graphs generated from the research data. As a result, the goal of this research, as well as the graphs presented, will be answered by examining the trends in the temperature and CO graphs created in the vehicle cabin.

Table 1. Description of the experimental scenario

Scenarion	Descriptions
1	Temperature increase and carbon monoxide concentration were measured in the cabin of a parked car with no shade, all windows closed, and no temperature reduction strategy applied. The parking lots used are the UNP Auditorium, UNP Dormitory, and FMIPA UNP.
2	Measuring the increase in carbon monoxide concentration in the cabin of a parked automobile after a lengthy travel (2 hours) with the engine and air conditioning running and distinguishing the treatment of the car by slightly lowering the windows (5 cm) versus not lowering the windows.
3	Temperature increases and carbon monoxide concentration in the cabin of a parked car were measured using the temperature reduction method with and without the installation of a heat-shielding material (Aluminium foil).

Table 2. Description of measurement cases

Cases	Date	Location	Treatment	Outside temperature
1	10 June 2025	Auditorium area	Without treatment	36.65 ^{0}C
	11 June 2025	Auditorium area	Without treatment	35.43 ^{0}C
	12 June 2025	Auditorium area	Without treatment	35.78 ^{0}C
	19 June 2025	Dormitory area	Without treatment	37.56 ^{0}C
	20 June 2025	Dormitory area	Without treatment	35.92 ^{0}C
	21 June 2025	Dormitory area	Without treatment	36.15 ^{0}C
	24 June 2025	FMIPA area	Without treatment	35.63 ^{0}C
	25 June 2025	FMIPA area	Without treatment	35.06 ^{0}C
	26 June 2025	FMIPA area	Without treatment	35.78 ^{0}C
2	29 June 2025	Auditorium area	Wear protection	36.85 ^{0}C
	1 July 2025	Auditorium area	Wear protection	37.09 ^{0}C
	2 July 2025	Auditorium area	Wear protection	35.41 ^{0}C
3	4 July 2025	Auditorium area	Window opened (5 cm)	36.81 ^{0}C
	6 July 2025	Auditorium area	Window opened (5 cm)	36.80 ^{0}C
	8 July 2025	Auditorium area	Window closed	35.74 ^{0}C
	9 July 2025	Auditorium area	Window closed	35.50 ^{0}C

3. Results

Based on the research on the design and implementation of an ambient temperature and carbon monoxide measurement tools in a car cabin, with the parking area of Universitas Negeri Padang as the case study, the following section presents the research findings.

3.1. Temperature and Carbon Monoxide Measurements with Three Different Parking Positions

According to [3], the air temperature in the cars cabin is 20-30°C higher than the ambient temperature after heat soak. Furthermore [1] and [20] state that when the driver enters the car, it is influenced by the heat wave and feels uncomfortable. High temperatures will also cause the dashboard, seat covers, and other accessories to emit harmful gasses, accelerating their aging [21]. According to the research findings in Figure 6 and Figure 7, both graphs show a positive link between temperature increase and CO content in the cabin of a parked car.

Figure 6 depicts the average temperature in the cabins of automobiles parked at Padang State University in three locations: the UNP Auditorium, the UNP Dormitory, and the FMIPA UNP. Figure 5 shows that the temperature in the cabin of each car parking place gradually increases over time. At 12.20, the temperatures in the automobile cabins in each parking area were 55.4°C, 54.33°C, and 54.7°C.

The UNP Auditorium parking area had the greatest temperature (61.17℃), while other regions had temperatures of 60.67℃ and 60.37℃, respectively. The temperature inside the cabin climbed by 38.59% when compared to the outside temperature.

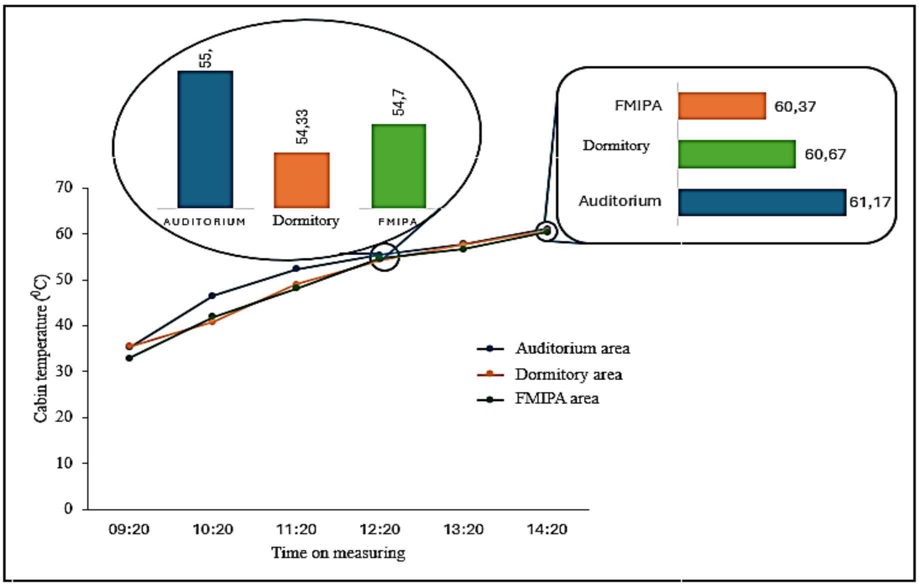

Figure 6. Measurement curve of temperature increases in the vehicle cabin in 3 parking positions

Figure 7 depicts the average concentration of CO in the cabins of automobiles parked at Padang State University, namely in the parking areas of the UNP Auditorium, UNP Dormitory, and FMIPA UNP. As the cabin temperature rose, so did its CO concentration.

At 12:20, the CO concentration in the cabins of each parking lot was 15.67 ppm, 14.33 ppm, and 12.67 ppm. The maximum concentration of carbon monoxide was recorded when the vehicle was parked in the UNP Dormitory parking lot, at 18.67 ppm, while other sites recorded 17.33 ppm and 17.67 ppm.

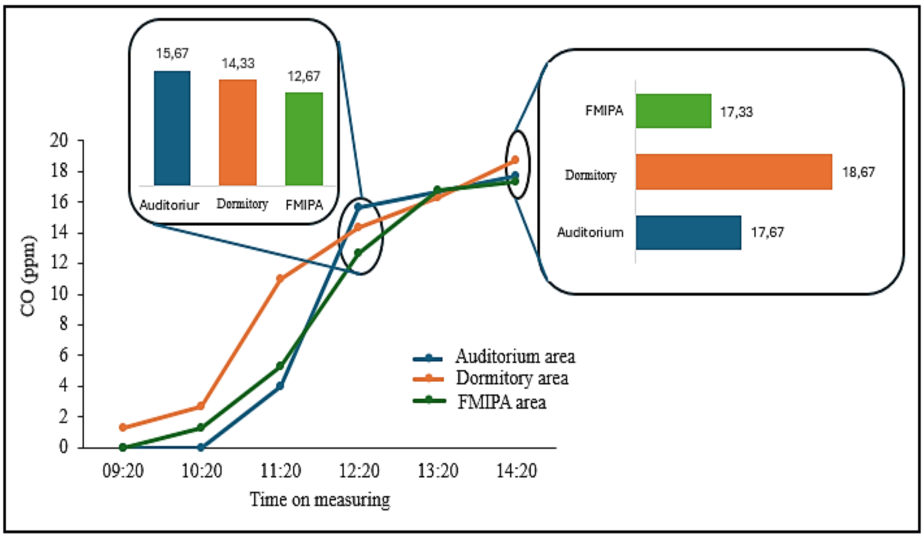

Figure 7. Measurement graph of carbon monoxide increases in vehicle cabin in 3 parking positions

3.2. Carbon Monoxide Measurement in Parked Cars After a Long Trip

Figure 8 depicts the measurement of carbon monoxide levels in the cabin of a parked car, with the window glass slightly lowered and closed. Figure 7 shows data acquired after a long travel with the car's engine and air conditioner operating while parked.

Within an hour of slightly opening the window glass, the carbon monoxide concentration went from 2.5 ppm to 9.5 ppm, while closing the window glass increased the CO concentration from 3.5 ppm to 17 ppm. This considerable rise implies that inadequate ventilation in a confined location might accelerate CO collection, particularly while the automobile is running, and the air conditioning is turned on.

When the car is parked, slightly opening the window glass reduces CO concentration in the cabin by 44.1% compared to closing the window glass.

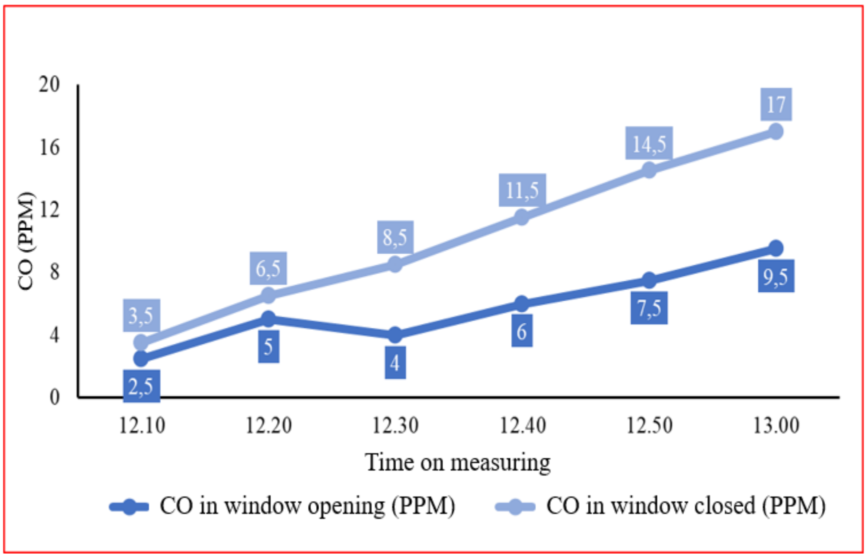

Figure 8. Carbon monoxide measurement chart after a long trip

3.3. Car Temperature and Carbon Monoxide Measurements by Different Car Treatments

Figure 9 indicates that the temperature and carbon monoxide in the unprotected cabin grew from 35.20°C to 61.17°C, while CO increased from 0 to 17.67 ppm.

With window protection, the car's temperature rose from 32.7°C to 46.6°C, while CO His climbed from 0 to 5.3 ppm. The increase in temperature and carbon monoxide concentration in cars with shields is 23.8% and 69.8% lower than in cars without shields, respectively.

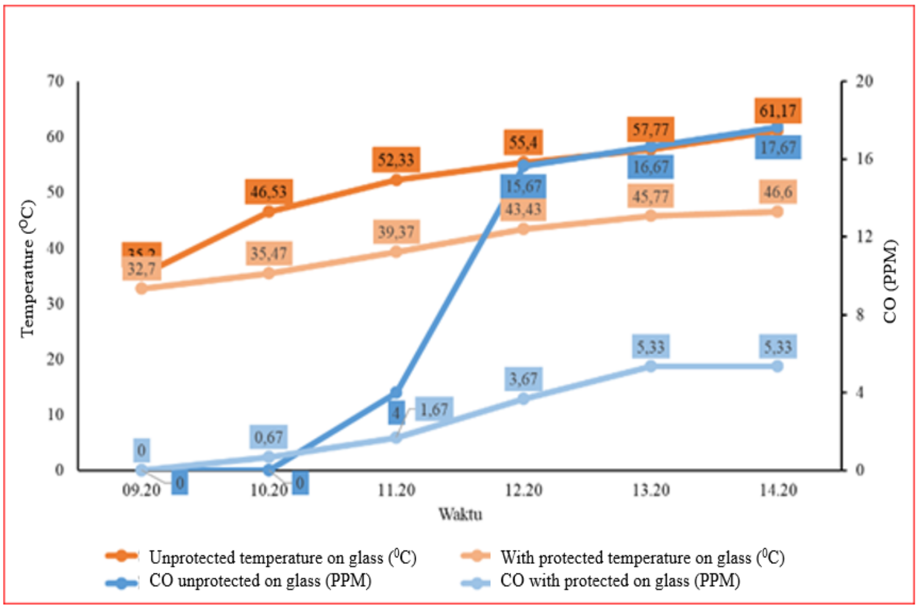

Figure 9. Temperature and carbon monoxide measurement graphs of cars with different treatments

4. Discussion

According to the study conducted by [11], [14], and [20], which investigated the increase in vehicle cabin temperature due to various situations. Furthermore, [1] and [15] investigated the influence of changes in vehicle window glass apertures on cabin air temperature.

Research has also been conducted on the relationship between cabin temperature and interior temperature inside the vehicle cabin by [21] and [9]. While various photovoltaic cooling solutions have been implemented, such as [3] and [5] who have measured carbon monoxide levels in the vehicle interior while it is in motion.

This study adds to the existing knowledge by documenting the rise in air temperature and carbon monoxide levels in the cabin when the vehicle is parked. As a result, findings will provide researchers and the public with additional information to help them park wisely near UNP. Furthermore, the findings of this study revealed that in order to prevent a drastic increase in temperature in hot weather and the reflection of direct sunlight when parked, vehicle owners should protect their vehicles with a car cover made of high-quality materials that do not harm the surface layer of vehicle paint.

Based on study [17] that mention car covers have numerous advantages because, in addition to acting as a barrier to direct sunlight exposure to the vehicle, they also safeguard the longevity of the cars external body from fading colours caused by direct exposure to changing weather. In addition, [20] mention the car cover, the glass cover and the choice of quality window film are important aspects in keeping the vehicles cabin temperature stable. When parking a car in hot weather or in direct sunlight for an extended period of time, vehicle owners must also pay attention to the objects stored within the vehicle. During hot weather, [22] suggest that vehicle owners should quickly dispose of any remaining food or beverage waste and avoid storing volatile aerosol-based things such as perfume, deodorant spray, car fragrance spray, lighters, and so on. This is because aerosol-containing goods are prone to exploding when exposed to high temperatures. Make sure to do so to ensure your driving comfort. It would be preferable if vehicle owners could park their autos in a shaded area. Aside from increasing driving comfort, [23] suggest that parking in a shady area has a far broader impact, such as ensuring the durability of the vehicle's exterior and interior.

Relating to research [3] the interior temperature of an automobile parked in the scorching sun might reach 76 degrees Celsius. This temperature is sufficient to melt lipstick, which is normally stored in the glove compartment.

Even though the temperature outside the car, particularly in the tropics, ranges between 28 and 31 degrees during the dry season. This condition is caused by ultraviolet radiation and hot air trapped without proper circulation. The heat-reflective properties of the dashboard materials contribute to heat accumulation, while the presence of window tint also affects interior temperature, making it hotter due to its insulating properties.

In tropical regions, [14] mention that the temperature inside the automobile cabin will rise dramatically throughout the day, whereas in subtropical countries it will rise significantly during the summer. During the dry season, for example, a car in direct sunlight with the windows closed will rapidly raise the temperature in the cabin.

Such rises in temperature have a negative influence on passenger comfort and health. Several experts have already investigated the temperature of the car cabin while the air conditioner is turned on. Solar radiation and passengers can cause cabin seat temperature to rise slightly beyond the outside temperature, but the cooling rate in the cooling stage is substantially lower than the outside air temperature. The model can estimate the average temperature, which is equivalent to the experimental results, indicating that the actual thermal comfort of the human body under idle and driving situations varies with time. The forecast accuracy of the two models is higher during idle conditions than under driving conditions, and the comparable temperature model outperforms the average predictive model.

5. Conclusion

This study demonstrated a favourable relationship between temperature increase and CO levels in the cabins of vehicles parked at three locations at UNP detected by the prototype of measuring tools. High temperatures in the cabin cause an increase in CO content due to chemical reactions and gas accumulation from external sources. In example, the temperature increase in the cabins of parked cars can reach deadly levels within an hour, especially during the day when sun radiation intensity is higher, as well as parking in UNP dormitories. CO concentrations also increased, while they remained within safe limits when parking at the auditorium and using FMIPA for short-term exposure. However, prolonged exposure to high CO concentrations might be harmful to one's health. In summary, these findings highlight the necessity of maintaining proper ventilation and avoiding lengthy parking in direct sunlight to decrease health risks. Mitigation techniques, such as using sunshades on windshields and opening windows before entering the vehicle, can help limit the rise in temperature and CO concentration in the cabin.

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