

ASSESSMENT OF $PM_{2.5}$ AND PM_{10} EMISSIONS IN THE METALLURGICAL INDUSTRY FROM ROMANIA

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ABSTRACT

The article focuses on the evaluation of $PM_{2.5}$ and PM_{10} , pollutants resulting from the metallurgical industry in Romania. The analysed period is 2008-2018 and the dataset was provided by the National Institute of Statistics. The purpose of this paper is to examine the impact of final energy consumption in the metallurgical industry on PM_{10} and $PM_{2.5}$ emissions. We included in the study three fundamental factors: the final energy consumption in the metallurgical industry and the particulate matter (PM_{10} and $PM_{2.5}$). The average of PM_{10} for reference period is 4026 Tone (Mg) while for the $PM_{2.5}$ the average is 3645 Tone (Mg). The trend of final energy consumption in the metallurgical industry is identical to the trend of $PM_{2.5}$ and PM_{10} , which indicates that this factor has a major influence on the amount of $PM_{2.5}$ and PM_{10} emissions. $PM_{2.5}$ and PM_{10} emission factors represent primary emissions from the metallurgical industry activities and do not consider the formation of secondary aerosol from chemical reaction in the environment afterwards the discharge.

KEYWORDS: PM_{10} , $PM_{2.5}$, energy consumption, metallurgical industry

1. Introduction

Air pollution is presently the most critical environmental threat to human health, and it is considered as the second major environmental concern for Europe, following climate change [1]. More than that the air quality has an essential impact on human health and aquatic and terrestrial ecosystems.

In the last decades constant concentrations of dust particles with aerodynamic diameters $\geq 10 \mu m$ (PM_{10}) and fine particulate matter $< 2.5 \mu m$ ($PM_{2.5}$) have been an important issue for air in terms of achieving the limits of pollution and the relevant related health hazards. According to European Environment Agency (EEA) among 2006 and 2016, the exposure of citizens to concentrations of $PM_{2.5}$ above the EU limit was diminished from 16% to 5%, while the PM_{10} concentrations has decreased from 32% to 13% over the period 2000-2016 [2].

Efficient measures to decrease air pollution and its effects demand a proper comprehension of its sources, transport and circumstances of different transformation in the atmosphere, the chemical composition alterations during a certain period and

the effect of pollutants on population, flora and fauna and afterwards the impact on community and on economy [3, 4].

Low incomes population is living in major area of Europe, more frequently those who reside close to busy streets or industrial zones consequently confront larger vulnerability to air pollution. Energy neediness is further predominant in southern and central-eastern Europe and it is a major factor of the burning of low-quality solid fuels, such as charcoal and wood, in low-efficiency furnaces for domestic heating [5]. This causes significant vulnerability of the poor inhabitants to particulate matter (PM) and polycyclic aromatic hydrocarbons (PAHs), either inside and outside [6].

As stated by EEA the dominant sectors contributing to pollution of atmosphere in Europe are: transport (road and non-road); housing, commercial and institutional; energy providers; production and mining industry; agriculture; and waste management [7, 8].

The metallurgical operations require melting techniques, improvement of alloys and casting in various forms contingent on the demand. Fundamentally, extraction of the metal and

subsequent operations generates a contamination of the natural environment especially alterations in ecosystems [9, 10].

Starting with 1992, it was introduced the European Monitoring and Evaluation Programme EMEP/EEA air pollutant emission inventory guidebook, with the purpose to monitor and assess the long-range transportation of air pollutants. Air Emission Accounts (AEA) are secondary accounts in the European System of Accounts (ESA) providing information on the link between the environment and the economy. The National Institute of Statistics of Romania has applied the procedure of Air Emission Accounts (AEA) developed by Eurostat and data have been stated starting with 2008, in compliance with the demands and the reporting pattern - split by section of economic activities and households [11].

The aim of this paper was to analyse the impact of PM_{2.5} and PM₁₀ resulted from metallurgical industry between 2008 and 2018 in Romania and also to observe the trend of pollution depending on final energy consumption and final heat consumption. This analysis is useful over a decade, especially as PM_{2.5} and PM₁₀ have a significant share in pollution at the national level.

2. Materials and methods

The database used in this paper assesses the period 2008-2018 and it was collected by Romanian National Institute of Statistics according to the methodology of Air Emission Accounts (AEA) developed by Eurostat. National inventories include calculations for the calendar year within which the emissions to the atmosphere are generated. If suitable data are absent, emissions may be approximate using data from other years and applying adequate methods in particular averaging, interpolation and extrapolation.

According to European methodology air emissions at the level of national economies are estimated. The main idea is to assess air emissions, applying distinct emission factors technology, which are increased by a certain variable activity (e.g., use of a type of fuel). A general emission model can be expressed as:

$$E_{\text{pollutant}} = AD_{\text{production}} \times EF_{\text{pollutant}} \quad (1)$$

where: E = Emissions; AD = Activity Data; EF = Emission Factor.

The air emissions included in the analysis refer to those physical flows of gaseous materials or suspended particles that originate in the economic system (production or consumption processes) and that are released into the atmosphere and remain suspended in the air for a substantial period of time.

Most of these residues are in the gaseous state, others in a solid state remain effectively suspended in the atmosphere for a long time, respectively the suspended particles (PM_{2.5} and PM₁₀) and heavy metals.

Air emissions accounts provide a close framework for national accounts and a general image of air emissions of the national economy and household consumption. In accordance with the data collected, diverse technical measures can be adopted to protect the environment, prevent, reduce and eliminate emissions of air pollutants, that directly damage health of citizen and the environment.

Industrial operations are commonly facile to identify considering the fact that the company frequently must report these data to pollution control authorities. The industry classification is connected with the reporting company within a business register number.

Evaluations of emissions of particulate matter from metallurgical industry may use techniques that provide filterable, condensable or total particulate matter (PM). Several factors bias the measurement and calculation of primary PM emissions from activities like iron and steel manufacture. The amount of PM obtained in an emission measuring relates to a substantial proportion on the measurement regime. This is especially true for activities including upper temperature and semi-volatile emission elements – therefore the PM emission may be divided amongst a solid/aerosol stage and material that is gaseous at the analysing area, but that may condense in the atmosphere. The percentage of filterable and condensable element will change, determined by the temperature of the flue gases and in sampling device. A mixture of filterable PM determination techniques is used generally with 70-160 °C filter temperatures.

Condensable portions can be obtained outright by recovering condensed constituent from chilled impinger schemes downstream of a filter. A regular method for total PM includes dilution where sampled flue or exhaust gases are combined with ambient air (likewise using a dilution sampling procedure) which accumulates the filterable and condensable constituents on a filter at low temperatures (15-52 °C) [12].

Emissions used in this paper consist in PM_{2.5} and PM₁₀ dataset collected for a period of 11 years. To these emissions were added final energy consumption, final electricity consumption and final heat consumption for the same reporting period 2008-2018.

3. Results and discussions

In order to evaluate the percentage wherewith the PM_{2.5} and PM₁₀ is accountable for metallurgical

industry from national emissions we calculated the percentage for each pollutant. In Figure 1 we compared the percentage of PM_{2.5} and PM₁₀ between

2008-2018. It is obvious that these pollutants make a significant contribution to the total amount of emissions into the atmosphere.

Percent of PM_{2.5} and PM₁₀ resulted from metallurgical industry

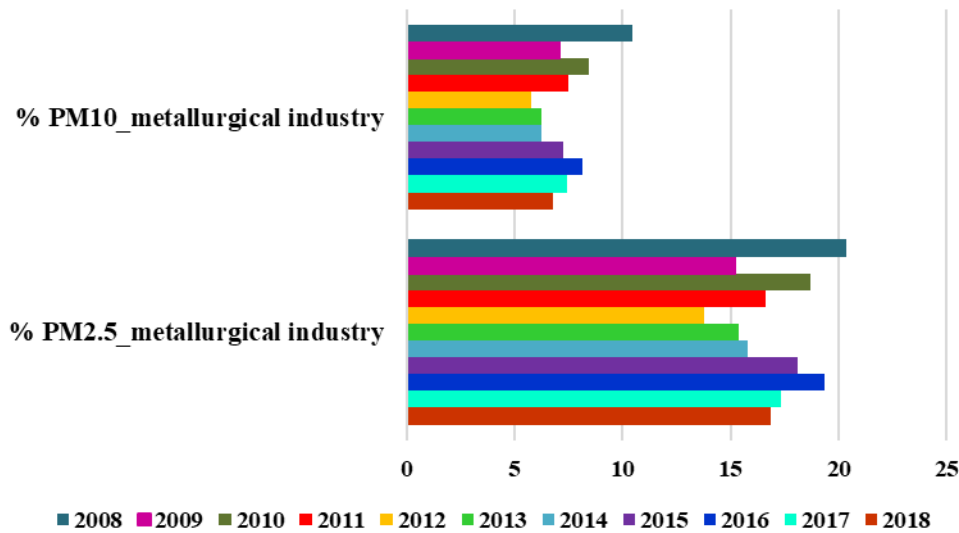


Fig. 1. Percentage of PM_{2.5} and PM₁₀ resulted from metallurgical industry

According to the analysed data, it cannot be stated that there is a clear, increasing or decreasing trend of pollutants. From the PM₁₀ analysis it is obvious that the percentage with which it contributes to the pollution in the metallurgical industry varies from 5.74% in 2012 to 10.44% in 2008. In the case of PM_{2.5} the percentages are much higher, starting from

20.35% in 2008 and the lowest being 13.78 in 2012. For both PM₁₀ and PM_{2.5} it can be affirmed that 2008 is the year in which the highest percentage of contribution of pollutants in the metallurgical industry was obtained, and 2012 is the year with the lowest percentage.

Particulate matter vs. Final energy consumption

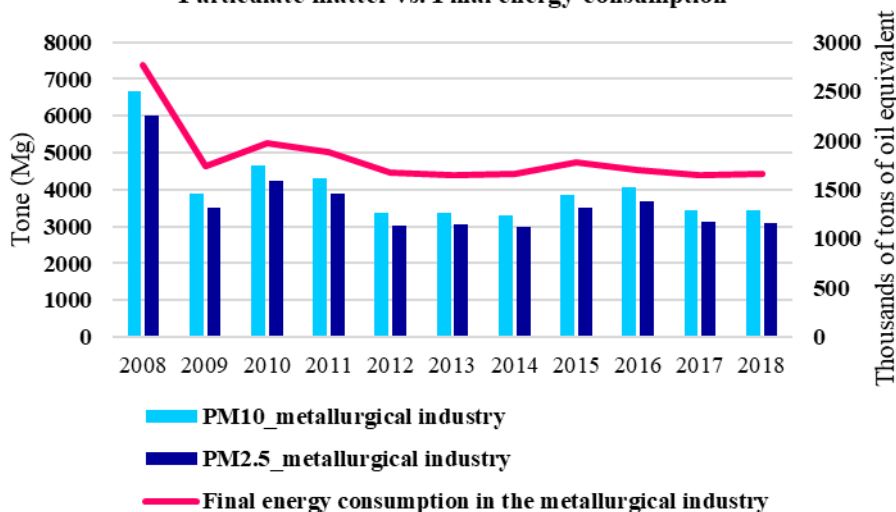


Fig. 2. Particulate matter vs. Final energy consumption in metallurgical industry between 2000 – 2018 in Romania

In most EU countries the metallurgical industry and industry of supplying electricity is among the

largest contributors of greenhouse gas emissions. It is extremely interesting to identify which pollutant or

industry is contributing greater proportion to national totals and when. The energy consumption is a significant parameter that indicates the amount of fuel/energy, implicitly the intensity of the production process in the metallurgical industry.

By overlapping the final energy consumption in the metallurgical industry over the PM₁₀ and PM_{2.5} it is clear that the three elements analysed have the same trend, which leads to the conclusion that there is a significant correlation between these factors.

Between 2008-2009 there is an obvious decrease in both final energy consumption in the metallurgical

industry and PM₁₀ and PM_{2.5}, and in the following years the trend remains relatively constant with small increases between 2010-2011 and 2015-2016.

The final energy consumption in the metallurgical industry has two major components: final electricity consumption and final heat consumption. The final electricity consumption varies from 7826 million of kilowatt- hours in 2008 to 5899 million of kilowatt- hours in 2018. The differences between final energy consumption from the analysed period are not too large, the trend remaining more or less constant in the 11 years.

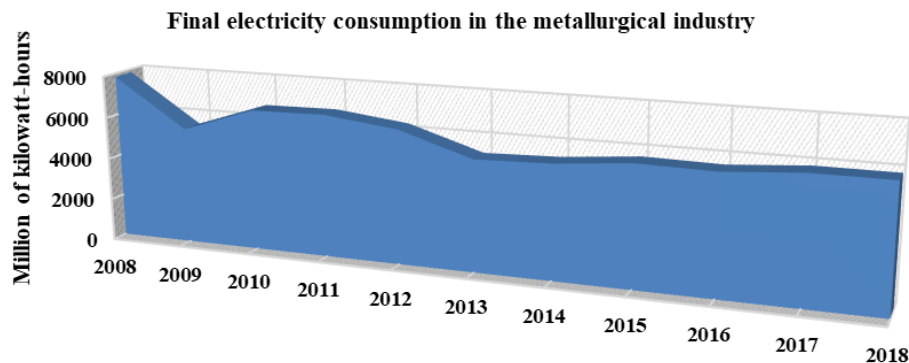


Fig. 3. The final electricity consumption in metallurgical industry between 2000-2018 in Romania

The final heat consumption is the second type of energy analysed. The quantities of final heat consumption in the metallurgical industry in the 11 years analysed vary from 6 thousand of giga calories in 2008 to 10 thousand of giga calories in 2018.

In contrast to the final electricity consumption the trend is not a constant one but there is a sudden

increase up to 131 thousand of giga calories in 2011 the trend is not a constant one but there is an unexpected increase up to 131 and a significant decrease from 59 to 15 thousand of giga calories in the period 2014-2015.

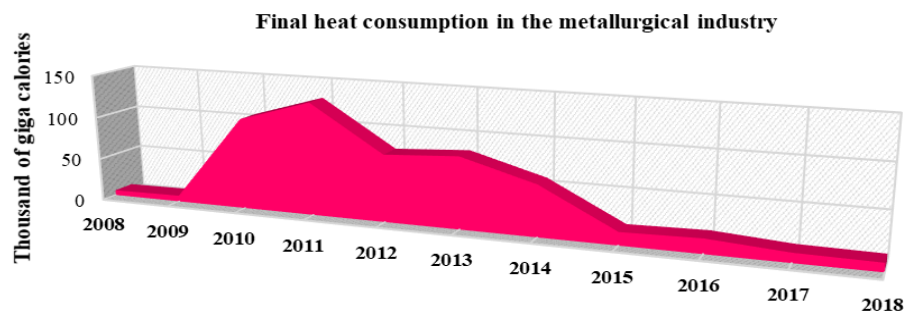


Fig. 4. The final heat consumption in metallurgical industry between 2000 – 2018 in Romania

4. Conclusions

The metallurgical industry is a considerably material and energy - intensive sector. Exceeding half of the mass input turns into outputs through released gases and solid wastes or derivatives. The emissions of PM₁₀ and PM_{2.5} dominate the general emissions for most of the sectors. The role of this sector to the total

emissions to air in Romania is significant for a considerable number of pollutants.

In the present paper we calculated the percentage of PM_{2.5} and PM₁₀ resulted from metallurgical industry for period 2008-2018 from Romania. For PM_{2.5} these percentages vary approximative 15-20%, while the percentages for PM₁₀ ranged between 5-10%. The final energy consumption in metallurgical industry was analysed

together with PM_{2.5} and PM₁₀ and it is obvious that in the analysed period these factors are very well connected.

The contribution of this article to the specialized literature consists in the analysis for a period of eleven years at national level of particulate matter emissions as well as of final energy consumption.

The periodical pollution assessment is crucial for establishing environmental priorities and determining the activities accountable for the various issues, the estimation of the environmental costs and benefits of distinct strategies and more than that to monitor the status of the environment conditions and to check if objectives are being accomplished.

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