The impact of road transport emissions on air quality in Brăila, Romania

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Abstract: Road transport, including accessibility and individual mobility is considered unanimously as a fundamental element of contemporary living. The study area is considering Braila County with a total population of around over 305,000. The area it is well served by 6 national roads, 27 county roads and 42 communal roads and contains some of the most heavily trafficked stretches of road in the Romania. The emissions analysed in this study CH₄, CO, CO₂, N₂O, NH₃, NO_x, PM_{2.5} and PM₁₀, were collected by the Agency for Environmental Protection Braila during 2015-2019 based on questionnaires according to EMEP/EEA air pollutant emission inventory guidebook. The highest level of pollutant emissions was recorded in 2017, more exactly 191714,5 Megatons. In this article we analysed five categories of pollution sources: Passenger car, Light commercial trucks, Heavy-duty vehicles, Motorcycles and Non - Road vehicles and other mobile equipment. With the exception of CO₂, N₂O and NH₃, pollutant emissions decreased for the eight pollutants analysed.

1. Introduction

Transport is the third major cause of greenhouse gas emissions in Romania. Starting with 1990, emissions released from transport in Romania have been intensifying and as part of the Paris Agreement this trend should be immediately inverted (Earl T., 2018). Romania is already facing magnified impact of climate change and warming in comparison with Europe. If no constraint is assumed, Romania risks not respect their mid-term European diminution objectives.

The aim of this paper is to analyse the types of pollutants, sources and their impact on air quality in Braila County in the period 2015-2019, in the context of national decreasing the transport emissions from a wide variety of European and national actions. There is an ample mixture of national actions that may encourage diminish need and facilitate changing strategy to fewer polluting forms. Actions refers to replacing automobiles with trains, buses, and bicycle (EC, 2017, 2020).

According to European Commission achieved separately, challenging of national actions might reduce the loophole by 42%, but linking national operations with competitive standards and electrification would observe Romania being unsuccessful as regard the target by 2.6 Mt, with all actions mixed delivering 71% of the target. Moreover, Romania ought to endorse strict vehicle norms, and expressly insist on the 2025 objectives. Inasmuch as for passenger cars, vans, and trucks this must be a real 20% decrease until 2025. (EC, 2018).

Climate change is a general issue demanding worldwide initiatives to control it, despite that there are particular risks and costs associated for Romania that have already been noticed. During the interval 1901 until 2007 the annual mean for air temperature in Romania increased by 0.5°C (CCP, 2021). As long as Romania takes no measure and the projected 2030 CO₂ norms for road vehicles are not applied, Romania will not respect the 2030 goals by 9.2 Mt of emissions. As stated in the Climate Action Regulation (CAR), this could cause the demand of acquiring of up to 59 million allowances. Supposing that the other fields fulfil their goals, no flexibilities and a share price of 100 euro/tonne, this would be 5,9 billion, if gaps in the regulation are not applied. (EC, 2020).

Romania has been classified among countries with oldest automobiles fleet in Europe, 16.2 years averaging for passenger cars and 15 years for heavy – duty vehicles, while the EU average is 11 and 12 years (ACEA, 2021). Romania is one of nine EU countries that implement time-based charging vignette system but without separating in conformity with vehicle weight and axle number, regardless of the emission class of the vehicle (Vasile et al., 2012).

According to Environmental Implementation Review 2019 — Romania, the inadequate air quality continues to be a problem. The major causes of air pollution originate from the transport and energy sectors, mainly from fossil fuel utilized by households (EC, 2019).

Member States of the European Union must draw up, annually, an Informative Inventory Report in accordance with UNECE Convention on Long Range Transboundary Air Pollution and Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC. As stated in Romania's Informative Inventory Report 1990-2019, starting with 2009, SO_x emission had decreased significantly due to installed desulphurization equipment. NO_x emissions decreased with 49% in 2019, compared to 1990 and with 34% in 2019, compared to 2005, mostly as result of the implementation of emissions reduction program in some specific installations in addition to the decrease of the liquid fuel consumption. NH₃ emission have decreased moderately from 214.6 kt in 2005 to 178.2 kt in 2019. The trend of PM_{2.5} emission have been varying to a maximum of 133 kt in 2008, but starting with 2008 have been gone down constantly to 112 kt in 2019. Also, in the mentioned document is discussed the idea that the trend reflects several issues: the economic progress in Romania, earlier the global economic crisis that induced the decline of industrial production, the reduction of energy production in fossil fuels power plants and the application of emission reduction technologies (EIONET CDR- CLRTAP, 2021).

As specified by Annual European Union greenhouse gas inventory 1990–2019 and inventory report 2021 the major emitters of CO between 1990 and 2019 are France, Germany, Italy, Romania and the UK reduced their emissions from 1990 levels considerably. Bulgaria, Germany, Romania, Spain and the UK are the largest emitters of SO₂ and all other countries reduced their emissions substantially starting with 1990. In the same document it is mentioned that major reasons of the reduced CO₂ emission in Romania were the transition to a market economy and the reduction of energy intensive activities. (EEA, 2021).

Several studies have argued different tools that can be applied for the evaluation of uncertainty in emission inventories, but a methodical procedure that differentiate among uncertainty regarding accuracy and uncertainty concerning reliability has not been created yet (Aardenne, Pulles, 2002; Huang et al., 2021). The ambiguity in emission inventories should be approached from two aspects: firstly, the uncertainty about accuracy is the absence of data regarding the sources and size of the errors of an

emission inventory and the second case: uncertainty about reliability is the insufficiency of comprehension about the degree to which the emission inventory is accomplished customized quality criteria (Pulles et al., 1998).

The emission assessment approach includes exhaust discharges of CO, NO_x, NMVOC, CH₄, CO₂, N₂O, NH₃, SO_x, exhaust PM, PAHs and POPs, dioxins and furans, PCBs, HCB, and heavy metals contained in the fuel and lubricant (lead, arsenic, cadmium, copper, chromium, mercury, nickel, selenium and zinc). NO_x emissions are additional divide in NO and NO₂. PM is as well split within elemental carbon and organic carbon as a part of vehicle technology. A special attention is paid to NMVOC, including homologous series like alkanes, alkenes, alkynes, aldehydes, ketones and aromatics compounds. PM mass emissions in vehicle exhaust principally appear as PM_{2.5}- dimension range. Thereby, all PM mass emission factors are supposed to be equivalent to PM_{2.5}. Emission factors for particle number and surface are in the same time provided for various particle size ranges (EMEP/EEA, 2020).

2. Materials and Methods

For the purpose of analysing the impact of transport emissions on air pollution in Braila County we used the datasets collected by Agency for Environmental Protection Braila within the period 2015-2019 relied on questionnaires in conformity with EMEP/EEA air pollutant emission inventory guidebook. The most important pollutants emitted by road vehicles include: ozone precursors (CO, NO_x, NMVOCs; greenhouse gases (CO₂, CH₄, N₂O); acidifying substances (NH₃, SO₂), particulate matter mass (PM) including black carbon (BC) and organic carbon (OC), carcinogenic species (PAHs and POPs, toxic substances (dioxins and furans) and heavy metals (Boulter, McCrae, 2007). For this paper we selected: CH₄, CO, CO₂, N₂O, NH₃, NO_x, PM_{2.5} and PM₁₀, trying to analyse most of these categories of pollutants. Data collection questionnaires calculate emissions on the following categories: passenger cars, light commercial vehicles (less than 3.5 t), heavy-duty vehicles (more than 3.5 t) and busses, mopeds and motorcycles and non-Road vehicles and other mobile equipment. The emission assessment schemes these four categories are frequently sub-divided in conformity with fuel used, and by engine dimensions, weight or technology level of the automobile.

Actually, road transport is doubtless a fundamental category in all states. Based on the level of detail accessible, and the method used for the calculation of emissions, the pollutants may be separated into the four groups: the first category include pollutants for which a precise approach exists, based on specific emission factors, the second group pollutants are calculated in reference to fuel consumption, the third group contain pollutants for which a simplified method is utilized, predominantly because of the deficiency of detailed data and fourth group includes pollutants that are originated as a fraction of total Non-methane volatile organic compounds (NMVOC) emissions.

The total discharge emissions from road transport are computed as the sum of hot emissions (normal operating temperature of the engine) and emissions during transient thermal engine operation ('cold-start' emissions). It must be borne in mind that exist a substantial difference in vehicle emission performance for the two conditions: the 'hot' stabilised phase and the transient 'warming-up' phase.

Distinct procedures are used because the concentrations of several pollutants during the warming-up period are significantly higher than during hot operation. The total emissions may be estimated by using of the subsequent equation:

$$E_{TOTAL} = E_{HOT} + E_{COLD} \quad (1)$$

where:

E_{TOTAL} = total emissions (g) of any pollutant for the spatial and temporal resolution of the application,

E_{HOT} = emissions (g) during stabilised (hot) engine operation,

E_{COLD} = emissions (g) during transient thermal engine operation (cold start).

Vehicle emissions are strongly contingent on the engine process circumstances. Different driving cases require distinct engine working conditions, and consequently an individual emission efficiency. It is taken into account a difference between urban, rural and highway driving and distinct emission factors are assigned to separately driving condition. Cold-start emissions are assigned principally to urban driving. Thus, total emissions can be calculated by using the equation:

$$E_{TOTAL} = E_{URBAN} + E_{RURAL} + E_{HIGHWAY} \quad (2)$$

where:

E_{URBAN} , E_{RURAL} and $E_{HIGHWAY}$ are the total emissions (g) of any pollutant for the respective driving situations.

Total emissions are calculated by associating activity data for each vehicle category with proper emission factors. The emission factors fluctuate based on the input data (driving situations, climatic conditions).

As stated in EMEP/EEA air pollutant emission inventory guidebook 2018, the flow chart of the utilization of the baseline methodology is shown in Figure 1.

Figure 1. The utilization of the baseline methodology according to EMEP/EEA air pollutant emission inventory guidebook 2018

From a climatic point of view, the municipality of Brăila is located in the continental climate province, in the plain climate, under the Danube-Siret-Prut meadow climate contract. For its climate, the Măcin Mountains are also of great importance, as their NW-SE orientation represents a natural dam in the way of the east winds, determining the phenomenon of air conditioning that passes over Balta Brăilei, with large masses of hot and dry air. The air temperature regime through the monthly average values and especially through the absolute amplitude, most clearly reflects the characteristics of the continental temperate climate, with excessive nuances. The average annual temperature varies in the period 2015-2019, between 10.6 °C and 12.3 °C. The nebulosity depends on the altitude, in the municipality of Brăila being reduced. During the summer it reaches an average of 50 clear days and only 18 covered by clouds. Every year there are 80 cloudy days in Brăila. The brightness of the sun is between 2000 and 2500 hours per year in the period 2015-2019, the summer being between 90-100 very bright days. This is due to the continental air masses that fly over the area and which brings to 290 the number of sunny days per year. The solar radiation is 123.0 kcal/cm², one part propagating in summer in the soil, another part being consumed by water evaporation, and the rest being lost in the atmosphere. Atmospheric pressure is characterized by a maximum in the cold season of 754.9 mm, due to anticyclonic fields and by a minimum in the warm season of 754 mm. The minimum average variation is characterized by a maximum in the morning and a minimum in the evening, not posing any particular problem for acclimatization. Atmospheric humidity is a climatic factor that has a not very favourable effect on the dispersion and transport of pollutants and contributes to the formation of very harmful effects on life, such as fog and even smog. The average relative humidity (%) varied between 75% and 79%, in the studied period. Like the thermal regime, the precipitation regime reflects the continental character of the climate, in the sense that they fall in variable quantities from one year to another and are unevenly distributed during the year. The monthly amounts of precipitation recorded in the period 2015 - 2019 varied between 4 mm and 83 mm. In the period 2015-2019, the predominant general trend of the N wind direction is observed, except for the summer months when there are variations from NW and S.

3. Results

For the purpose of assess the air quality in Braila County starting to 2015 until 2019, Romania we selected eight from the most common pollutants: CH₄, CO, CO₂, N₂O, NH₃, NO_x, PM_{2.5} and PM₁₀. The dataset was collected by the Agency for Environmental Protection Brăila in accordance with questionnaires as stated by EMEP/EEA air pollutant emission inventory guidebook.

In order to have an overview of the emission trend in Brăila County, we summed up the emissions for each year of the reference period.

Total emissions for the pollutants analysed CH₄, CO, CO₂, N₂O, NH₃, NO_x, PM_{2.5} and PM₁₀, vary from 166261.79 Megatons in 2015, there is a slight increase to 171393.98 Megatons in 2016. In 2017 we had the largest quantity of emissions in Braila County, 191714.52 Megatons, followed by lower emissions, for example 173083.04 Megatons in 2019. In order to try to understand this downward trend, we analysed the number of existing cars in the city of Braila in the period 2015-2019, we can see a significant increase in their number, for example in 2015 their number was 46511 compared to 56749 cars in 2019. In the analysis of air pollution is essential to study emissions of car pollutants according to pollution regulations. In 2015, approximately 35% of the total number of cars were manufactured according to regulations over Euro 4, while in 2019 they exceeded over 50%, noting the trend of renewal of the car fleet (see figure 2).

The set of data was grouped into the following categories: Passenger cars, Light commercial trucks, Heavy-duty vehicles, Motorcycles and Non - Road vehicles and other mobile equipment, thus having the possibility to observe the type of pollutants depending on the sources.

Figure 2. The trend of pollutants in Braila during the period 2015-2019

The emissions for each pollutant were transformed into megatons and due to the fact that the quantities vary considerably, we calculated the percentages (figure 3). Our basic idea was to include in the same graph all the pollutants from the five categories of sources.

Figure 3. Pollutants resulting from road transport in Braila, Romania in period 2015-2019

Based on dataset analysing we observed the passenger cars are the major source that contributes the most to the air pollution in Brăila area. The percentages vary between 89.05 % for NH_3 , 78.21 % for CO and lowest percent is 34.68 % for NO_x . Motorcycles are included in this paper, but it represents a very small percentage of road transport emissions. CH_4 is the pollutant with the highest percentage, 0.72%, having as source Motorcycles, followed by CO with 0.52 %. The emissions from Heavy-duty vehicles consist in NO_x - 50.09%, 37,02% the percent for PM_{10} , while CO_2 represent 31.3% and 4.76% is the lowest percent for NH_3 .

Inasmuch as Passenger cars represent the largest source of pollution, we decided to analyse, more detailed, the specific emissions, grouping them into three main categories: greenhouse gases, ozone precursors plus acidifying substances and suspended and sedimentable dusts. This detailing of the type of pollutant according to a certain source is extremely important, being the first step in making decisions by local and national authorities.

With the exception of CO_2 , other pollutants maintain a downward or constant trend. CO and CO_2 are the only pollutants in Figure 4., for which the second axis has been added, to the right of the graph.

Figure 4. Pollutants resulting from passenger cars, road transport in Brăila during 2015-2019

For the category of greenhouse gases were analysed CO₂, CH₄, N₂O emissions collected during 2015-2019. CO₂ emissions varies between 81732.78 Megatons in 2015 to 93934.21 Megatons in 2019, with a peak in 2017, 95628.72 Megatons. This is the pollutant with the largest contribution to the total amount of emissions and the only one that has an upward trend in the analysed period. If we study the CH₄, we notice the downward trend and a clear decrease from 13.87 Megatons in 2015 to 8.24 Megatons in 2019, the maximum value being that of 2018, 14.88 Megatons. N₂O has a relatively constant trend in the period 2016-2019, around 3.20 Megatons and only in 2015 the quantity of emissions was 2.62 Megatons.

For ozone precursors plus acidifying substances we selected NO_x, NH₃ and CO. The NO_x emission's variation between 2015-2017 is approximative 340 Megatons, while in 2018 increase to 404.77 Megatons and in 2019 there is a decrease up to 285.5 Megatons. NH₃, as NO_x it has a peak in 2018, 10.29 Megatons, other than that the studied period the emissions were between 7.9 Megatons in 2015 and 9.51 Megatons in 2019. CO has an evidently decreasing tendency, from 1910.77 Megatons in 2015 to 709.9 Megatons in 2019. The decrease is almost 40% and this cause should be examined more precisely.

Both PM_{2.5} and PM₁₀ have a decreasing trend, but not very noticeable. Emissions for PM_{2.5} varies from 19.28 Megatons in 2015 to 16.5 Megatons in 2019. As with other pollutants analysed, the maximum value is the one from 2018, 20.7 Megatons. This observation is also valid for PM₁₀ emissions, pollutant that had 25.35 Megatons in 2018, compared to 22.56 Megatons in 2015 and 20.69 Megatons in 2019.

4. Conclusions

In order to determine the emissions for the eight pollutants from Braila County, during 2015-2019 we analysed the dataset collected by Agency for Environmental Protection Braila. This study is a first analysis of emissions for the mentioned period, subsequently this the study can be improved by adding data from the South-East region of Romania and trying to get a clear picture of a larger area.

Passenger cars have the greatest impact on pollution in Braila area. The percentages for the analysed pollutant emissions vary between 78% for CO, 73.94% for CH₄, 89.05% for NH₃. The lowest impact has non-Road vehicles and other mobile equipment with

2,58% for NO_x and only 0.06% for NH₃. In the case of Motorcycles, the percent varies between 0.01% for NH₃ and 0.72% for CH₄.

CO₂ is the pollutant with the most ascending trend and with the largest contribution to the total amount of emissions. In the case of this pollutant, the emissions vary from 81732 Megatons in 2015 to 93934 Megatons in 2019. Heavy-duty vehicles represent the second important source of polluting emissions in the studied area, in the 5 years, NO_x and PM₁₀ being pollutants, being the pollutants emitted in the largest amount. NH₃ comes in 89.05 % from passenger cars. Light commercial trucks are the third pollution source, for approximately all eight pollutants studied.

As a final conclusion, we may affirm that although the number of cars increased during the analysed period, pollutant emissions decreased for most of the studied pollutants, with the exception of CO₂ and N₂O, two greenhouse gases and NH₃.

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