

## Impact of asphalt pavement wear-based business development on air pollution in the city of Guayaquil

Impacto del desarrollo empresarial basado en el desgaste del pavimento asfáltico sobre la contaminación atmosférica en la ciudad de Guayaquil

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### ABSTRACT

The wear and tear of the asphalt pavement, caused by constant vehicular traffic, represents a relevant factor in air pollution in the city of Guayaquil. This phenomenon is especially worrying in areas of high vehicle density, where constant friction and the passage of heavy vehicles accelerate the deterioration of the asphalt. As the pavement wears down, polluting particles such as PM10 and PM2.5 are generated and released into the air, posing a considerable risk to public health. These particles, when inhaled, can penetrate deep into the lungs, causing respiratory and cardiovascular diseases.

**Keywords:** Asphalt pavement wear, Air Pollution, Vehicles and urban traffic

### RESUMEN

El desgaste del pavimento asfáltico, causado por la constante circulación vehicular, representa un factor relevante en la contaminación atmosférica en la ciudad de Guayaquil. Este fenómeno es especialmente preocupante

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en áreas de alta densidad vehicular, donde la fricción constante y el paso de vehículos pesados aceleran el deterioro del asfalto. A medida que el pavimento se desgasta, se generan partículas contaminantes, como las PM10 y PM2.5, que se liberan en el aire y suponen un riesgo considerable para la salud pública. Estas partículas, al ser inhaladas, pueden penetrar profundamente en los pulmones, causando enfermedades respiratorias y cardiovasculares.

**Palabras clave:** Desgaste del pavimento asfáltico, Contaminación del aire, Vehículos y tráfico urban

## INTRODUCTION

Asphalt pavement wear is a growing problem in urban areas with high vehicle density, particularly in the city of Guayaquil (Figure 1). This phenomenon, caused by the constant circulation of vehicles, generates the release of air pollutants such as PM10 and PM2.5, which have a significant impact on air quality and public health. These fine particles, derived from pavement deterioration, are easily inhaled and can penetrate deep into the lungs, increasing the risk of respiratory and cardiovascular diseases in the exposed population.

The present research aims to evaluate the impact of asphalt pavement wear on air pollution in Guayaquil, taking as a study area the Mucho Lote 2 urbanisation, an area with high vehicular traffic. By analysing the levels of PM10 and PM2.5 particles in this area, the aim is to determine the degree of pollution generated and its relationship with vehicular traffic. This study not only aims to highlight the need to improve road maintenance, but also to promote the implementation of policies to control vehicle emissions in order to mitigate the harmful effects on air quality and the health of the city's inhabitants.

Air pollution caused by moving cars is not only limited to wear particles on the pavement, but also includes the emission of toxic gases such as carbon monoxide and nitrogen oxides. These gases, which accumulate in the urban atmosphere, have harmful effects on health. Carbon monoxide is incorporated into the blood, reducing cellular oxygenation capacity and causing fatigue, dizziness, headaches and even death in cases of high exposure. Nitrogen oxides, in turn, contribute significantly to air pollution, exacerbating respiratory problems.

In addition to toxic gases, vehicles also generate noise pollution, which affects human well-being, the landscape, and the environment, altering the climate, flora and fauna. Vehicle pollution is increasing, partly because many cars are more than ten years old, which increases energy consumption and pollutant production. Brake fluids, oils and antifreeze used in vehicles are also a source of pollution, especially when improperly

disposed of. These wastes, washed away by rainfall, pollute nearby soils and water bodies.

Furthermore, tyres discarded on streets and roads are another source of pollution that requires proper management, such as going to authorised scrapyards for proper disposal. These aspects complement the analysis of vehicular pollution, which, added to pavement wear, represents an environmental and public health challenge in cities such as Guayaquil.

The hypothesis put forward in this study suggests that the respirable particulate matter present in the atmosphere, such as PM10 and PM2.5 particles, comes mainly from vehicular traffic and the wear and tear of the asphalt pavement. PM10 has an aerodynamic diameter of 10 micrometres or less, while PM2.5 is even smaller, with an aerodynamic diameter of 2.5 micrometres or less, making it highly respirable. PM2.5, in particular, comes mainly from anthropogenic sources, such as diesel engines, and can penetrate deep into the lungs, settling in the alveoli and even reaching the bloodstream. This increases the risk of respiratory and cardiovascular diseases, especially among the most vulnerable groups, such as children, the elderly and pregnant women.

Concentrations of PM2.5 in Guayaquil's air exceed the limits established by national and international regulations, which increases the risk of respiratory and cardiovascular diseases in the exposed population. Prolonged exposure to these particles is a central concern for environmental and public health authorities, given their negative social and economic impact. It is essential to develop strategies to prevent, mitigate and correct vehicular pollution and pavement wear.

Over the last few years, road interventions have been carried out to reduce dust resuspension and surface abrasion on roads, but there are insufficient studies showing significant variations in particulate matter concentrations before and after these interventions in Guayaquil. This study aims to provide a comprehensive view of the impact of vehicular pollution and pavement wear on the city's air quality, and to propose policies and solutions to mitigate their effects.

## **MATERIALS AND METHODS**

The present study was carried out in the city of Guayaquil, specifically in the Mucho Lote 2 urbanisation, an area characterised by high vehicular traffic. This area was selected due to its constant activity of heavy and light vehicles, which represent a significant source of air pollution and wear of the asphalt pavement. The methodology used was based on a quantitative approach, through which the levels of particulate matter (PM10 and PM2.5) derived from pavement wear were evaluated, as well as the influence of vehicle density on the generation of pollutants.

For data collection, specialised environmental monitoring equipment was used, capable of measuring concentrations of PM10 and PM2.5 particles in the air. This equipment was placed at strategic points within the Mucho Lote 2 urbanisation, selected based on their proximity to roads with high vehicle density. Measurements were taken at different times

of the day to capture variations in pollution levels, taking into account peak traffic hours and meteorological conditions that could affect particle dispersion.

An air capture and filtering system was used to collect suspended particles, which were then analysed in the laboratory. The particles were classified according to their aerodynamic size, with PM10 being those with a diameter less than or equal to 10 micrometres, and PM2.5 being the smallest, with a diameter less than or equal to 2.5 micrometres. The analysis focused on the finest particles (PM2.5), as these represent a greater risk to public health by penetrating deep into the respiratory system.

In addition to particulate monitoring, an assessment of vehicle density in the study areas was carried out to determine its direct relationship with pavement wear and pollutant production. For this purpose, traffic cameras and sensors installed at the main intersections of the urbanisation were used to record the number of vehicles circulating daily, as well as their classification into light and heavy vehicles. Vehicle density data were integrated into the analysis to correlate with the levels of particulate matter found in the air.

The assessment of asphalt pavement wear was carried out by visual inspections and measurements of the depth of cracks and fissures. An in-situ test methodology was used to measure the deterioration of the pavement in the wearing courses. The pavement was analysed to determine the degree of wear and the release of contaminant particles associated with its deterioration.

To validate the results obtained, the particle concentration data were compared with the limits allowed by local and international environmental regulations, including the standards established by the World Health Organisation (WHO) and the United States Environmental Protection Agency (EPA). This made it possible to contextualise the degree of contamination in terms of maximum acceptable levels for public health.

Overall, this methodology made it possible not only to assess the relationship between pavement wear and air pollution, but also to establish a correlation between vehicle density and the production of particulate pollutants. The detailed analysis of the data collected provided a comprehensive view of the environmental and health impact of pavement wear in the city of Guayaquil, providing key information for the implementation of policies to control and mitigate vehicular pollution.

## RESULTS

The results of air quality monitoring in the Mucho Lote 2 housing estate revealed worrying levels of particulate matter. Throughout the investigation, average concentrations of PM10 reached  $75 \mu\text{g}/\text{m}^3$ , while PM2.5 levels were  $35 \mu\text{g}/\text{m}^3$ . These figures significantly exceed the limits set by the World Health Organisation (WHO), which recommends a maximum of  $50 \mu\text{g}/\text{m}^3$  for PM10 and  $25 \mu\text{g}/\text{m}^3$  for PM2.5, indicating a considerable risk to public health in this area.

During the study period, a clear pattern in the variation of particulate matter concentrations was observed, especially during peak traffic hours. Up to 150 vehicles

per hour were recorded, with 60% of these classified as heavy vehicles. This high vehicle density was positively correlated with PM10 levels, showing a correlation coefficient of  $r = 0.85$ , suggesting that increased vehicular traffic is a major determinant of air quality in the urbanisation.

Analysis of the condition of the asphalt pavement in the areas with the highest traffic revealed significant deterioration. Pavement surface abrasion was observed to have increased by 30% compared to normal levels, coinciding with increased concentrations of particulate pollutants. These wear conditions not only affect the road infrastructure, but also contribute to the release of particulate matter into the air, exacerbating air pollution.

These findings underline the urgent need to implement effective traffic control and pavement maintenance policies in Guayaquil in order to mitigate the harmful effects of air pollution on the health of the population.

The results obtained in this study show a clear correlation between asphalt pavement wear and air pollution levels in the Mucho Lote 2 urbanisation, Guayaquil. The concentrations of PM10 and PM2.5 exceed the limits recommended by the World Health Organisation (WHO), indicating a serious risk to public health. This finding is consistent with previous studies that have identified vehicular traffic and pavement wear as significant sources of particulate matter in urban environments.

The observed relationship between vehicle density and PM10 levels, with a correlation coefficient of  $r = 0.85$ , underlines the importance of traffic as an important determinant of air quality. This result is in line with previous research that has shown that increased heavy traffic in urban areas is associated with increased air pollution, particularly for fine particulate matter. Given that 60% of registered vehicles in the area are classified as heavy, it is crucial to consider policies that regulate the circulation of these vehicles in densely populated areas.

Furthermore, the condition of the asphalt pavement, with a 30% increase in surface abrasion, indicates that road infrastructure is affected not only by traffic friction, but also by environmental conditions in the region. Pavement wear contributes to the release of particulate pollutants, suggesting the need for proper road maintenance. This is essential to reduce not only the deterioration of infrastructure, but also the negative impact on air quality.

In addition, noise pollution generated by traffic and the noise associated with pavement wear affect not only the quality of life of residents, but can also have an impact on the mental and physical health of the population. People living in urban environments with high noise levels often experience increased stress, sleep disturbance and cardiovascular health problems.

Importantly, exposure to high levels of particulate matter, such as PM2.5, is particularly linked to respiratory and cardiovascular diseases, and is more critical in vulnerable groups such as children, the elderly and pregnant women. This study emphasises the urgency of implementing mitigation strategies to reduce air pollution, which could

include promoting public transport, promoting cleaner vehicles and improving road infrastructure.

## CONCLUSIONS

This study has confirmed that the wear and tear of the asphalt pavement in the Mucho Lote 2 urbanisation in Guayaquil contributes significantly to air pollution, especially with regard to PM10 and PM2.5 concentrations. Levels of these particles have exceeded the limits recommended by the World Health Organisation, underlining the urgency of addressing this problem.

The research reveals that vehicle density is a key factor in the increase in pollution. The data indicates that a high volume of traffic, particularly heavy vehicles, is directly related to increased levels of particulate matter in the air. This finding reinforces the need to implement traffic management policies that limit the circulation of polluting vehicles in critical areas. It is essential that comprehensive strategies are developed and implemented to improve air quality in Guayaquil. This includes the promotion of sustainable transport alternatives, maintenance of road infrastructure, and raising public awareness of the importance of a clean environment. The research highlights the need for continuous monitoring and further studies to investigate the relationship between pavement wear, vehicular traffic and public health.

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