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THE IMPACT OF ATMOSPHERIC POLLUTION GENERATED BY INTERNAL COMBUSTION ENGINES ON HUMAN HEALTH

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ABSTRACT

This paper addresses the issue of emissions generated by vehicle engines and their impact on human health. The study aims to analyse the levels of major pollutants resulting from fuel combustion, such as carbon monoxide, nitrogen oxides, hydrocarbons, and particulate matter. The analysis emphasizes the impact of exposure to emitted pollutants on human health, identifying increased risks of respiratory and cardiovascular diseases. The study highlights the need to adopt effective measures to reduce pollutant emissions through the development of environmentally friendly technologies and the implementation of sustainable policies, to protect the environment and public health.

KEYWORDS: motor vehicle emissions, air pollution, human health, particulate matter, emission levels, engine technology, environmental impact

1. Introduction

Exposure to atmospheric pollutants is associated with increased risks of premature mortality, adverse effects on child development, and heightened susceptibility to infectious diseases.

Exhaust emissions contain a complex mixture of toxic compounds, including carbon monoxide (CO), nitrogen oxides (NO_x), particulate matter (PM), and hydrocarbons (HC), which exert detrimental effects on human health. Furthermore, pollutants originating from exhaust gases can negatively influence plant physiology, inhibit growth processes and contribute to the degradation of agricultural crops.

Fine particulate matter ($PM_{2.5}$ and PM_{10}) penetrates deeply into the pulmonary system and can enter the bloodstream, while nitrogen oxides (NO_x) induce inflammatory responses and oxidative stress. Polycyclic aromatic hydrocarbons (PAHs) and sulphur dioxide (SO_2) act as respiratory and cardiovascular irritants. These pollutants can also stimulate bone marrow activity, leading to increased production of inflammatory cells.

Air pollution adversely affects human health by increasing the risk of respiratory diseases (such as asthma and bronchitis), cardiovascular disorders, and lung cancer, as well as by causing irritation of the eyes and skin.

The European Parliament and the Council establish the need to reduce pollution to levels that minimize harmful effects on human health, with particular attention given to sensitive population groups and the environment [1].

To protect human health, it is essential to identify and implement the most efficient emission reduction measures. Emissions of harmful atmospheric pollutants should be prevented, controlled, or reduced, and appropriate ambient air quality objectives should be established, considering the standards and guidelines of the World Health Organization [2].

It is necessary to adopt detailed mechanisms for the transmission of information regarding ambient air quality [3].

Data quality objectives have been established, and these objectives need to be updated to ensure a higher degree of accuracy and clarity. Reference methods for the assessment of pollutant concentrations have also been defined, and these methods should be periodically revised to reflect the evolution of relevant standards [4].

Furthermore, provisions have been established regarding reference methods, data validation, and the siting of sampling points for the assessment of ambient air quality [5].

Within the framework of efforts to reduce CO_2 emissions and to achieve climate neutrality by 2050, it is necessary to reduce greenhouse gas emissions from the transport sector by 90% compared to 1990 levels.

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To reduce emissions from road transport, the European Union intends to complement the CO_2 targets for cars and vans with additional measures [6]. These include the introduction of a new emissions trading scheme for road transport and buildings, increasing the share of renewable fuels in transportation, and phasing out fiscal advantages for fossil fuels [7].

2. Case study analysis on the impact of emissions on human health

A gradual decrease in emissions can be observed, from approximately 820 million tonnes in 2015 to 660 million tonnes in 2025. This trend reflects the increased adoption of electric and hybrid vehicles, the implementation of stricter emission regulations, and improvements in the efficiency of internal combustion engines.

The comparative chart showing the evolution of CO_2, NO_x, and PM emissions from thermal engines between 2015 and 2025.

Transport accounted for approximately one quarter of total CO_2 emissions in the European Union in 2019. Of these, 71.7% originated from road transport, according to a report by the European Environment Agency. There are two main approaches to reducing CO_2 emissions from vehicles: improving their efficiency or changing the type of fuel used.

In 2019, most of the road transport in Europe relied on diesel (66.7%), followed by gasoline (24.55%). However, electric vehicles are gaining significant ground. They represented 17.8% of all newly registered vehicles in 2021, a considerable increase from 10.7% in 2020. Sales of electric vehicles (fully electric and plug-in hybrid) have grown substantially since 2017 and tripled in 2020, when the current CO_2 targets began to apply. Electric vans accounted for 3.1% of the newly registered van market in 2021.

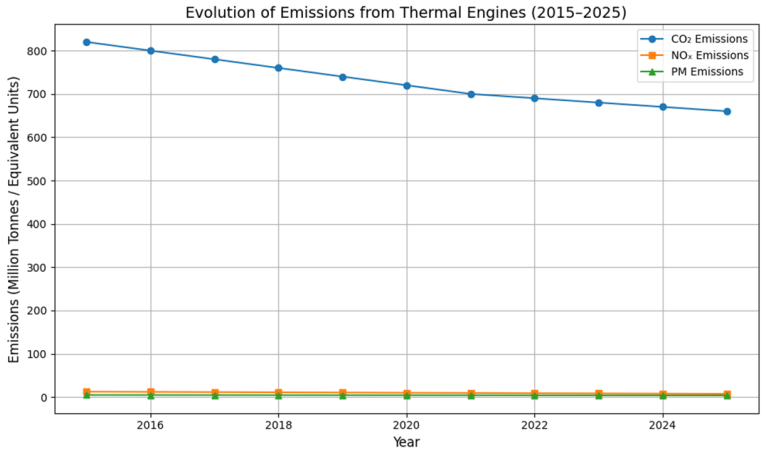

Fig. 1. *Assessment of Emission Trends from Internal Combustion Engines during 2015-2025*

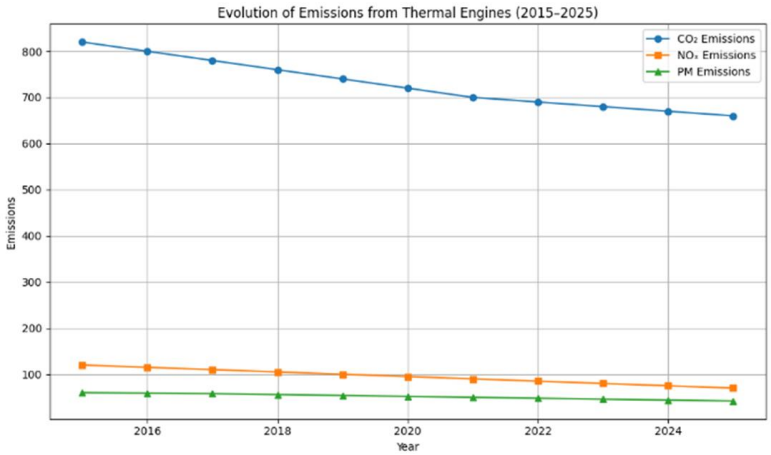

Fig. 2. *Evolution of CO_2, NO_x and PM emissions from internal combustion engines between 2015 and 2025*

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When assessing the amount of CO_2 emissions generated by a vehicle, it is essential to consider not only the emissions produced during its operation, but also those associated with its manufacturing and end-of-life disposal.

Studies have shown that individuals exposed to elevated levels of $PM_{2.5}$ exhibit increased bone marrow activity and arterial inflammation, which consequently lead to a higher risk of myocardial infarction and stroke.

2.1. Impact of pollutant emissions on human health

According to recent studies, fine particulate matter can penetrate the bloodstream and induce systemic inflammation, thereby increasing the risk of arterial hypertension, atherosclerosis (arterial thickening), and blood clot formation-leading to an elevated risk of deep vein thrombosis and pulmonary embolism, myocardial infarction, and stroke. Nitrogen oxides are also associated with increased hospitalization rates for cardiovascular conditions.

Inhalation of air pollutants causes irritation of the respiratory tract, resulting in coughing, wheezing, shortness of breath, and exacerbation of asthma.

Exposure to fine particulate matter ($PM_{2.5}$, PM_{10}) and toxic gases such as nitrogen dioxide (NO_2) can trigger or aggravate asthma, chronic bronchitis, and other pulmonary diseases.

Air pollution is further associated with an increased risk of hypertension, cardiac arrhythmias, physiological stress, myocardial infarction, and cerebrovascular accidents.

Approximately 99% of the global population breathes air that exceeds safe limits, according to the World Health Organization (WHO).

Furthermore, approximately 22% of deaths due to myocardial infarction and 15% of deaths caused by stroke are associated with exposure to air pollution.

An increase in the concentration of fine particulate matter ($PM_{2.5}$) is associated with a progressive rise in:

- arterial blood pressure;
- the risk of myocardial infarction;
- the risk of stroke.

An increase in the concentration of fine particulate matter ($PM_{2.5}$) is associated with a progressive elevation in arterial blood pressure, as well as a higher risk of myocardial infarction and cerebrovascular events. This relationship is primarily attributed to the induction of systemic inflammation, oxidative stress, and endothelial dysfunction, which collectively contribute to the development and progression of cardiovascular diseases.

Biological Mechanisms Involved:

- Chronic inflammation: the body responds to pollutants in a manner similar to an infectious process.
- Oxidative stress: adversely affects endothelial cells lining the blood vessels.
- Vascular dysfunction: arteries become stiffer, leading to increased arterial blood pressure.

2.2. Quantified risks associated with $PM_{2.5}$ exposure

Evidence indicates a clear association between increased concentrations of fine particulate matter ($PM_{2.5}$) and an elevated risk of cerebrovascular events.

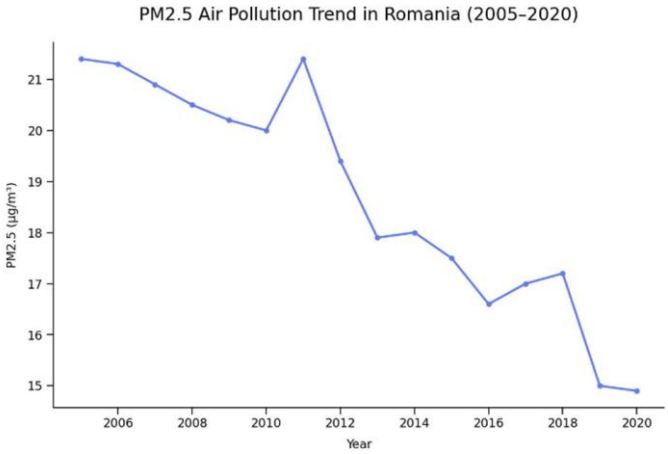

Fig. 3. *$PM_{2.5}$ emissions*

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Specifically, an increase of +1 μg/m³ in $PM_{2.5}$ levels has been shown to correspond to a rise of approximately 0.7–2.2% in the incidence of certain types of strokes. This finding underscores the sensitivity of cerebrovascular outcomes to even minor variations in ambient air pollution levels.

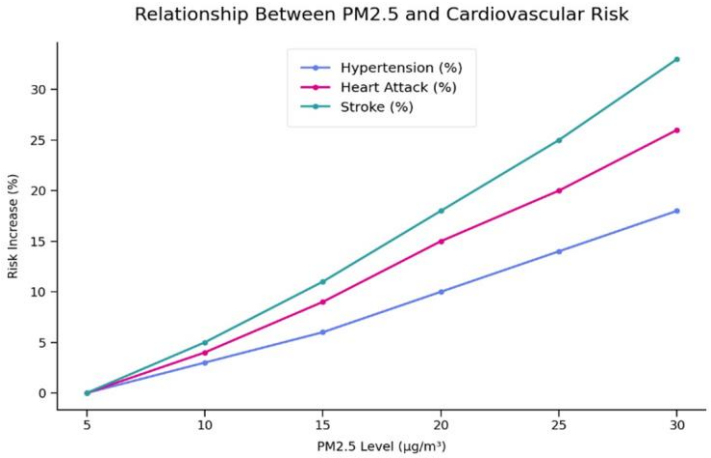

Fig.4. *Mortality associated with air pollution*

Moreover, moderate elevations in $PM_{2.5}$ concentrations are associated with a significant increase approximately 11–12% in hospitalization rates due to stroke. This suggests that population-level exposure to particulate matter not only contributes to disease onset but also exerts a measurable burden on healthcare systems.

Short-term exposure to elevated concentrations of $PM_{2.5}$ further exacerbates clinical outcomes, being linked to increased severity of stroke manifestations, including more pronounced neurological deficits and complications. These effects are primarily mediated by acute inflammatory responses, endothelial dysfunction, and alterations in cerebral blood flow.

Collectively, these findings emphasize the critical role of air quality in influencing both the incidence and severity of cerebrovascular diseases, highlighting the importance of effective environmental and public health interventions aimed at reducing exposure to fine particulate matter.

Deaths due to air pollution: Cardiovascular diseases ~70%; respiratory diseases ~20%; cancer and other causes ~10%.

Figure 5 presents the temporal evolution of $PM_{2.5}$ emissions in Romania during the period 2005-2020.

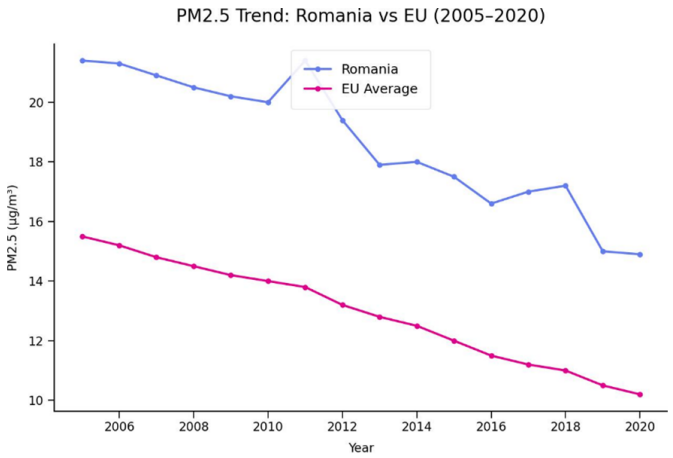

Fig. 5. *Comparative Analysis between Romania and the European Union*

The figure shows that both curves exhibit a decreasing trend, indicating an improvement in air quality. The European Union experienced a more consistent and rapid decline.

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Chemical substances present in the atmosphere can cause skin irritation and aggravate pre-existing dermatological conditions. Certain pollutants may also contribute to headaches, migraines, and even an increased risk of neurodegenerative conditions, including intracranial cysts, brain tumours, Alzheimer's disease, and Parkinson's disease.

Short-term and long-term exposure to air pollution represents a major cause of premature mortality, particularly due to cardiovascular and pulmonary diseases.

Exposure to air pollution during childhood can impair lung development, leading to reduced pulmonary function and an increased susceptibility to infections.

Poor air quality generates increased healthcare costs and reduces productivity, exerting a significant economic impact.

Vulnerability to the effects of air pollution varies, being higher among elderly individuals, those with pre-existing medical conditions, and children.

The resulting systemic inflammation affects arterial walls, promoting the formation of atherosclerotic plaques. Studies indicate that approximately 29% of the cardiovascular risk associated with air pollution is explained by this mechanism. Arterial wall thickness increases proportionally with the concentration of fine particulate matter in the air.

Fuel vapours contain toxic substances such as benzene, toluene, xylene, ethylbenzene, and volatile organic compounds. Inhalation of these compounds, even in small quantities, may cause irritation of the eyes, nose, and throat; dizziness, headaches, and nausea; breathing difficulties or fatigue; and, in severe cases (for example, in confined spaces), loss of consciousness.

Long-term exposure may lead to chronic respiratory conditions, such as bronchitis and asthma, as well as liver and kidney disorders and dysfunctions of the nervous system. It also increases the risk of cancer, particularly due to benzene, which is a well-established carcinogen.

When fuel vapours are released into the atmosphere, they contribute significantly to air pollution, including the formation of photochemical smog, the enhancement of the greenhouse effect and climate change, as well as the contamination of soil and water resources.

3. Conclusion

Although arterial wall damage is often attributed to associated conditions such as diabetes, growing evidence suggests that air pollution may represent a major underlying contributing factor. The inhalation of vapours originating from diesel fuel and motor oil can adversely affect multiple physiological systems, particularly the respiratory and cardiovascular systems.

Exposure to diesel emissions and used motor oil poses significant health risks, primarily due to the presence of toxic compounds such as polycyclic aromatic hydrocarbons, which are known for their carcinogenic potential and long-term adverse effects. In addition to inhalation risks, direct contact with these substances may lead to various health complications, while inadequate waste management practices can further amplify environmental contamination and public health risks at the community level.

These findings highlight the critical importance of reducing pollutant emissions, improving fuel handling practices, and implementing effective environmental regulations. The adoption of cleaner technologies, proper waste management, and increased public awareness are essential measures for minimizing exposure and protecting both human health and the environment.

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