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AN ASSESSMENT OF THE TRAFFIC-RELATED EMISSIONS IN THE CITY ON NIŠ

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Abstract. *The most of the air pollution originates from combustion processes, so it is important to make quantitative as well as qualitative analysis, as the sources of pollution can be stochastic - especially the road traffic. The goal of the study is to determine closer road traffic as one of the major sources of the pollution in the city of Niš. The analysis was performed on the vehicle fleet composition and the estimation of the annual mileage on the city territory. These data were used as the input for the COPERT methodology of air pollutant emissions calculation from road transport. Based on these data, annual emissions of CO_2 and major pollutants were calculated, as well as the specific average emissions on roads.*

Key words: *COPERT, CO_2, pollution, emissions, traffic*

1. INTRODUCTION

The impact of pollutants as a consequence of a traffic activity (CO, NO_X, CO_2, SO_X, VO_X) has been well documented [1-3]. Recently, since recognizing the problem of global warming caused by GHG emissions, more attention has been focused on CO_2 emissions. Vehicles represent one of the greatest emitters of all pollutants, as well as carbon dioxide. As estimated, in the overall balance of CO_2 vehicles contribute 10%, and in Europe, 20% of anthropogenic emissions [1]. Countries with rapid urbanization, such as India and China, are becoming increasingly dependent on automobile transport, which has become a major air pollutant in urban areas [4-7]. As has been presented by Živković et al., in the city of Niš this percentage is even higher [2]. Although measuring pollutant concentrations themselves is not difficult, a closer determination of traffic sources is very

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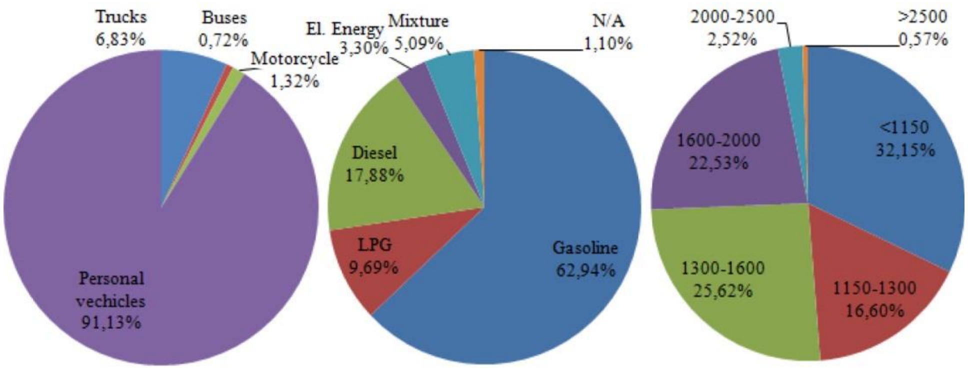
complicated considering their stochastic nature [5]. For this reason, different methods for modeling emissions from traffic were suggested. Such estimates are of great importance for the more efficient management of air quality. Emissions from traffic depend on many parameters: vehicle type, engine volume, vehicle age, fuel type, cruising speed, etc. Examining the emissions of CO_2 and pollutants during the study, the authors have chosen a "macro" or "top-bottom" approach to determine emissions from a single vehicle, based on obtained emissions data. Such data, when they are sufficiently determined, can be used for building a national inventory of emissions [8-10]. In recent years, there have been significant efforts to determine emissions in the function of engine type, engine size and the cruising speed of the vehicle [9-12]. For this purpose, various models for prediction of gaseous emissions were developed [1,8,13,14]. The COPERT computer program developed by Ntziachristos and Samaras was used for this study, which utilizes the macroscopic approach [15]. Basically, COPERT was used as a tool for assessing emissions from traffic at the national level. COPERT operation is based on the analysis of large amounts of data from several European vehicle testing facilities. This is a very reliable methodology since the actual high-level agreement of data obtained [14].

In the current study, the assessment of the traffic related emission on the city of Niš territory has been done. The vehicle fleet composition data were imported into the COPERT software package, from which overall traffic emissions, and thus, the specific emission factors for CO_2 and pollutants per vehicle and km were calculated.

2. Vehicle Fleet Analysis in the City of Niš

The fleet composition data used in this research were obtained from the Ministry of Interior of the Republic of Serbia. For the specific emission factor assessment and the annual emissions calculation the vehicles were divided into three categories:

- passenger vehicles,
- buses and
- trucks.



a) in respect of categories b) in respect of fuel c) in respect of engine volume

Fig. 1 Vehicle fleet composition

In the fleet passenger cars occupy by far the largest share of the fleet, where the petrol driven engines are the most common, making almost 2/3 of the fleet. The average age of vehicles is approximately 14 years (Fig. 1). As constant vehicle velocity was adopted, the emission factor for substance *i* in the specific vehicle category could be calculated as [14,16]:

$$EF_i = c + bv + av^2. \tag{1}$$

Equation (1), from which one calculates the emission factor, is generally approximated by a second degree polynomial function of average vehicle velocity, or a graph [1,10,11,14,15]. Nejadkoorki et al. suggest more complicated formulas for emission calculation as a function of average velocity [1]:

$$EF_i = g + av + bv^2 + cv^3 + \frac{d}{v} + \frac{e}{v^2} + \frac{f}{v^3}. \tag{2}$$

In the eq. (1) and (2) a,b,c,d,e,f and g are constants.

Some authors obtain the emission factor as a function of acceleration, as well as velocity [10,12,17-19]. Although EFi is not a constant, it is assumed that for an average vehicle velocity, it is approximately a constant [15], where the mean vehicle speed in the city is 23 km/h according to [20].

2.1. Personal vehicles

For the average mileage per year in the city, a value of 3500 km annually was adopted, assuming that the average urban drive amounts 10 km daily [16] with a deviation of 7.5%, which was adopted as the value of data uncertainty [20].

2.2. Buses

Four-hundred and seventy-seven buses are registered in the city of Niš. However, during the emissions calculation only buses from the public transport company were used in the account. According to the most recently available data, 124 buses were engaged in the city of Niš public transport, and they were driven 8609250 km annually [21]. This makes public transport buses far more influential in comparison with other busses that travel through the city.

2.3. Trucks

In the analysis, light trucks were counted among passenger cars. The authors have adopted as a boundary between personal vehicles and trucks the engine volume of 2000 cm^3. All transport vehicles with an engine volume larger than 2000 cm^3 were categorized as trucks. According to this, there are 2286 trucks in the city. For annual mileage, 2000 km was adopted for the city territory, with an assumed uncertainty of 7.5% [20].

3. RESULTS AND DISCUSSION

The calculation results for major pollutants and CO_2 obtained by COPERT are presented in Table 1 and 2. Table 1 shows the specific emission factors for major pollutants and CO_2, while in Table 2 presents annual emissions from traffic in the city of Niš.

Table 1 Specific emission factors for pollutants and CO2 for the specific vehicle category [g/km]

	CO_2	CO	NOx
Personal veh.	242.3	9.7	0.76
Busses	2410.8	4.7	1.43
Trucks	500.0	9.4	2.51

Table 2 An assessment of the total annual emissions of pollutants for the specific vehicle category in [t/yr]

	CO2	CO	NOX
Personal veh.	51495	2054	162.14
Busses	20755	40.82	123.38
Trucks	525	9.84	2.64

From the results obtained by COPERT, one could conclude that the values of specific emission for CO_2 and COPERT's results as well as results from other sources listed in the table are not significant. The difference between the average results and current research is 25.5 g/km, which gives an acceptable value of the simulation error of up to 9.51%. On the other hand, errors in specific emissions calculations of CO and NO_X are difficult to identify due to their low emissions. Compared to various studies, the value of specific emission factors for CO is of the same order of magnitude, ranging from 2.2 g per km [10] to 9.7 g per km in the current research (Table 5).

Table 3 Comparison of specific emission factors for CO_2 [10,22,23]

Authors	Em. factor [g/km]
Joumard *et al.*	240
Samaras	350
Current research	242.3
EPA	238.9
Average value	267.8

Table 4 Comparison of specific emission factors for CO [10,22,23]

Authors	Em. factor [g/km]
Joumred *et al.*	2.2
Samaras	5
Current research	9.7
EPA	5.8
Average value	5.7

In the evaluation of NO_X emission, the situation is similar with CO emission estimation. The differences in specific emissions could be explained partly old vehicle fleet in the city. In favor of this is the fact that on the basis of [24] can see that the specific NO_X emissions in 1995 amounted to about 0.85 g per km, while the same figure in 2009 is only 0.3 g per km (Table 5).

Table 5 Comparison of specific emission factors for NO_x [24]

Authors	Em. factor [g/km]
Current research	0.763
EPA	0.430
EEA – 1995	0.85
EEA – 2009	0.3

4. CONCLUSIONS

Based on the above, it can be concluded that the COPERT represents an efficient tool for the assessment of road transport emissions, especially in the case CO_2 emission. However, in the case of pollutants whose emission factors are two or three orders of magnitude lower than CO_2 emission one could not guarantee the accuracy. This difference could be a consequence of average age of the fleet, as well as vehicle maintenance and the fuel quality. Regardless of the results for CO and NO_X, they give a good assessment of traffic-induced pollution in the city of Niš territory.

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PROCENA EMISIJA KOJE POTIČU IZ SAOBRAĆAJA U GRADU NIŠU

Najveći deo zagađenja vazduha potiče od procesa sagorevanja, tako da je važno izvršiti kvantitativnu, kao i kvalitativnu analizu, kako izvori zagađenja mogu biti stohastički - posebno drumski saobraćaj. Cilj studije je da se bliže utvrdi drumski saobraćaj kao jedan od glavnih izvora zagađenja u gradu Nišu. Analiza je izvršena na osnovu sastava voznog parka i procene godišnje kilometraže na teritoriji grada. Ovi podaci su korišćeni kao ulaz za metodologiju COPERT za proračun emisije zagađenja vazduha iz drumskog saobraćaja. Na osnovu ovih podataka, godišnje emisije CO_2 *i veliki zagađivači su izračunati, kao i specifične prosečne emisije na putevima.*

Ključne reči: *COPERT,* CO_2*, zagađenje, emisija, saobraćaj*