Environmental impact evaluation associated to road traffic. A case study for Iasi city

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Abstract. Development means a strong transportation network. Still, it comes associated with negative consequences, among them climate change and environmental disruptions. The pollution effects associated with road transportation are determined by a serial of factors like atmospheric conditions, topography, climate, traffic, fuel type, vehicle age but also improper maintenance of vehicles. All these components lead to atmospheric emissions caused by fuel leakage on rolling surface, dust and noise, accidental leakage of toxic chemical products. The present paper brings its contribution to the issue of sustainable development, approaching the problem of environmental impact associated with road traffic, quantifying pollutant emissions and comparing values. The evaluation is based on statistics for the most crowded road in Iasi City, namely Independence Boulevard, consisting of traffic data for the last 3 years obtained from the local Office of Traffic Management.

1. Introduction to the Environmental Impact of Road Traffic

The pollution effects associated with road transportation are extended and subjected to multiple factors like atmospheric conditions, topography and climate, traffic congestion, fuel type, vehicle age, maintenance and so on. These effects consist of gases emissions in atmosphere, fuel leakage on road surface, accidental spilling of toxic substances, dust and noise.

CO₂e emissions, ecosystems fragmentation and elimination in atmosphere of suspended particles PM₁₀ are currently the most urgent problems on mankind [2]. Exhaust gases disorder the air quality, population health, ecosystems equilibrium but also intensify the global warming. There is a wide diversity of toxic gases associated with road traffic. In table 1 below can be found a detailing of the most significant emissions.

Prevention and remission methods of the impacts produced by transportation consist of improving the vehicles production and maintenance techniques, usage of electric, hybrid and "flex fuel" vehicles, where fossil fuel is replaced with bio fuel or electric systems, but also development of public transportation and usage of other way of transport.

Reduction of negative effects associated with road transportation can be realised also by changes of vehicles characteristics [10] like reducing the inertial load, improvement of aerodynamic characteristics, reduction of friction forces inside the engine, transmission improvement, usage of alternative fuels and electric systems.
Table 1. Emissions associated with road vehicles.

| Emission                  | Symbol | Description                                                                 |
|---------------------------|--------|-----------------------------------------------------------------------------|
| Carbon dioxide            | CO₂    | Results from the chemical reaction of fuel burning, is considered the most important greenhouse gas which contributes to ocean acidification |
| Carbon monoxide           | CO     | Results from the incomplete burning of fuel due to low combustion, contributes to the reduction of oxygen necessary to the normal functioning of the human body. Also it increases the ozone content in atmosphere, contributing to global warming. |
| Nitrogen oxides           | NOₓ    | Resulted from combustion process, contribute to acid rain.                  |
| Sulphur oxides            | SOₓ    | Take in atmosphere the form of sulphur dioxide (SO₂), sulphuric acid (H₂SO₄) and sulphate particles. Contribute to acid rain, tropospheric ozone, suspension powders and engine corrosion. |
| Hydrocarbon               | HC     | Emitted together with exhaust gases and during the supply process with fuels. |
| Benzene                   | C₆H₆   | Can be found in small quantities (below 2%) in fuel, emitted by exhaust gases as unburned fuel or during alimentation. It contaminates the groundwater and is highly carcinogenic. |
| Material particles in suspension | PM       | Are fuel components partially burned, characteristic to diesel motors and tire friction with road surface. |
| Volatile organic compound | VOC    | Contribute to urban smog and have a high toxicity level                    |
| Smoke                     | -      | The particles contain a carbon nucleus that absorbs burned and unburned hydrocarbon. |
| Lead emissions            | -      | Determined by additive fuel with lead tetraethyl. This type of pollution has severe effects on health and environment, its effects maintaining for hundreds of years. [6] |

Statistics of Association of Vehicles Producers and Importers (APIA) [1] refer to an increase of 69% in 2019 for electric and hybrid car selling, as compared with 2018. Most important sellers for full electric are Nissan (119 units) and Renault (81 units), for hybrid Toyota (1611 units) and Lexus (82 units). [3]

2. Case Study on Road Traffic for the most crowded road sector in Iasi

Road transportation is currently the leading way of transport for people and merchantize. Due to a significant increase of traffic in urban areas, it is important to reconsider the traffic management in these areas, proving solutions like rerouting, signalizing, increase of road capacity, using alternative transportation vehicles (scooters, bicycles) and so on.

Similar to other large cities, the City of Iasi follows the same trend in road transportation. The Office of Traffic Management in Iași provided a serial of information on the local traffic and corresponding statistics. For further analysis of the environmental impact associated with road traffic, will be considered the sector with the highest registered values. This is Independence Boulevard, a 6 lane street, positioned in Iași City Centre. This boulevard connects the city entrances with the commercial and business centre, connects the University Centres (Al.I.Cuza University, Medicine and Pharmacy University, Agriculture and Veterinary Sciences University, „Gh. Asachi” Technical University of Iasi) and the road to Iași airport.
Figure 1. Independence Boulevard Mapping Overview [7].

Figure 2. Independence Boulevard Street View [8].

Figure 3. Independence Boulevard Traffic Light System.
Figures 1, 2 and 3 above provide visual information on the most crowded street of Iaşi City. As seen in figure 1, Independence Boulevard is very close to the old city centre, providing connections with main touristic objectives (marked with yellow bullet). Figure 2 details the number of lanes on the Boulevard while figure 3 is an overview of the Traffic Light System on the boulevard. Figure 1 and 2 show images provided by Google Maps, while figure 3 image was put at our disposal by the Office of Traffic Management in Iaşi.

According to the information received from the Office of Traffic Management in Iaşi the traffic for Independence Boulevard scheduled for 2016 – 2018 is presented in table 2 below and associated graph 1, where can be observed the increase with almost 8%, in road traffic, in a very short time period (2 years).

Table 2. Traffic Report on Independence Boulevard.

| Days month of October | Average traffic |
|-----------------------|-----------------|
|                       | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   |
| 2016                  | 43082| 36833| 55818| 478735486354800| 56576| 40773| 38908| 47725.1111|
| 2017                  | 43326| 54675| 56320| 566735744058155| 42684| 38955| 53446| 51297.1111|
| 2018                  | 54278| 50029| 54059| 572355868343572| 42231| 46805| 56510| 51489.1111|

Figure 4. Graphical representation of road traffic for 2016-2018 on Independence Boulevard of Iasi.

3. Environmental Impact associated with Road Traffic for the most crowded road sector in Iasi

For a proper analysis of pollutant emissions associated with road traffic has been used the computer software COPERT 5, provided by European Environmental Agency (EEA). [4] This software was developed in order to determine quantitative emissions characteristics to road traffic [5]. Specific information for the analysis refer to local environment temperature and humidity, average annual fuel consumption, configuration of vehicle fleet and their number, vehicle speed. [9]

The objective of the case study was to determine the environmental impact characteristic for the road with the highest traffic in Iasi, namely Independence Boulevard presented in the previous chapter. The analysis was performed for years 2016 and 2018 in order to highlight the level of emissions and the traffic changes.

For the evaluation, the available number of vehicles was divided into 33 categories like passenger cars, light commercial vehicles, buses and motorcycles, with specific characteristics. COPERT 5 software
provides information on 26 types of pollutants. Among these have been considered the value of $\text{CO}_2$ and CO and presented in table 3.

Table 3 below details the values characteristic for passenger cars (petrol, diesel and hybrid) considered for urban off peak and urban peak time intervals. The values are expressed in tones of pollutant.

As observed in the table, the increase in the number of vehicles by 3764 vehicles in 2 years’ time brought an increase of approximately 1 tone of pollutant emissions of $\text{CO}_2$, respectively 0.01 tons of CO. If it is considered that this increase is valid only for one road under evaluation, can be concluded on the significant increase of environmental impact associated with road traffic for the entire city of Iasi.

| Emission | 2016 (t) | 2018 (t) |
|----------|----------|----------|
|          | urban peak | urban off peak | urban peak | urban off peak |
| $\text{CO}_2$ | 11.94 | 18.42 | 12.74 | 19.69 |
| CO | 0.039 | 0.053 | 0.059 | 0.0068 |

The results of this evaluation showing significant increase of pollutant emissions in a short time period, brings us to the idea that it is highly important for the transportation management system to start taking action in this direction by identify methods to prevent and reduce the pollution level, improving the vehicle fleet, replacing fossil fuels cu biofuels or by improving their characteristics.

4. Conclusions
Considering the high level of pollution and the fact that, according to European Commission, the transportation activities are responsible for 32% of Europe energetic consumption and 28% of total $\text{CO}_2$ emissions (Eurostat, 2016), technologies development and sustainable construction processes from road sector becomes more and more important. More than this, the road traffic represents a major factor in greenhouse gas emissions expansion. According to PIARC report, the highest energetic consumption is associated with road traffic and less to the constructive process of road structures. [11]

The evaluation of greenhouse gas emissions associated with road traffic, performed for the road with the most traffic from Iasi City, called Independence Boulevard, confirmed the general trend of increasing the number of vehicles and of the pollutant emissions. If no measures are taken and the trend continues to be the same, the consequences might be more severe than imagined.

COPERT 5 computer software facilitated the environmental impact evaluation process, still there is a wide diversity of programs and methodologies that implement similar types of analysis.

The pollution effects due to road traffic are extended, caused by a significant number of factors like atmospheric, topographic and climatic conditions, traffic congestion, fuel type, vehicles age and wrong vehicle maintenance. Consequences refer to gases emissions in atmosphere, fuel leakage on road surface or accidental leakage of toxic substances in case of accidents. As an answer to all these issues, must be developed and implemented specific measures for prevention, reducing and compensation. Newly appeared technologies, in the area of $\text{CO}_2$ emissions reduction, refer mainly to efficient vehicles which use alternative fuel types, hybrid, electric fuel cell cars, or the so called flex – fuel vehicles. The new configuration of vehicles-park in the transition process towards mobility with reduced carbon emissions consists of efficiency in fuel consumption by the use of improved vehicles structure and engines but also the use of alternative fuels. These measures have the purpose of reducing the $\text{CO}_2$ and NOx emissions but also suspension dusts emissions. The increase of fuel efficiency can be
obtained by improvements in their aerodynamic characteristics, reducing the vehicles total load and use of high performance engines. Also, the development of new polymers, composite materials and the so-called “memory metals”, more light and resistant, should determine significant reduction of burned fuel quantities. The use of alternative fuels like liquid hydrogen (H2), bio-fuels, synthetic fuels and liquefied petroleum gases (GPL) as alternative energy sources also leads to a significant reduction in the quantity of emissions released in the atmosphere.

Complementary to the new technologies, materials and processes it’s recommended a significant change of transport policies in road traffic in order to support the city sustainable development. These changes refer to integration, in the current transport network, of cycling infrastructure, promote un-motorized vehicles, intelligent use of resources and joint transportation (like electric buses) or use of eco-efficient vehicles.

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