CONSIDERATIONS REGARDING THE INFLUENCE OF TRAFFIC MANAGEMENT SYSTEMS ON POLLUTANT EMISSIONS IN CONGESTED URBAN AREAS

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Traffic management systems are generally used to reduce traffic congestion and improve road safety. The paper presents the effect of traffic management systems on vehicle emissions and environment pollution levels. It also presents the most common types of traffic management systems used and their possible effects on vehicle emissions and consumption of fuel. Carbon dioxide (CO_2) is not a pollutant but a greenhouse gas which contributes mainly to global warming effects and which is associated with climate changes. The field of transport is one of the main sectors of economy with impact on climate change, in which an action plan for reducing CO_2 emissions is required. Using public transport on a larger scale, combined with the minimum service obligation, will allow increasing the density and frequency of services, thus generating very good premises for public transport modes development. Demand management and landscaping plans can reduce the traffic volumes.

Keywords: Traffic management systems, vehicles emissions, Poisson distribution, intermodal transport

1. Introduction

Many large cities face the impact of a high growth in motorized vehicle use caused by population increase and high expansion of local economy, especially in developing countries, which threatens the accessibility, the life quality and the natural environment. Facing the competition with individual motorized vehicles, which exclusively offers comfortable door to door journey service, the intermodal transport – meant as the efficient integration of different transport modes and services in the same journey – has become both a successful condition for encouraging public transport and non-motorized modes and a reasonable restriction on the growth of individual motorized vehicles fleet.

Traffic management systems are usually used to try lowering the congestion and improve the road safety. Recently, though, an interest has increased in

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exploring the effect of their operation on vehicle emissions and air pollution ([1], [2]). In this context, two main research objectives can be defined:

- if the traffic management system functionality addresses safety and congestion problems, should it also be designed so that the operation does not excessively increase emissions,
- Traffic management systems can be developed specifically to reduce emissions.

In a rather complex process, design and optimization of traffic management systems with reduced pollution is based on a better connection understanding, since the management system itself does not directly affect emissions rates. The initial impact of a traffic management system is on the vehicle driver and often involves a large number of decisions ([2], [3]). Depending on the traffic management system functionality, the driver can choose whether or not to limit the vehicle speed, decides for a change of route or mode of transport, where priority is given to public transport. Any change in the decisions of the vehicle driver results in a different way of operating the vehicle.

There are several ways in which these changes may occur in operating the vehicle. For example, a change of the total number of kilometers traveled, of traffic composition and of speed of movement profile may appear, and any such changes or a combination thereof can affect the emission rate [2].

A change in the rate of vehicle emissions leads to a change of the local air pollution levels. The rate of air pollution level change is not corresponding in degree with the emissions rate change, because the former is determined by many other factors, such as non-traffic sources emissions, existing concentrations of pollutants and specific photochemical processing time.

2. Urban Traffic Control

There are several types of traffic management systems. Several studies have shown that better control of urban traffic can lead to a reduction in fuel consumption [1], [5]. The systems which adapt the signaling process to driving conditions can provide additional savings of 5 to 15% compared with systems with fixed signaling programs. The effect on pollutant emissions is less documented, but the improvement is estimated to be approximately 20%. A significant reduction in pollutant emissions from vehicles by using traffic control systems may not be observed in some cities.

Traffic congestion is a very important and acute problem of nowadays for many groups of actors that perform in the field of transports: fleet managers, transport operators, traffic administrators, public transport administrators, traffic participants or travelers. Increasing the actual transport systems is a main purpose of the Intelligent Transport Systems at the international level. At the European

Union level, there are specific, clearly defined programs to deploy in an integrated, harmonized and standardised manner ITS[4] on specific transport corridors, known as the TEN-T[5]. These specific corridors are conceived to include ITS technologies developed for specific modes of transportation:

- For road transportation, ITS (urban traffic management, public transport management, highway management, advanced vehicle systems etc.);
- For railway transportation, the ERTMS/ETCS[6] solutions;
- For water transportation (Rhine-Main-Danube corridor #7), the RIS[7] solutions;

2.1 Surface parking control on road lanes

Reducing the number of vehicles parked on the street can lead to low incidence of congestion phenomena, reduced travel time and high traffic flow, unless the parked vehicles occupy road lanes. Based on the study results and using the emission model, it was estimated that the effect on emission rate consists of a reduction between 1 to 20%. To estimate the effects of a traffic management system on the rate of emissions is necessary to know how this system will change the traffic operation and the effect that these changes will have on the rate of emissions ([8], [9]). In principle, this information can be evaluated by experimental observation, but the wide range of possible traffic management systems and different circumstances that can be implemented, is impossible to achieve a comprehensive program of measurement. Consequently, it is necessary to select an appropriate model for simulation of traffic management system operation and estimation of impact on air pollution level.

3. Mobile environment monitoring system

The goal of this mobile air monitoring project is to overcome the limits of conventional monitoring technologies. Traditional air monitoring technologies are based on:

- *a network of fixed control centers* with gas analyzers and appropriate equipment consistent with the laws in force,
- *movable monitoring stations in fixed points* enhanced with the same equipment of the fixed control centers,

[4] ITS – Intelligent Transport Systems
[5] TEN-T – Trans-European Network for Transports
[6] ERTMS/ETCS – European Rail Traffic Management, European Train Control System
[7] RIS – River Information Services

- *mathematical models* for simulation and analysis of pollution effects according to the data collected.

The limit of these technologies is that these systems are actually designed for measurement of air concentration elements in order to alert public authorities polluting when certain threshold levels are exceeded. Air pollution testing stations collect precise data in the areas where they are located, disregarding completely the characteristics and distribution of the sources of air polluting agents and their spreading mechanism over to the territory [1], [6].

A wide range of traffic statistics is required to estimate pollutant emissions, such as: the quantity and composition of traffic, driver behavior, conditions of use and operation of vehicles [3]. This data can be obtained by statistic methods or by using some models, if those exist. To achieve an "inventory" at European level or international comparisons, it is necessary to ensure data compatibility (in terms of methods, data quality, etc.) for all the statistic data provided by various sources. This is the reason why investigations were conducted to determine precisely what statistics are needed to verify availability of data and compatibility with the objectives and their analysis [6].

The distribution which satisfies these conditions is:

$$P(n,q,T)=\frac{(q\cdot T)^n \exp(-q\cdot T)}{n!} \qquad (1)$$

Where: *P (n, q, T)* is the probability of *n* arrivals in *T* seconds, when the traffic flow is *q* vehicles per second;

The working system with Poisson equations allows development of graphics for each value *qT*, representing the average flow, which have different abscissa values of *n* (number of arriving vehicles) and the *P* probability as ordinate [4], [6].

A particular case is the probability of not having any arrival in the time T *(n* = 0). The above equation becomes:

$$P_n\,(0,q,T)= \exp(-q\cdot T) \qquad (2)$$

Interdependency connections are made between vehicles flows, speed, density and travel time which are important for studying and designing circulation systematization. Three types of environmental impacts are taken into consideration for design: the air emission, the noise pollution and the risks [3], [4].

Air pollution of transportation has the most direct environmental effects: local air pollution, global atmospheric pollution, etc. The air emissions considered here include CO_2, NOx, CO, HC, and PM10. And the total emission is described as follows [3], [4]:

$$I_g = \sum_{k=1}^{K}\sum_{i=1}^{I} x_{i_k}\left(\mu_i+\xi_i+(1-\xi_i)\sqrt{\frac{(Q/A)-\mu_i B}{B}}\cdot d_{i_k}\cdot\sum_{t=1}^{J} e_{i,t}(Q,V)\right. \qquad (3)$$

$$\mu_i = \max\left(\left| \frac{Q}{CQ_i} \right| \bullet \left| \frac{V}{CV_i} \right| \right) \tag{4}$$

$$0 \le \xi_i \le 1,$$

With,
Ig - total air emission during the shipment;
$e_{i,t}$ - unit of air pollution t in weight per unit of weight transported per unit of distance shipped by transportation mode i.
Q - The total weight of the products to be transported;
V - The total volume of the products to be transported;
CQ_i - Weight capacity of transportation mode i;
d_{ik} - Covered distance on zone k with mode i;
CV_i - Volume capacity of transportation mode i.
ξ_i - Constant.

In the present context, the passenger intermodal trips combine at least two modes of transport in the same journey: public transportation and the using at least two different ways of transport, etc. Those are the principal journey taken by passengers in urban zones or in peripheral urban zones [2], [4].

Strategic objectives related to infrastructure [2], will generate a significant impact on internal market development and will increase economic competitiveness and the speed of the economic integration of Romania into the EU. The current situation of the Romanian transport infrastructure is characterized by the existence of an insufficient capacity to increase the volume of goods and passenger transportation, especially in some areas and at certain times of the year (summer, weekends). Using intermodal public transport in large urban areas will make the reduction of the exhaust emissions possible by reducing the number of vehicles, the introduction of dedicated public transport strips and elaborate and implement a lower cost of the trip [1], [5], [6].

Table 1

Impact of speed on emissions [5]

Speed (km/h)	**NOx (g/km)**	**PM10 (g/km)**	**CO (g/km)**	**CO_2 (g/km)**
5	3.06	0.144	7.37	580.3
10	2.24	0.097	4.12	384.8
15	1.84	0.076	2.93	302.8
20	1.62	0.065	2.33	262
25	1.47	0.057	1.96	237.6
30	1.37	0.051	1.7	221.1

35	1.29	0.047	1.51	209.3
40	1.24	0.043	1.37	200.4
45	1.20	0.04	1.25	193.6
50	1.17	0.038	1.16	188.5
55	1.15	0.036	1.09	184.9
60	1.14	0.035	1.03	182.6
65	1.14	0.034	0.98	181.6
70	1.15	0.034	0.96	181.9
75	1.16	0.034	0.94	183.6
80	1.18	0.034	0.94	186.5

From the data in the Table 1, it is observed that the largest amounts of pollutants are emitted at minimum speed of 5 km/h for all pollutants. The small amounts are issued at speeds of 60-65 km/h for NOx (fig. 1), 65-80 km/h PM10 (Fig. 3), 75-80 km/h for CO (fig. 2) and 65-70 km/h for CO_2 (fig. 4). The increase of vehicle speed will determine an increase of amount of gaseous substances emitted into the atmosphere. This increase is however higher for some pollutants, such as PM10, than for others, such as NOx, in which case the dependence curve of emissions vs. vehicle speed is relatively flat.

The vehicle speed intervals for which the emissions of pollutants in the atmosphere are reduced, with values 10% higher or lower than the minimum emissions are shown in Table 1.

The recent studies carried out on the road revealed that at a speed of vehicles very large or very small, a minor change will lead to major changes in emissions of pollutants. It was found, for example, that the increasing of travel speed of vehicles at an average of 5 km/h to 10 km/hour, achieved growth by reducing congestion and traffic jams can result in lower emissions of pollutants by 27 % for NOx and 33% for PM10.

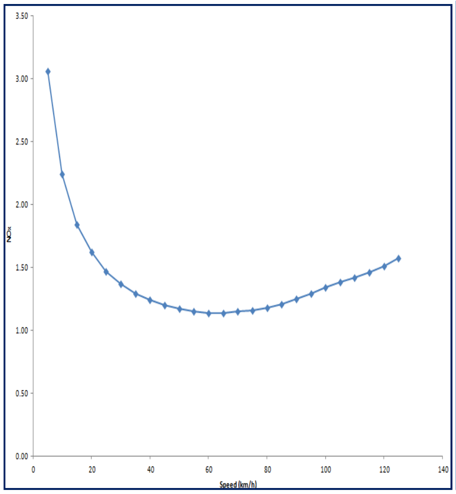

Fig. 1 Impact of speed on NO_x emissions

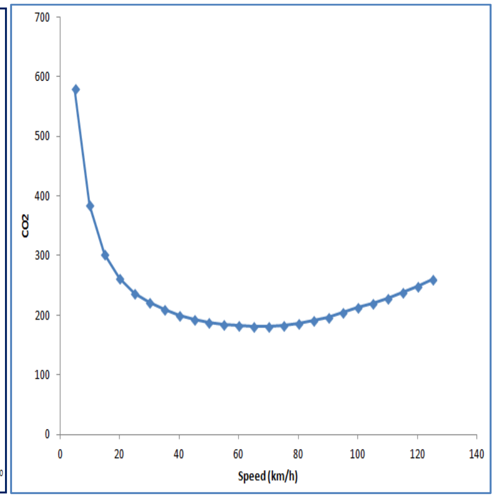

Fig. 2 Impact of speed on CO_2 emissions

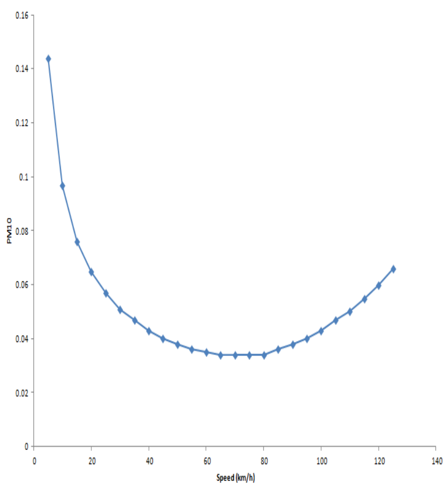

Fig. 3 Impact of speed on PM10 emissions

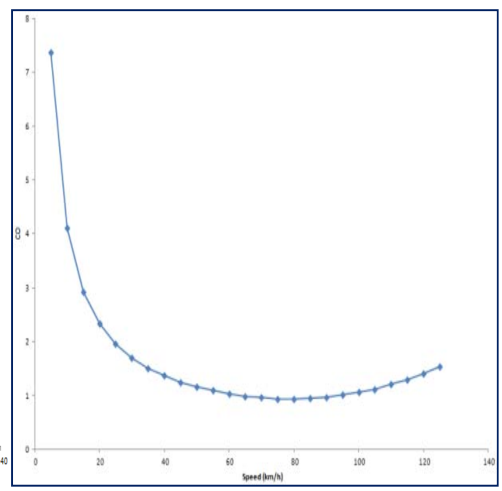

Fig. 4 Impact of speed on CO emissions

4. Conclusion

Most of the traffic management systems were designed and used to improve road safety and congestion, but their effects on vehicle emissions make them very popular. However, not all the possible evaluations were already conducted. The improvements are needed for all models which contain vehicles operations and emission models, to increase their accuracy on the effects on traffic management.

Increasing the vehicles' speed also increases the level of particles and gas emissions. This behavior is, however, more intense for specific pollutants, such as PM10, than for others, such as NOx, where the dependency with vehicle speed is relatively limited. Recent studies in the environmental impact revealed that, for very high or very low speeds of vehicles, a relatively small modification of the speed produces major changes in pollutant emissions.

There are necessary improvements to both vehicle operation models and emission models in order to increase the prediction accuracy for the effects of traffic management. It is also considered that the vehicle performance and emissions monitoring performance systems and subsystems will utilize a combination of electrochemical sensors, optical light scattering techniques and infrared methods to cover almost all possibilities and interest areas.

Basically, all savings in CO_2 emissions realized by intermodal transport can be traced back to three sources [6]:

- Intermodal transport consolidates smaller loads into large volumes which can be moved with less specific energy consumption;
- Transport operations with intermodal transport shifts from road to rail;
- Rail transport, at least in long distance traffic on the main axes, uses mainly electric traction in Europe. This electric energy is partly generated from other sources of conventional fuel burning. When electric energy is generated by waterpower or nuclear power, the energy for rail traction is provided without CO_2 emission.

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R E F E R E N C E S

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