Transportation-Related Air Pollution: Implementing Electric Bikes in Paraná

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Summary **- Paraná, in Argentina, is the capital city of Entre Ríos and a place where there is a convergence of industrial sectors, cultural events, and urban growth. This city is characterized by these activities and a diverse landscape with 270 neighborhoods spread across its expanse of 137 square kilometers. This urban vitality comes with increased transportation, which contributes to air pollution. The purpose of this work is to address the problem of air pollution caused by transportation in Paraná, Entre Ríos, Argentina. This will be achieved by describing the implementation of electric bikes as a solution. This work is structured as follows. First, a detailed description of the city of Paraná is provided, with a focus on three key aspects: the cultural, historical, and tourist. Following that, the issue under study is presented, and its critical aspects are identified. Then, some images are described to help the reader visualize and understand the problem being addressed. Subsequently, the analysis of the causes that generate the issue is done. In the fifth section, the identification and detailed description of the consequences resulting from this problem are carried out. Then, the solution to the problem is proposed. Finally, in the last section, a comprehensive analysis of the advantages and disadvantages that come with the implementation of this solution is conducted. The expected impact of this work is the reduction of greenhouse gas emissions, the improvement of air quality, and a healthier urban environment, ultimately enhancing the well-being of city residents and providing a sustainable transportation alternative. Therefore, this project represents a significant step towards a more sustainable future and a better balance between urban growth and environmental preservation.**

Keywords: **bikes, Paraná, pollution, traffic**

Resumen **- Paraná, en Argentina, es la capital de Entre Ríos y un lugar donde convergen sectores industriales, eventos culturales y crecimiento urbano. Esta ciudad se caracteriza por estas actividades y por un paisaje diverso con 270 barrios repartidos en su extensión de 137 kilómetros cuadrados. Esta vitalidad urbana viene acompañada de un aumento del transporte, lo que contribuye a la contaminación atmosférica. El propósito de este trabajo es abordar el problema de la contaminación atmosférica causada por el transporte en Paraná, Entre Ríos, Argentina. Esto se logrará describiendo la implementación de bicicletas eléctricas como solución. Este trabajo se estructura de la siguiente manera. En primer lugar, se ofrece una descripción detallada de la ciudad de Paraná, con especial atención a tres aspectos clave: el cultural, el histórico y el turístico. A continuación, se presenta el problema objeto de estudio y se identifican sus aspectos críticos. A continuación, se describen algunas imágenes para ayudar al lector a visualizar y comprender el problema abordado. Posteriormente, se realiza el análisis de las causas que generan la cuestión. En la quinta sección, se lleva a cabo la identificación y descripción detallada de las consecuencias derivadas de este problema. A continuación, se propone la solución al problema. Finalmente, en el último apartado, se realiza un análisis exhaustivo de las ventajas e inconvenientes que conlleva la implantación de esta solución. El impacto esperado de este trabajo es la reducción de las emisiones de gases de efecto invernadero, la mejora de la calidad del aire y un entorno urbano más saludable, mejorando en última instancia el bienestar de los residentes de la ciudad y proporcionando una alternativa de transporte sostenible. Por lo tanto, este proyecto representa un paso significativo hacia un futuro más sostenible y un mejor equilibrio entre el crecimiento urbano y la preservación del medio ambiente.**

Palabras clave: **bicicletas, Paraná, contaminación, tráfico**

I. INTRODUCTION

Paraná is the capital city of Entre Ríos. It was founded on June 25, 1813 [1] and stands as a vibrant city that has approximately 380,000 inhabitants.

In Paraná, the city's unique characteristics, including its role as the provincial government's seat and thriving industrial sectors, contribute to air pollution. Industries like dairy, packaging, furniture, animal feed, juices, and wood processing, emit pollutants. Cultural events and gatherings with energy intensive equipment also add to air pollution.

Paraná is characterized by these activities and a diverse landscape with 270 neighborhoods spread across its expanse of 137 square kilometers [1]. In May 2021, the city had a motorized population of approximately 136,775 cars, reflecting the dynamic urban life that thrives within its boundaries. However, this urban vitality comes with increased transportation, which contributes to air pollution.

The purpose of this work is to address the problem of air pollution caused by transportation in Paraná, Entre Ríos, Argentina. This will be achieved by describing the implementation of electric bikes as a solution.

This work is structured as follows. First, a detailed description of the city of Paraná is provided, with a focus on three key aspects: the cultural, historical, and tourist. Following that, the issue under study is presented, and its critical aspects are identified. Then, some images are described to help the reader visualize and understand the problem being addressed. Subsequently, the analysis in the fifth section, the identification and detailed description of the consequences resulting from this problem are carried out. Then, the solution to the problem is proposed. Finally, in the last section, a comprehensive analysis of the advantages and disadvantages that come with the implementation of this solution is conducted.

The expected impact of this work is the reduction of greenhouse gas emissions, the improvement of air quality, and a healthier urban environment, ultimately enhancing the well-being of city residents and providing a sustainable transportation alternative. Therefore, this project represents a significant step towards a more sustainable future and a better

balance between urban growth and environmental preservation.

II. PROBLEM DEFINITION AND ANALYSIS

A. Description of the Context

Paraná, the capital city of Entre Ríos province in Argentina, located on the eastern bank of the Paraná River. It forms an urban connection with Santa Fe through the Raúl Uranga-Carlos Sylvestre Begnis Subfluvial Tunnel (Fig. 1). In this city, there are municipal and provincial government institutions. The Government House, which is the administrative government of the province, can be seen in Figure 2.

Fig. 1. Raúl Uranga-Carlos Sylvestre Begnis Subfluvial Tunnel.

Fig. 2. Government House.

The city's beautiful ravines, like the ones that can be seen in Urquiza Park, make it extra special because they are connected to the river. These captivating ravines not only make the city look great but also give its residents a peaceful place to relax in nature. Urquiza Park (Fig. 3) has many green plants, which, in combination with the Paraná River create a calm atmosphere, offering a nice break from the busy city life.

Fig. 3. Urquiza Park.

Paraná's cultural vibrancy is evident in venues like 3 de Febrero Theatre (Fig. 4) and cultural centers such as Juan L. Ortiz, La Vieja Usina, La Hendija, and Gloria Montoya. The city's historical and cultural significance can be explored through museums, architectural landmarks, monuments, and historical sites. The Huerto School building was the former seat of the Confederation Senate when the city served as the National Government's headquarters from 1854 to 1860. Additionally, the Argentine Post Office building used to be Urquiza and Derqui's home in the 19th century. 1º de Mayo Square commemorates General San Martín and Argentina's nationhood centenary in 1910 (Fig. 5).

Fig. 4. 3 de Febrero Theatre.

Fig. 5. 1º de Mayo Square.

B. Problem Statement

The city of Paraná stands as a major urban center with a growing population and an increasing reliance on motorized vehicles. The increase in vehicular traffic, and the inadequate gas emission control measures, have led to a worrying deterioration of air quality. Consequently, the health of the city's inhabitants is at risk.

C. Description of Scenes that Help Picture the Problematic Situation

Traffic congestion becomes visible in many contexts, impacting the citizens' quality of life and the air quality. There are many scenarios that can help understand the problematic situation.

Fig. 6. Pre-toll route leading to subfluvial tunnel entry point.

Figure 6 illustrates the morning National Route 168 taken by workers before reaching the toll to enter the Raúl Uranga-Carlos Sylvestre Begnis Subfluvial Tunnel, as they commute to Santa Fe. Additionally, the prolonged idling of vehicles in traffic further intensifies emissions, which has a direct impact on local air quality and overall environmental sustainability.

Fig. 7. The city's central five-way intersection.

In Figure 7, we observe a daily occurrence, primarily during peak city hours, where cars are often stuck between traffic lights until they get the green signal to move. Those traveling along Almafuerte Avenue occupy four lanes, in addition to the exclusive bus lane, all merging at the traffic light leading towards Gualeguaychú Avenue, except for those who turn onto Ramírez Avenue.

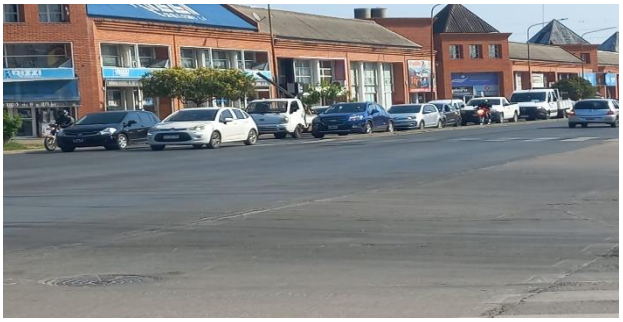

Fig. 8. Almafuerte Avenue.

Figure 8 depicts Almafuerte Avenue at noon, as workers are returning from the morning workday. The avenue captures the pulse of the city's midday activity, with a mix of pedestrians and vehicles creating a dynamic scene that showcases the urban rhythm of daily life.

These traffic-intensive routes present a significant concern about the problem being addressed. The high volume of vehicles during peak hours leads to congestion, longer travel times, and elevated exhaust emissions. This exacerbates air quality issues and contributes to increased pollution levels.

D. Identification and Analysis of Causes or Factors that Give Rise to the Problem

Several factors contribute to the issue of transportation-related air pollution in Paraná. On one hand, the reliance on conventional, fossil fuel-powered vehicles is a significant driver of this problem. The prevalence of cars, trucks, and motorcycles in the city emits pollutants such as carbon dioxide, nitrogen oxides, and particulate matter, which degrades air quality.

Additionally, the limited availability of sustainable transportation alternatives plays a crucial role. The lack of a well-developed public transit system and safe cycling infrastructure discourages residents from adopting cleaner modes of transportation, thus perpetuating the use of polluting vehicles.

Furthermore, inadequate environmental regulations and their enforcement contribute to the persistence of air pollution. Weak oversight allows for the unchecked emissions from vehicles, which further deteriorates the city's air quality.

Addressing these root causes through the implementation of electric bikes in Paraná can mitigate the negative environmental impacts of transportation and promote a cleaner, healthier urban environment for its residents.

E. Identification and Description of the Consequences

The reliance on conventional fossil fuel-powered vehicles in Paraná results in poor air quality due to emissions of pollutants like carbon dioxide, nitrogen oxides, and particulate matter. This, in turn, negatively impacts the health of the city's residents, leading to a higher prevalence of respiratory diseases and other health issues.

The scarcity of sustainable transportation alternatives, including a well-developed public transit system and safe cycling infrastructure, perpetuates the use of polluting vehicles. As a result, city residents face challenges in adopting cleaner modes of transportation, contributing to ongoing air pollution. This situation directly impacts the health of the inhabitants, increasing the risks of respiratory diseases and other health problems related to air quality.

The inadequacy of environmental regulations and their enforcement allows unchecked emissions from vehicles and industrial activities, further degrading the city’s air quality. Weak oversight leads to continued pollution, which not only negatively affects the environment and public health in Paraná but also causes damage to infrastructure and buildings. The accumulation of pollutants can cause corrosion and other structural damage, which in the long run can lead to costly repair and maintenance work.

III. THE WAY FORWARD

A. Problem Approach

To address the transportation-related air pollution problem that affects the city of Paraná, the integration of advanced battery technologies is proposed. This technology relies on the use of a Lithium-ion battery with 800-1000 charge cycles and an 80% depth of discharge. This battery is acid-free, which means that the risk of leaks or spills is eliminated, and features a high-quality electric core. It is equipped with a 30-amp Battery Management System (BMS)

to optimize the range, charging time, and battery lifespan of electric bicycles (Fig. 9) [2]. Also, there is a focus on reducing charging time through fast-charging systems and energy recovery via regenerative braking.

Fig. 9. LI-OIN E-Bike Battery. [2]

Furthermore, it is important to improve aerodynamics and to reduce weight in the electric bicycle design. This can be achieved by incorporating advanced materials like graphene and silicon.

Energy recovery systems, including regenerative braking, play a crucial role in electric bicycle performance. These systems recharge the battery during deceleration and also redirect excess motor energy to the battery, maximizing performance and efficiency.

The use of regenerative braking technology is essential, as it converts kinetic energy into electrical energy during downhill descents, recharging the battery. This process, in turn, reduces energy consumption during uphill climbs.

To increase autonomy on steep terrains, the implementation of an intelligent system called Pedal Assist System (PAS) is suggested (Fig. 10). This system allows cyclists to adjust the motor power according to their needs, optimizing efficiency and preserving battery energy on challenging terrains [3].

Moreover, the use of low rolling resistance tires is proposed. Preferably, they should be 26" to guarantee future availabity as spare parts.

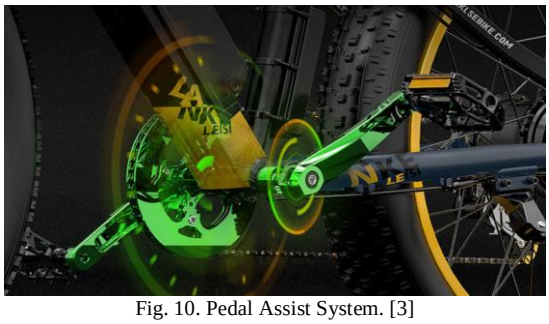

Fig. 10. Pedal Assist System. [3]

These electric bicycles should be implemented in the city center, where mobility is a constant concern and distances are typically short, making commutes easier. Additionally, densely populated residential areas and neighborhoods with high traffic levels are also suitable locations for implementing this system, which would improve air quality and local mobility. Integrating these electric bicycles into public transportation stations, such as bus stops and train stations, may allow users to conveniently combine public transportation with the use of electric bicycles to reach their final destinations. Furthermore, these bicycles could be implemented in areas of tourist interest, such as the city's historical center or natural parks, to promote sustainable tourism and provide tourists with a unique way to explore the city.

B. Strengths and Weaknesses of the Proposal

Electric bicycles are becoming an increasingly popular transportation alternative in cities due to their environmental, economic, and physical advantages. Firstly, electric bicycles do not emit greenhouse gases, making them a more environmentally friendly option than motorized vehicles. Additionally, they allow cyclists to travel longer distances with less physical effort and are more economical than motorized vehicles, both in terms of initial cost and maintenance.

However, there are also disadvantages associated with the implementation of electric bicycles in cities. Firstly, the initial cost of an electric bicycle is higher than that of a conventional bicycle. Additionally, electric bicycles are heavier than conventional bicycles, which can make transportation and storage difficult. Lastly, the battery life of electric bicycles is limited, which can be a problem for those who need to travel long distances.

IV. CONCLUSION

In summary, the city of Paraná faces a critical challenge due to its growing population and deficient public transportation system that is increasingly dependent on motorized vehicles. This has led to a marked deterioration in air quality, with direct implications for the health of residents. The implementation of electric bicycles in the city emerges as one of the most effective solutions to address this problem. These bicycles have the potential to reduce carbon dioxide emissions associated with transportation modes, reduce traffic congestion during peak hours, and offer a low-maintenance mobility option.

Despite the significant initial investment when purchasing an electric bicycle, in the long term, they become an efficient alternative for getting around the city. In short, this work aims to provide an alternative sustainable and solution to discourage the use of vehicles among the people in Paraná.

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The present project is a skills integration activity in Inglés I at Universidad Tecnológica Nacional, Facultad Regional Paraná, carried out by EFL engineering students. The yearlong project requires students to delve into a problem in the city where they live and to address it by means of a simple project in English. Should the reader have any questions regarding this work, please contact Graciela Yugdar Tófalo, Senior Lecturer, at gyugdar@frp.utn.edu.ar.