

# Modeling of non-methane volatile organic compound emissions in Polish industry sector: sugar production

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**Abstract** – The main greenhouse gas emission sources have been analyzed and the mathematical model of emission processes during the production of sugar in Poland has been developed. As a result of numerical experiments the estimates of non-methane volatile organic compound emissions in production of sugar on the level of voivodeships and individual plants have been obtained. Results of spatial inventory of greenhouse gas emissions are displayed as digital maps.

Key words – mathematical modeling, spatial analysis, greenhouse gas emission, industrial sector, food industry, Poland.

## I. Introduction

The last twenty years humanity thinks more and more about climate changes. Scientists argue that one of the main reasons of climate changes is a high level of the concentrations of greenhouse gases (GHG) in the atmosphere, because of the various types of human activity. On the purpose to prevent these changes, on the international level the obligations have been accepted on performance of national GHG inventories for major sectors of the economy by all countries. In this regard, assessment of GHG emissions is an urgent problem in checking of the compliance of the international obligations on the GHG emissions reduction. Intergovernmental Panel on Climate Change has been developed appropriate methods of the GHG emissions inventory on the national level [1].

The share of the industrial sector in total GHG emissions is ponderable. According to Polish national inventory report on GHG emissions [2], the food industry as one of the five sub-sectors of the industrial sector wasn't considered. However, the assessment of GHG emissions from this subsector is extremely important to find out the structure of total GHG emissions in the industrial sector. Therefore, the development of mathematical models of GHG emission processes from the different categories of the food industry is an actual scientific problem. Using such mathematical models it is possible to carry out the spatially distributed GHG inventory and to estimate emissions in sufficiently small parts of the territory. According to the international classification of emission sources [1] the food industry is divided into several categories: bakery, meat production, fish production, milk production, alcoholic beverages and others. The goal of this research work is the mathematical modeling and the spatial analysis of non-methane volatile organic compounds emissions (NMVOC) during the production of sugar in Poland.

## II. Specificity of emission processes

In the result of the analysis of the statistical information it has been found out that sugar industry is widely developed in 10 voivodeships of Poland and represented by 18 sugar production plants owned by 4 large corporations: Krajowa Spółka Cukrowa S.A. (7 plants), Pfeifer & Langen (4), Südzucker Polska Sp. z o.o. (5) and Nordzucker Polska S.A. (2) (fig.1).

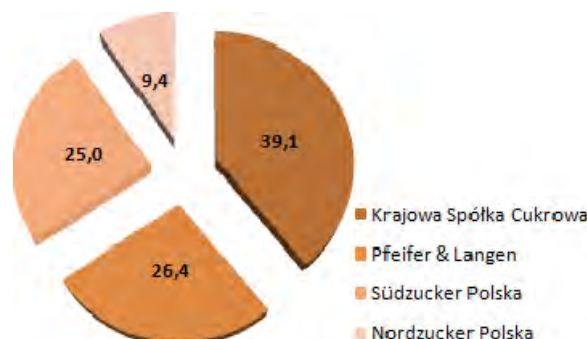


Fig. 1. Share (%) of the companies in the total production of sugar in Poland in 2010

The main greenhouse gas is non-methane volatile organic compound that belongs to indirect GHG (ozone and aerosol precursors). This gas forms during the processing of sugar beets and canes and the subsequent refining of sugar. To build the spatial cadastres of NMVOC emissions in the production of sugar such input data were used: annual amounts of sugar produced in Poland, share of the companies in the total production of sugar in 2010 (see fig.1), the production capacities of individual plants, the specific NMVOC emission factor for sugar, and the digital map of Poland.

## III. Mathematical model

In terms of spatial GHG inventory, each sugar production plant is considered as a point-type source of emissions. Mathematical model of emission processes from the production of sugar for such a point-type emission source is:

$$E_{Sugar}^{NMVOC}(\xi_n) = D_{stat}(\xi_n) \cdot K^{NMVOC}(\xi_n), \quad (1)$$

$$\xi_n \in \Xi_{Sugar}, n=1, \dots, N,$$

where  $E_{Sugar}^{NMVOC}$  is the amount of non-methane volatile organic compound emissions from the sugar production plant  $\xi_n$ ;  $D_{stat}$  is the activity data on (quantity of) sugar production for the plant  $\xi_n$ ;  $K^{NMVOC}$  is the NMVOC emission factor for sugar;  $\Xi_{Sugar}$  is the set of sugar production plants;  $N$  is the number of these plants.

For the purpose of spatial modeling of emission processes the georeferenced database of analyzed sugar plants, which includes needed for modeling input information with respective geographic linking, has been formed. Statistical data on the amounts of produced sugar is known on the national level according to GUS yearbook of industry in Poland [3]. Specific regional value of the emission factor were used from traditional methodologies of GHG inventory (IPCC 1996) and it is equal to 10 kg NMVOC per tonne of sugar [4].

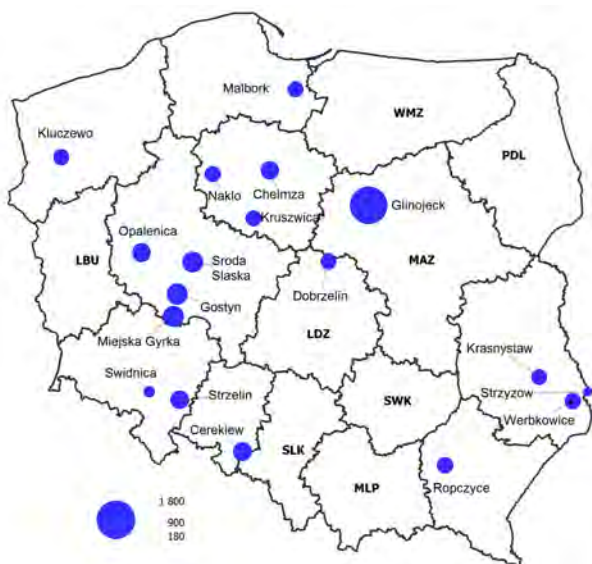


Fig. 2. Territorial distribution of NMVOC emissions from sugar production on the level of plants in Poland (tons, 2010)

## Conclusions

The mathematical model of GHG emission processes from the production of sugar in Poland has been developed and then realized in the specific geoinformation system. This model reflects the dependence of emissions from results of the economic activity and specific regional emission factors, and gives the possibility to build the spatial cadastres of emissions.

In the results of numerical experiments the estimates of NMVOC emissions from the production of sugar on the level of individual plants and voivodeships in general have been obtained, and also respective digital map of emissions has been constructed (see fig.2, territorial distribution of NMVOC emissions from sugar production on the level of plants). Total emissions of non-methane

volatile organic compound from the category “Sugar production” in 2010 amounted to 15 787 tons.

The results of spatial GHG inventory show that the territorial distribution of emission sources is extremely uneven. The largest emissions are observed in Greater Poland (3955,1 tons), Kuyavian-Pomeranian (2531,2 tons), Lubelskie (2002,1 tons) voivodeships, while the smallest ones in the south of Poland in Podkarpackie voivodeship (751 ton). The lider in terms of NMVOC emissions from the production of sugar is the plant “Gliniojeck” (1800 tons), owned by Pfeifer & Langen and situated in Mazovian voivodeship.

The results of modeling, displayed on built digital maps, present the regional specificity of GHG emission processes in Poland and are important for authorities in making strategic decisions on how to reduce emissions in the respective territories. The study was conducted within the European Union 7FP Marie Curie Actions IRSES project No. 247645, acronym GESAPU.

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