Method for determination of an emission factor for a surface source

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It is known that cross roads are intensively polluting surface sources, first of all because of the high intensity of traffic, but also due to the very slow velocities of the motor driving cycles that occur, disadvantaged also by the old status of the fleet. As result, high momentum values of NOx and CO are recorded. The development of a modern city, the traffic refreshment and the limitation of heavy trucks in the central area of a city that is not benefiting of good advection, but of a bad infrastructure and ancient traffic fleet, are essential. Thus, after a long repeated series of on line measurements, the authors are recommending a statistical approach of determination of a specific emission factor, that might be used, in same or similar meteorological conditions and topography for limiting the traffic or characterising the by completing the emission inventory of a city also by superficial pollutant sources.

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1. Introductory explanation

Air quality in urban areas might be determined either by direct, on line measurements, or by numerical simulation, based on real data and meteorological & topographic conditions. Another method might be the physical modeling, in a wind tunnel. All three possibilities involve a lot of incertitude. Most appropriate and closer to the reality are the on line measurements, which answer in real time and offer the most complex, but also the most costly, information. In Romania a new legislation, concerning air quality monitoring has been recently developed, in accordance to the EC norms [1], [2]. Standard measurements are based on special measuring methods [2]. In addition new methods, such as the optical ones, are used [3]. For accomplishing a correct air quality simulation, one must base on an environmental inventory of the sources, that are generally speaking, point sources, and surface (superficial) sources. For the point sources, it is relative easy to determine the intensity (flow, specie, coordinates), as mainly they are owned by industrial or energy sector [5], [6] [7], [18], [19], [20]. Actually the house hold sources (also stable sources), even they are of reduced intensity, are under control ISCIR). For superficial sources (meaning especially cross roads), it is difficult to establish a concrete and representative value, as it depends drastically on the traffic that is traversing trough.

Because lack of apparatus, and lack of professional care and capabilities, it is still not possible to achieve the continuous air quality monitoring standards, despite the existing legislation. Thus specific modalities for evaluating the strength of the sources that are polluting must be determined. The specificity is connected not only on the climate conditions, but also on the structure of the fleet.

Literature is offering a lot of sophisticated or more simple possibilities, for calculating, with a higher or only approximate accuracy, and with respect to different sources, from parking places, cross roads, stationary point sources, etc. [9], [10]. Unfortunately, the fleet composition and its shape are in Romania, very untypical for an European country, meaning that the structure of the fleet and its technical status are not of best quality, and are far from the state of art, presently existing in the European Community. Thus specific research, typical for local conditions is to be accomplished. Appropriate meteorological information must be known, in order to make all the necessary transformation and find possible explanations for a bad diffusion of the pollutants [12], [13].

The present paper is based on long term on line measuring campaigns, organised in open air in the plan city Timisoara, accomplished with standardised and non-standardised apparatus, and offers a possible solution for evaluating the intensity of superficial polluting sources, mainly the cross roads.

2. Experimental

Following apparatus have been used, in accordance to the Romanian standards for air quality that are in close correspondence to the EU legislation. Detailed description is offered in [4], [10], [12], and [15].

- CO HORIBA APMA-350E classic monitor working ND in IR (called classic method in the following),

- IR Hawk from Siemens Environmental Systems is an infrared DOAS instrument working as an optical remote instrument for CO,
- NO_x measuring apparatus Monitor Labs 8840 applying the principle of the chemiluminiscence,
- Monitor Labs 8850S for SO_2, working in UV,
- Particle sampler LVS3 for PM10.

Fig. 1 gives the schematic view of the entire analysed cross road and indicate the grid used for the aria calculation and the position of the traffic counters. Fig. 2 brings one example of the on line air quality measurements, accomplished at Timisoara during 2002 and 2004, by the authors. Figs. 3 and 5 present particularly results, respectively, for two large cross roads of the city of Timisoara, during the mentioned 2003 episodes. It is obvious that the measured concentration values are under close influence caused by the traffic. One remarks the daily peaks, and the nigh relaxation.

The maximum values are due to the traffic, and not to the activity of stationary sources, that are sending by dispersion their pollutants, into the analysed cross section. The point sources do not have regularly an interruption of their activity, and even if this might be the case, the differences between the episodes are not so obvious and discrepant one against the other [8], [17], [11]. Thus the question proposed for analysis trough the title of the paper finds an evident and simple answer.

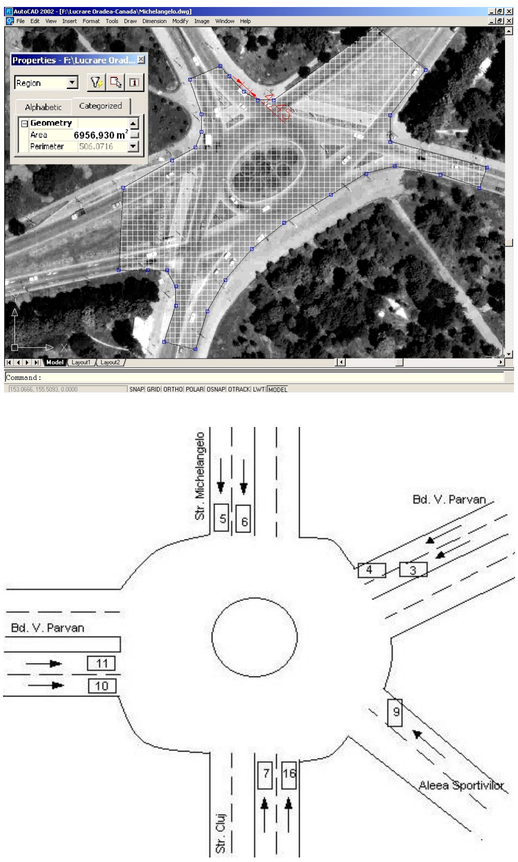

Fig. 1. Geometry and schematic of the Michel Angelo cross road and the position of the traffic counter of the fleet intensity.

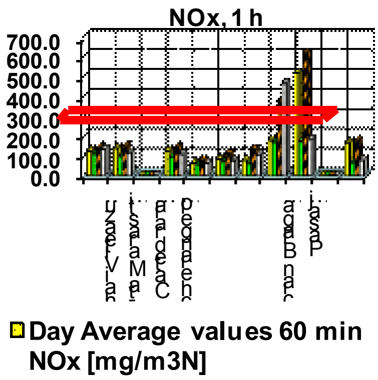

Fig. 2. NO_x concentration, average for 1 h, and maximum values, by day and by night, for all monitored Timisoara episodes.

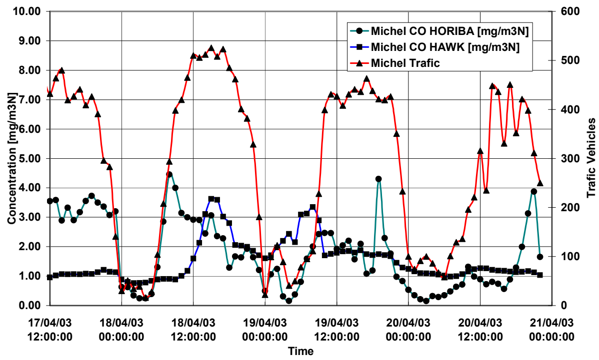

Fig. 3. Correlative CO mean values recorded with two comparative measuring devices and the traffic intensity, during a spring episode, as registered in the cross road Michelangelo from Timisoara, in 2003.

3. Calculation methodology of the emission factor

One determined the following values and constrains:

$$C_m = C_v \cdot \frac{22{,}4}{M_{pol}} \cdot \frac{273{,}15+t}{293{,}15} \cdot \frac{1{,}013 \cdot 10^5}{p_b} \quad [\text{mg/m}^3_{\text{N}}] \tag{1}$$

where:

C_m - mass concentration of the pollutant, in ppm,
C_v - volumetric concentration of the pollutant, in mg/m^3_N,
M_{pol} - molar mass of the pollutant, in kg/kmol,
22,41 - molar volume under normal conditions, in m^3/kmol,
t - temperature, °C
p_b - barometric pressure, in Pa.

Thus the mean value becomes:

$$[(C_m)_{med}]_i = \frac{\sum_{i=1}^{n} (C_m)_i}{n} \quad [\text{mg/m}^3_{\text{N}}] \tag{2}$$

where:

n is the simultaneous registered traffic values,
i - specie of the pollutant.

The equivalent dimension of the analysed cross road.

$$r_{echiv} = \frac{2 \cdot A}{P} \quad [\text{m}] \tag{3}$$

where:

A is the area, in m^2,
P - perimeter, in m.

One calculates specific and corrected traffic intensity (number):

$$N_{cor} = \sum_{k=1}^{t} \frac{N_k}{3600} \cdot \left(\frac{l_k}{w_k} + t_{stat_k} \right) \tag{4}$$

where:

N - the number of internal combustion engines of different categories, in h^{-1},
3600 - transformation factor seconds/hour,
k - classification index specific to the category of engine,
w - mean value of the velocity for the cross road traversing of the vehicle, in m/s,
t_{stat} - stationary interval of the vehicle, in s,
l - length of the distances necessary for the vehicle to traverse the cross road, in m.

Finally, a specific superficial emission factor for the cross road is to be calculated.

$$f_{superf} = \frac{[(C_m)_{med}]_i}{\pi \cdot r_{echiv}^2 \cdot N_{cor}} \quad [\text{mg}/(\text{m}^3_N \cdot \text{m}^2)] \tag{5}$$

4. Results and conclusions

Figs. 4 and 6 indicate the obtained specific values for the emission factor. It is obvious that during day and night different values are specific. But also it is remarkable that the values are quite constant and thus representative. The method has been repeated and attested for another 3 cross roads in the meteorological and climate and topographic conditions specific to the city of Timisoara (plain, 80 m over sea, continental climate with Mediterranean influence, high ground water level that determines probably temperature inversions). The curves inform about the evolution of the defined specific superficial emission factor, as resulted from the calculation, according to the on line measurements. Their mean values have been recorded in Table 1.

Closing concluded remarks are referring to the utility and modality of evaluating air quality in a cross road, that has been preliminary analysed. The method is very useful as it might be used, in lack of measurements, to characterise the emission capability of the analysed cross road. On other side, by using that maximum admitted value according to the legislation, in stead of the measured one, one might determine the maximum number of cars that might traverse the cross road, in order not to have bad air quality.

Table 1. Results for the average calculated specific emission factors, by day and by night, for different cross roads.

Cross Road	Time interval	f_{superf} CO Horiba mg/(m^3_N*m^2)	f_{superf} CO Hawk mg/(m^3_N*m^2)
Michelangelo	Day (05 – 24)	0.00012	0.00011
	Night (01 –04)	0.00050	0.00076
Marasti	Day (05 – 24)	0.000072	0.000063
	Night (01 –04)	0.00047	0.00043

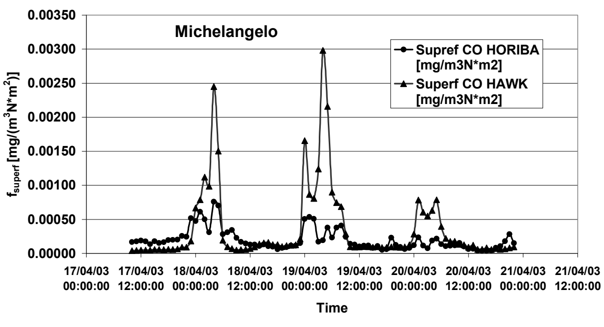

Fig. 4. Calculated superficial specific emission factor for the Michelangelo cross road.

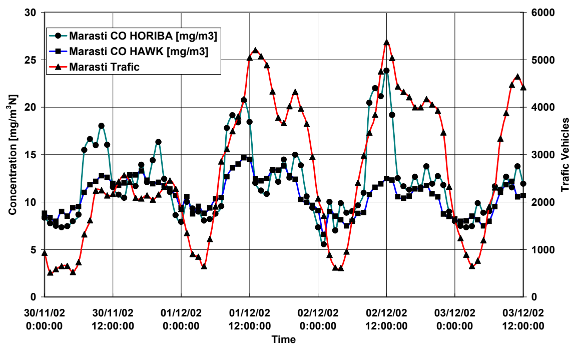

Fig. 5. Correlative CO mean values recorded with two comparative measuring devices and the traffic intensity, during a winter episode, as registered in the cross road Marasti from Timisoara, in 2003.

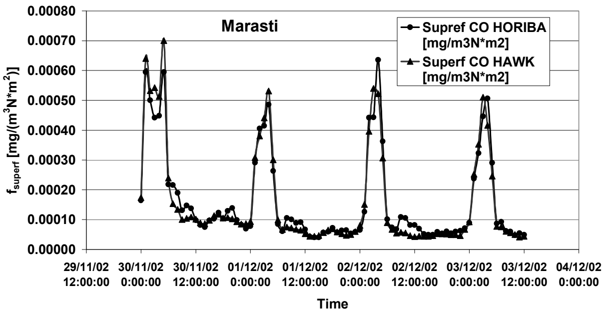

Fig. 6. Calculated superficial specific emission factor for the Marasti cross road.

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