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# Application of IT tools for environmental assessment and forecasts in road transportation


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***Abstract*— In this paper, the aspects of passenger transportation were estimated through the impact of traffic on the environment by air pollution assessed by using CALROAD software, and the overall estimation of the annual release of GHG in IBCM, calculated by using Greenhouse Gas Emissions Calculator, by UNFCCC (United Nations Framework Convention on Climate Change). The assessment of the pollution concentration on the 19th km road Mitrovica-Prishtina showed that the WHO and EU threshold was exceeded from the roundabout and junctions until 90 meters in the upright wind direction at the peak hour in January 2025. The annual $CO_2$ emissions from the road traffic by IBCM cars and employees commuting are in the following three scenarios: Using electric cars, plug-in hybrid cars, and diesel and LPG. The results showed that the difference between electric and hybrid cars is not significant for the electricity production in Kosovo originating from thermal electric power plants using lignite.**



**Keywords— air quality, traffic, CALROAD, simulation, Composite Emission Factor, GHG Calculator**


## I. Introduction

The relationship between transportation and the environment is complex and controversial since transportation contributes significant economic and social benefits, but it also impacts the environment and thus represents the burden the whole society has to pay in ecosystem capital and quality, human health, and wellbeing. Further, environmental conditions affect transportation systems in terms of operating conditions and infrastructure requirements such as construction and maintenance. Transportation and the environment can thus be perceived as a system with retroactive effects [1]. Transportation in all modes generates some 25% of global $CO_2$ emissions. There are also environmental impacts specific to transportation, such as $NO_x$ and solid particles emitted by transport activities, in all stages of transportation. The growing trend of passenger mobility has increased the role of transportation as a source of emission of pollutants. Total emissions are generally a function of the **emission factor** of each transport mode rather than their level of activity, which points to different environmental impacts. The environmental dimensions of transportation sequentially involve four stages: 1. Causes- A developed economy creates better transportation activities than a developing one. EU-28's CO2 emissions correspond to 10.8% of global CO2 emissions [2]. Land use determines travel distance and mode of transportation. 2. Activities include infrastructure construction and maintenance, vehicle and part manufacture, travel, vehicle maintenance and support, and finally, disposal of vehicles and parts, with or without recycling. 3. Output includes exposure, ambient levels, emissions, and habitat changes. The final results are health, environmental, and social effects [3]. Global warming and urban pollution focused a great interest on hybrid electric vehicles (HEVs) and battery electric vehicles (BEVs) as cleaner alternatives to traditional internal combustion engine vehicles (ICEVs). The environmental impact related to the use of both ICEV and HEV mainly depends on the fossil fuel used by the thermal engines, while, in the case of the BEV, it depends on the energy sources employed to produce electricity. The environmental benefits of electric vehicles (EVs) and plug-in hybrid vehicles (PHEVs) are highly dependent on the energy mix used for electricity generation. In Kosovo, where 94% of electricity is produced from fossil fuels, the advantages of EVs and PHEVs are significantly reduced compared to regions with a higher share of renewable energy sources. According to the International Renewable Energy Agency (IRENA) [4] transitioning to renewable energy is critical for maximizing the GHG reduction potential of EVs. IRENA highlights that countries with a high penetration of renewables, such as wind and solar, can achieve up to 50% greater reductions in lifecycle emissions from EVs compared to those relying on fossil fuels for electricity generation.

Furthermore, the World Health Organization (WHO) [5] has updated its global air quality guidelines, emphasizing the need for stricter standards to protect public health. The WHO report underscores that PM2.5 and PM10 concentrations above the recommended thresholds pose severe health risks, including respiratory and cardiovascular diseases. Our findings, which show respiratory solid particles (RSP) concentrations exceeding 100 µg/m³ near the Mitrovica-Prishtina road, align with these concerns and highlight the urgent need for measures to reduce traffic-related air pollution. Implementing stricter air quality standards, as recommended by WHO, could significantly improve public health outcomes in the region.

Moreover, the production phase of each vehicle may also have a relevant environmental impact due to the manufacturing processes and the materials employed [6].

Assessing the environmental impact of urban transportation is a challenge for environmentalists but also for city managers and public service providers due to the constant change in the intensity and frequency of traffic, released gas concentrations, and changing climatic conditions. Air pollution is considered the leading environmental threat in the region of the Western Balkans. A substantial portion of the pollution is caused by traffic. A monitoring network of sensors is not developed, but the measurements are irregular and random. There are several software solutions for estimating and predicting air pollution caused by traffic on the market. CALROAD View is an air dispersion modeling package for predicting air quality impacts of pollutants near roadways [7]. More complex approaches are needed in small geographic areas, as we have here [8]. Traffic-related air pollutant levels can vary on small (i.e., micro (0– 100 m), middle (100–500 m), and neighborhood (500– 4 km)) spatial scales immediately near roadways.

## II. Methodology

### A. CALROAD View modeling

In order to test the possibility of using application software as a valid environmental management tool for assessing the air quality along the analyzed road infrastructure, the environmental impact was calculated by using the CALRoads view software. CALRoads View combines the following mobile source air dispersion models into one seamless integrated graphical interface: CALINE4, CAL3QHC, and CAL3QHCR [9]. These models are used for predicting air pollution concentrations of carbon monoxide (CO), nitrogen dioxide (NO2), particulate matter (PM), and other inert gases from idle or moving motor vehicles. Terrain data and geometry data on the observed infrastructure were taken from WebGIS and processed by the AERMAP program. On-site data were processed through the RAMMET programs [10] [11]. The Composite Emission Factor, as a basic parameter for the modeling, was calculated based on the input data on traffic frequency and type of vehicle involved at the location along the road Mitrovica-Prishtina.

**Meteorological conditions**: The actual meteorological data were calculated to compare to the measured concentrations: temperature. 4°C, rush hour 17.00-18.00, wind direction N/NE, wind speed 2.1m/s.

**Road geometry:** The Road is At-grade type, with no depression or bridge calculation

**Road activity-Composite Emission Factor:** The emission factors for the different types of vehicles were used for calculating a composite emission factor for the vehicle fleet being modeled in this study.

$$\text{Emmision factor (E.F.)} = \frac{\Sigma\, EiZ \times Ni}{\Sigma\, Ni} \qquad (1)$$

Where Ei = fleet average emission factor

And Ni = the number of particular type of vehicles

TABLE I. Fleet Emission Factor in 2023-2028 (Guidelines for Measuring and Managing CO2 Emission from Freight Transport Operations)

| g/km-veh | Emission factor | | | |
|---|---|---|---|---|
| | ***PV*** | ***GV*** | ***SPB*** | ***PT*** |
| NOx | 1.1700 | 3.4600 | 4.960 | 6.150 |
| RSP | 0.1200 | 0.3600 | 0.3300 | 0.4500 |

Private Vehicle (PV)- Car+ Taxi+ Passenger Van

Goods Vehicle (GV)- All types of Goods Vehicles

Special Purpose Bus (SPB) – Non-franchised Bus

Public Transport (PT)- Franshised Bus + Mini Bus + Public Light Bus

### B. GHG Emmision

Green House Gasses emission can be measured by estimating the amount emitted using activity data (such as the amount of fuel used) and applying relevant conversion factors (e.g., calorific values, emission factors, etc.). These conversion factors allow organizations and individuals to calculate GHG emissions from a range of activities, including energy use, water consumption, waste disposal and recycling, and transport activities. In this case, the conversion factors for a single type of emissions releasing activity in driving BEVs (battery electric vehicles), HEVs – Plug-in Hybrid, or ICEVs (internal combustion engine vehicles) . For the purpose of this paper, only the results of the GHG discharged by transportation are presented.

## III. Discussion

### A. CALROAD Air pollution modeling

For the air pollution modeling purpose, data were collected during rush hour traffic counts by recording the frequency by camera. Meteorological conditions were taken from the nearest meteorological station. Table 2. shows the results from the calculation of the fleet composite emission factor, taking into consideration the Euro 4 engine.

TABLE II. Composite emission factor for the road near Emona on the Mitrovica-Prishtina road

| Traffic information 17.00 hr peak | | | | | Product of vehicle and fleet EF g/km | | | | NOx E.F. g/mveh |
|---|---|---|---|---|---|---|---|---|---|
| Q (veh/hr) | Traffic breakdown (number of vehicles) | | | | | | | | |
| | PV | GV | SPB | PT | PV | GV | SPB | PT | |
| | 1366 | 23 | 4 | 7 | 1598.22 | 79.58 | 19.84 | 43.05 | 1.2430 |
| **Traffic information 17.00 hr peak** | | | | | **Product of vehicle and fleet EF g/km** | | | | **RSP E.F. g/mveh** |
| Q (veh/hr) | Traffic breakdown (number of vehicles) | | | | | | | | |
| | PV | GV | SPB | PT | PV | GV | SPB | PT | |
| | 1366 | 23 | 4 | 7 | 163.92 | 8.28 | 1.32 | 3.15 | 0.1262 |

The obtained results are presented in Figure 1.

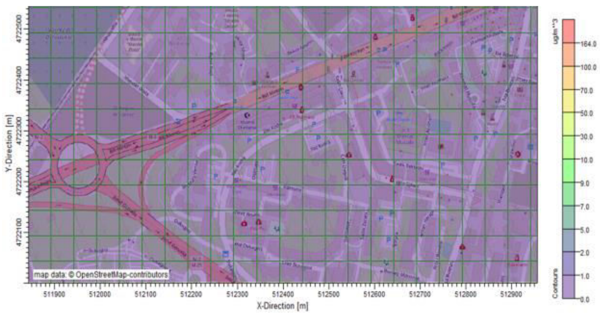

Fig. 1. RSP (Respiratory solid particles) concentration on the main road Mitrovica-Prishtina

The road itself is heavily polluted, reaching more than 100 µg/m3, exceeding three times the WHO threshold of 30 µg/m$^3$. As Traffic related air pollutant levels can vary on small (i.e., micro (0–100 m), middle (100–500 m), and neighborhood (500–4 km)) spatial scales immediately near roadways, the initial results point to the spatial classes immediately near roadways, micro spatial scale is further investigated. The results are presented in Fig. 2

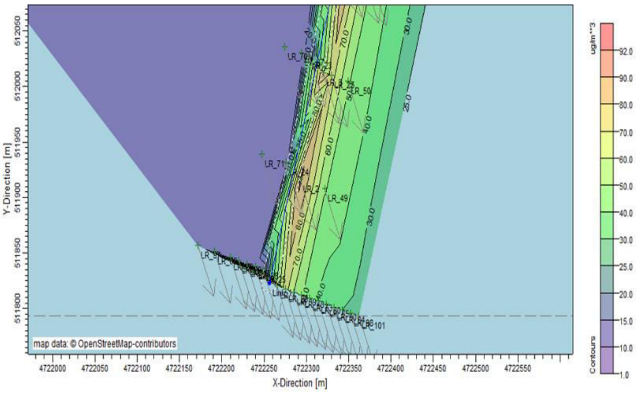


Fig. 2. RSP concentrations in the range of 100 m in the Southeast wind direction

The presented results show high RSP concentration in the close vicinity of the road. The red and orange stripes on the graph cover some 30 meters from the road, and the concentrations are dangerous for human health. Only dark green and violet surfaces are safe for longer presence. This is valid information for the landscape management and urban zoning of the municipality. The obtained data showed good agreement with the instrumental measurement for PM2,5 and PM 10.

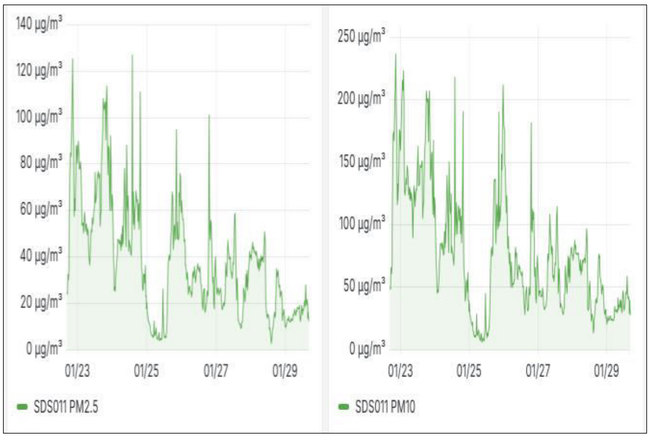


Fig. 3. Measured PM 2.5 and PM10 in the interval of four days in January 2025

The results for $NO_x$ are not presented here, as there is no experimental validation on the site done.

*B. GHG calculations*

To estimate the GHG emissions from EVs, we considered the lifecycle emissions associated with battery manufacturing and electricity generation. As the production phase of EVs, particularly battery manufacturing, contributes significantly to their overall environmental impact [12]. For this study, we incorporated these factors into our calculations using the UNFCCC GHG Emissions Calculator, adjusting for Kosovo's electricity mix, which is dominated by fossil fuels. By using the Greenhouse Gas (GHG) Emissions Calculator [13] and using a Full set of factors for kg CO2e from DEFRA [14], the report for IBCM was calculated. Here are presented the results for Scope 1 (GHG emission from own vehicles, driving 100,000 km per year), and Scope 3 (Employees commuting with their own cars, estimated to travel 500,000 km with 400,000 km with Diesel engine and 100,000 with LPG as fossil fuels). At the same time, the opposite situation was assessed, estimating the results for GHG if IBCM medium size cars and employees' small cars are Electric cars or Plug-in Battery cars.

IBCM - 2024 GHG emissions report 41.56 $tCO_2$, if IBCM is using Electric cars, from which 19.48 $tCO_2$ are released by IBCM vehicle and 22.08 $tCO_2$ are released by the employees commuting.
If Plug-in HEV are used, IBCM will produce 41.22 tCO2, with direct emissions from owned or controlled mobile sources of 6.48 tCO2 and Location-based emissions from the generation of purchased electricity for Electricity for EVS of 8.46 tCO2 and 26.28 $tCO_2$ for employees commuting.

If fossil fuel is used, IBCM will produce 90.58 tCO2 by IBCM car, but also by the Employees commuting, the Direct emissions from owned or controlled mobile sources using Diesel is 16.80 tCO2 and 73.78 $tCO_2$ by the employees commuting considering the fact that 30% of the fuel used was LPG. Calculation results are presented in Fig. 3. The graphic presentation shows that there is no significant difference in using Electric or Hybrid cars. The GHG estimation takes into consideration the electricity production in Kosovo, that is 94% from fossil fuel combustion, reducing the benefits of Electric and Plug-in Hybrids in comparison to other countries having better ratio between fossil fuel/ renewable energy sources.

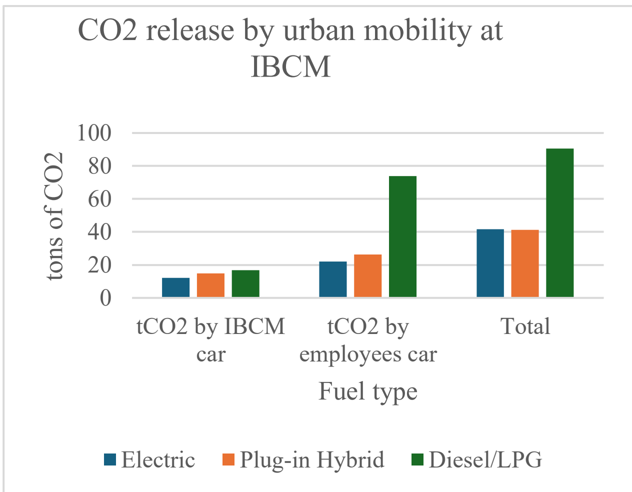


Fig. 4 Comparison of CO2 discharge at IBCM when using Electric cars, Plug-in Hybrid and Diesel/LPG in 2024

## IV. CONCLUSION

As the environment in all its aspects is heavily affected by transportation, including infrastructure construction and maintenance, vehicle production, vehicle parts production, use, and disposal, there is a strong need to find a method for environmental impact assessment by using modern IT tools, in the absence of networks of measuring probes and receptors in the field. A small number of software and calculation methods were presented here, showing the possibilities for in-depth environmental assessment using CALROAD Gaussian Distribution software assessment or quick estimation of the greenhouse gas emissions for companies' impact by using the GHG calculator recommended by UNFCCC. The results from CALROAD for RSP are confirmed by measuring g PM2.5 and PM10, and the GHG calculation emphasizes the significance of involving Electric cars in the IBCM operations and increases the public awareness of the employees.

The study highlights the significant environmental impact of road transportation, particularly in terms of air pollution and GHG emissions. Analysis of the Mitrovica-Prishtina road revealed alarming levels of RSP, exceeding the WHO threshold of 30 μg/m³ by more than three times (reaching over 100 μg/m³) during peak traffic hours. This pollution was particularly concentrated within 30 meters of the road, posing serious health risks to nearby residents and emphasizing the need for improved urban zoning and landscape management.

The results underscore that the environmental benefits of EVs and PHEVs are limited in Kosovo due to the country's reliance on fossil fuels for 94% of electricity production. This reduces the advantage of electric and hybrid vehicles compared to regions with a higher share of renewable energy sources. However, transitioning to EVs and PHEVs still offers a notable reduction in emissions compared to traditional diesel and LPG vehicles [15].

IT tools provided valuable insights for policymakers and organizations aiming to reduce transportation-related emissions and improve air quality. Further research should contain more elaborate investigation on utilization of calculation models in developing sustainable urban mobility plans and in urban pollution prevention. Together with energy efficiency and resilience, proper planning in urban development in area of urban land management should benefit on the utilization of data provided by these models.


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