The cross-boundary impact of the landfill fires in Poland on air quality

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Abstract: *In Poland, in 2018 there were 22044 fires of landfill and waste storage yards. Out of these, 79 covered area bigger than 300 m^2. For comparison in the years 2010-2017 the number of such fires was not exciding 36 (only in 2015 this number was 47). During these fires, many pollutants are emitted into the atmospheric air. These pollutants are subject to meteorological conditions, especially to dispersion. There are few models which can be used for the calculation of dispersion of these substances in the atmosphere. Depending on the location of the fire, its size and duration, burned material, the concentrations of the pollutants have different spatial distribution. In the case of particulate matter (PM), which has a negative health impact regardless of the concentration, identification of any additional concentration of PM in ambient air is important. In the work, the dispersion of green-house gases and the other selected air pollutants from two fires from 2018, which has the biggest impact on air quality in the international scale, is presented.*
Keywords*: WASTE FIRES, CO, CO_2, NO_x, PM_{10}, SO_2, DISPERSION MODELLING, HYSPLIT*

1. Introduction

In 2018 there were 23 landfill fires classified by Polish State Fire Service as very big fires [1]. This number is significantly higher than the average number in years 2010-2017 which equals 9.5. Each of very big fires covered object of area of at least 1000 m^2 or volume 5000 m^3. Apart from direct impact, the landfill fires cause long-range impact in the atmospheric air. The air is object to the meteorological conditions of atmosphere and is not limited by any borders, hence the problem of landfill fires in one country can have negative impact on air quality in other countries. The scale of the dispersion can be evaluated using dispersion modeling which can provide areas where the increase of concentration of the substances emitted during landfill fire changes air quality.

In the work, 2 fires with long range (continental) impact are described. As a measure of impact, the increase of 1-hour average concentrations were analyzed. The work presents the dispersion of the selected air pollutants and green-house gases.

2. Materials and methods

In the study the dispersions of pollutants from two of the biggest land fires in 2018 were analyzed. The amount of the emitted pollutants and green-house gases can be evaluated knowing the volume of the burned object, burned material and its emission factors (EF), according to the methodology described in [2]. The first fire was a tire fire on 26 May 2018 [3]. The fire was located in Trzebinia, Chrzanów Powiat[1] and firefighting action was 87h long. The fires of waste tires were already discussed [4]. For uncontrolled combustion of tires, the EF for only four substances were found. The EF of CO, CO_2 and SO_2 were taken from [5] and for PM_{10} according to [6] and the bulk density was assumed as 0.41 Mg/m^3 according to [7]. The second fire was on 24 July 2018, in Jakubów [8], Polkowice Powiat. The fire was 96h long and the unspecified, general waste were burned, some stated that they were chemical waste [8]. The EF for this fire were based on the following publications: CH_4 and CO from [9], CO_2 from [10], NO_x and SO_2 as an average of values in [9] and [11], PM_{10} from [11]. The bulk density of the waste was assumed as 0.5 Mg/m^3 according to [12].

In this work the dispersion of the pollutants was calculated using HYSPLIT [13], [14]. HYSPLIT allows to calculate dispersion of the gases and of the particulates in the atmosphere according to the meteorological conditions. For the particulate matter PM_{10} the simulation assumed dry deposition. All the calculations were performed in a domain between 0 and 10000 m above ground level, and the results were evaluated in region closest to the ground level. Due to the limitations of HYSPLIT, all results were obtained for minimum layer 0-100 m above ground level. As the results polygons with 1-hour averaged increase of concentrations of pollutants and green-house gases were obtained. The further processing was done in the GIS software, QGIS [15]. In the GIS software, all the polygons representing given 1-hour average concentration were aggregated and presented on the contour map of the Europe showing the maximal range of impact of the increase of concentration due to landfill fires.

The 1-hour average concentrations of NO_2, PM_{10} and SO_2 are subject to the law regulations in Poland [16] and the reference limits are 200 $\mu g/m^3$, 280 $\mu g/m^3$ and 350 $\mu g/m^3$ respectively. The increase in concentrations due to landfill fires were plotted in areas with the value of 500%, 100%, 20%, 4% and so on, of the reference value. The concentrations of CH_4, CO and CO_2 do not have 1-hour reference levels, however, in regulation about the levels of some substances in air [17], there is limit value of 8-hour average concentration of CO, i.e., 10000 $\mu g/m^3$.

3. Results

3.1 Tire fire on 26 May 2018

The pollutants emitted during tire fire on 26 May 2021 in Trzebinia were transported in atmosphere in the north west direction. The plume covered Belgium, Czech Republic, Denmark, France, Germany, Netherlands, Norway, Slovakia, Sweden and United Kingdom.

The concentration of CO is presented in Figure 1. The concentrations outside the Poland are lower than 16 $\mu g/m^3$ and are much lower than limit value. The increase in concentration of CO_2 due to tire fire are presented in Figure 2. The concentration 0.3 $\mu g/m^3$ was exceeded only in the Czech Republic and Germany.

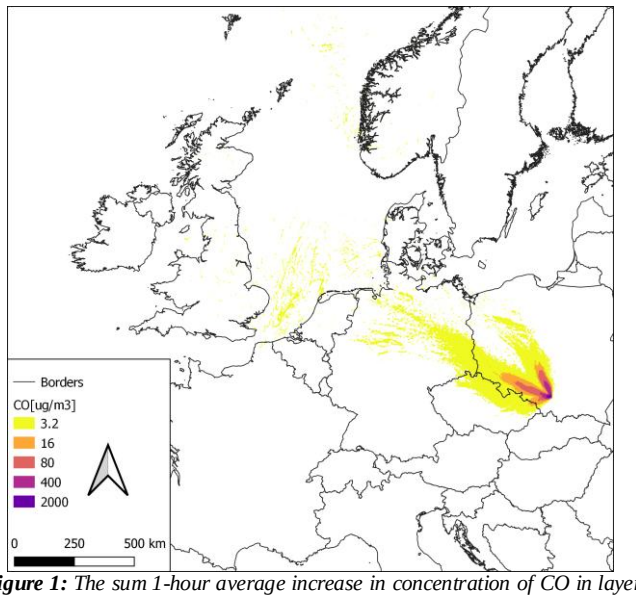

Figure 1: *The sum 1-hour average increase in concentration of CO in layer 0-100 m above ground level emitted during tire fire at 26 May 2018.*

[1] Powiat is LAU-1 unit [21] in Poland (former NUTS-4 unit)

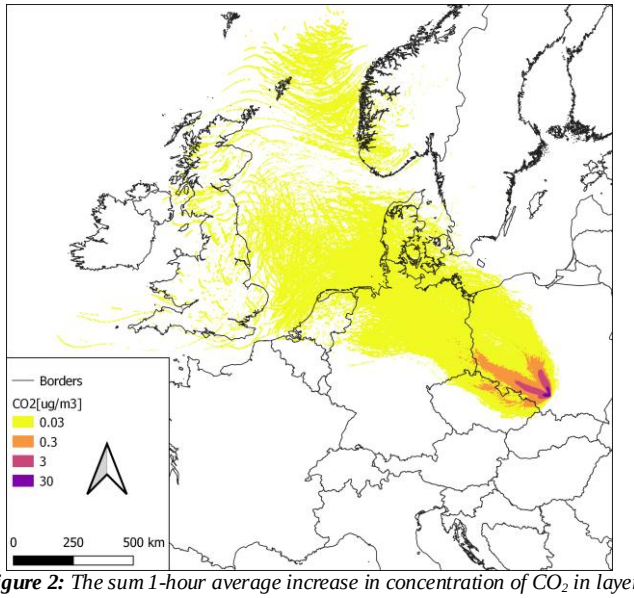

Figure 2: *The sum 1-hour average increase in concentration of CO_2 in layer 0-100 m above ground level emitted during tire fire at 26 May 2018.*

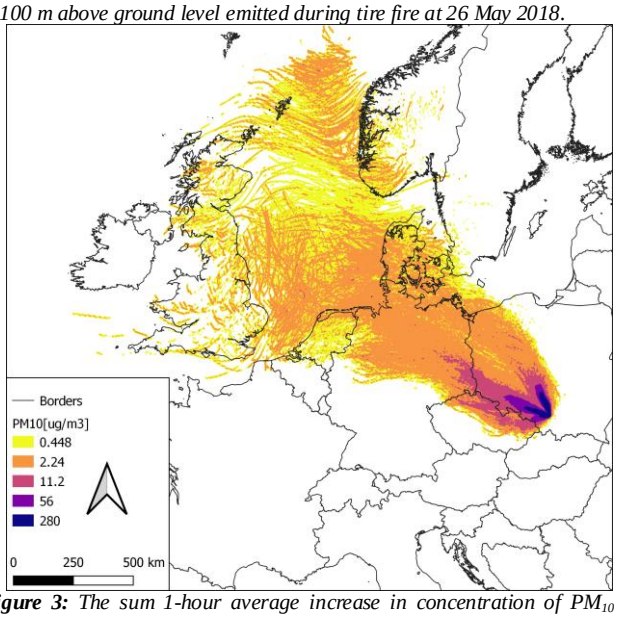

Figure 3: *The sum 1-hour average increase in concentration of PM_{10} in layer 0-100 m above ground level emitted during tire fire at 26 May 2018.*

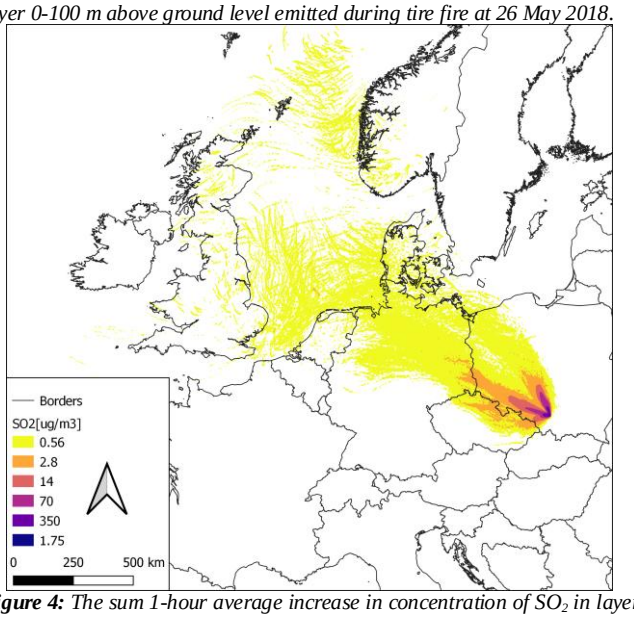

Figure 4: *The sum 1-hour average increase in concentration of SO_2 in layer 0-100 m above ground level emitted during tire fire at 26 May 2018.*

The reference level of the 1-hour average concentration PM_{10} in the layer 0-100 m above the ground level (Figure 3) was exceeded only in the territory of Poland, while the 4% of the reference level, i.e., 11.2 $\mu g/m^3$, was exceeded also in the Czech Republic and Germany. The level of 0.8% of reference level was exceeded in territories of Belgium, Denmark, France, Netherlands, Norway, Slovakia, Sweden and United Kingdom.

The 1-hour average concentration of SO_2 (Figure 4) in layer 0-100 m above the ground exceeded the reference level only in Poland. In other countries, level was not exceeding 4% of reference level (only Czech Republic and Germany), while in the remaining countries in Figure 4 the level was not exceeding 2.8 $\mu g/m^3$ of SO_2 (0.8%).

3.2 General waste fire on 27 July 2018

Due to the transport in the atmospheric air the pollutants and green-house gases emitted during waste fire on 27 July 2018 caused increase in their concentrations in territories of Albania, Austria, Belgium, Bosnia and Herzegovina, Croatia, Czech Republic, France, Germany, Greece, Hungary, Italy, Kosovo, Montenegro, Netherlands, Northern Macedonia, San Marino, Serbia, Slovenia, Switzerland

The emission of CH_4 in waste fire caused the increase in concentration in over 16 $\mu g/m^3$ only in Poland and Germany (Figure 5) while increase over 3.2 $\mu g/m^3$ was found also in Austria, Czech Republic Italy and small isolated spots at other countries (see to the Figure 5).

The concentrations of CO are presented in Figure 6. The values of 2000 $\mu g/m^3$ were exceeded only in Poland while 80 $\mu g/m^3$ also in Czech Republic and Germany. The increase in 1-hour average concentration by 16 $\mu g/m^3$ were present Austria, Hungary, Italy and in isolated locations in almost all countries covered by plume. The increase in 1-hour average concentration of CO_2 is presented in Figure 7. The increase exceeded value 0.3 $\mu g/m^3$ only in Czech Republic and Germany.

The concentration of NO_x emitted in waste fire is presented in Figure 8. The 4% of the reference value was exceeded only in Austria, Czech Republic, Germany and Italy while in Poland, the reference value, 200 $\mu g/m^3$, was also exceeded.

The dispersion of the PM_{10} emitted during waste fire is presented in Figure 9. The 4% of the reference value of 1-hour average increase in concentration PM_{10} was present only in Germany, while the refence value (280 $\mu g/m^3$) was exceeded in Poland. The emission of SO_2 during this fire was small and the 1-hour average concentration increased outside Poland by no more than 0.8% of reference value.

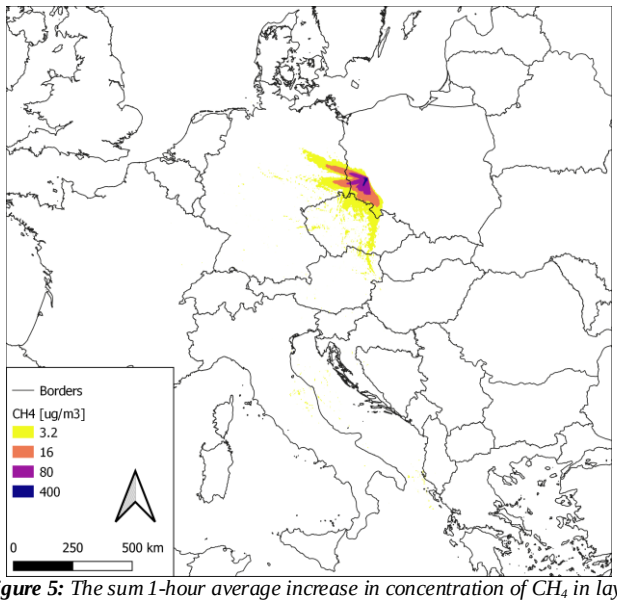

Figure 5: *The sum 1-hour average increase in concentration of CH_4 in layer 0-100 m above ground level emitted during waste fire at 24 July 2018.*

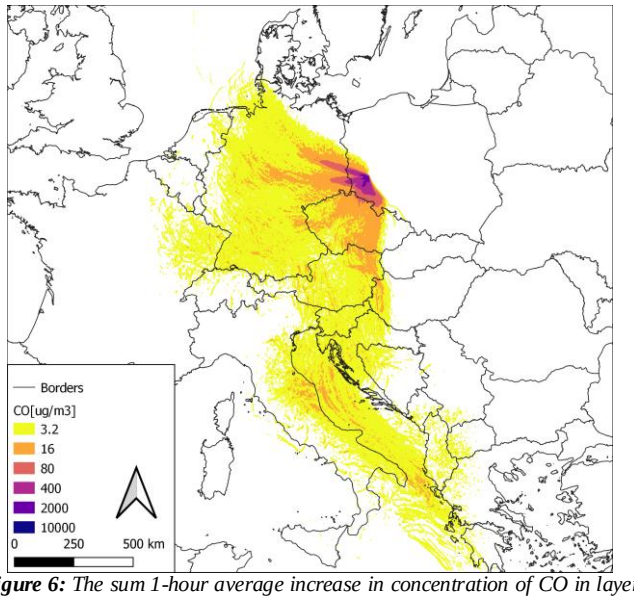

Figure 6: *The sum 1-hour average increase in concentration of CO in layer 0-100 m above ground level emitted during waste fire at 24 July 2018.*

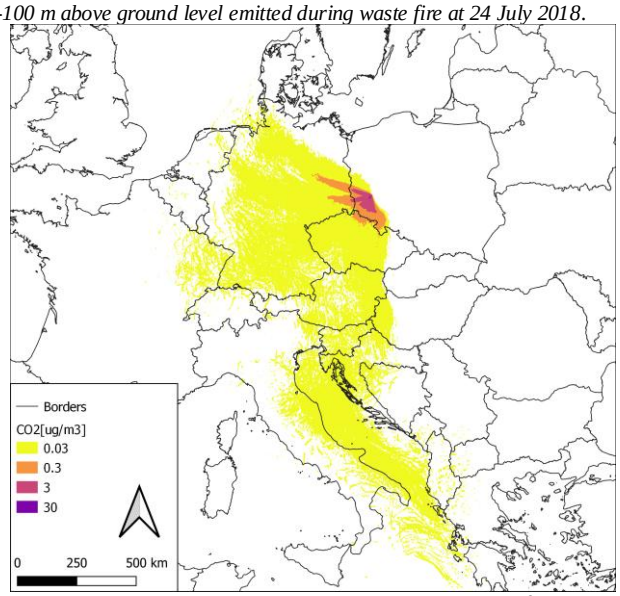

Figure 7: *The sum 1-hour average increase in concentration of CO_2 in layer 0-100 m above ground level emitted during waste fire at 24 July 2018.*

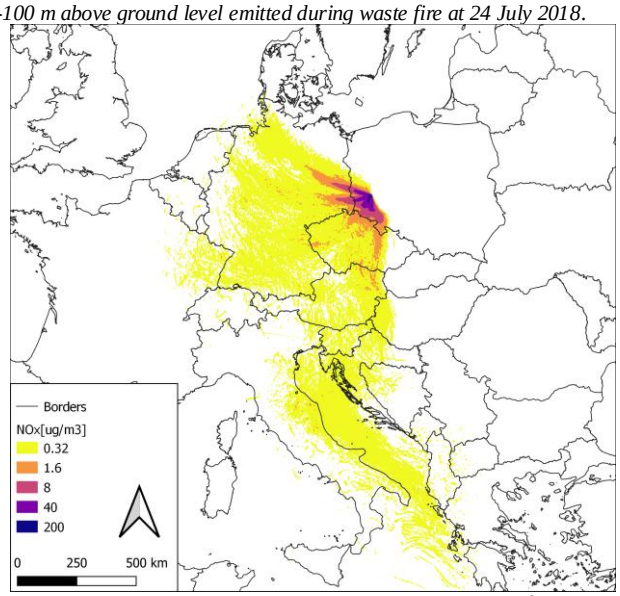

Figure 8: *The sum 1-hour average increase in concentration of NO_x in layer 0-100 m above ground level emitted during waste fire at 24 July 2018.*

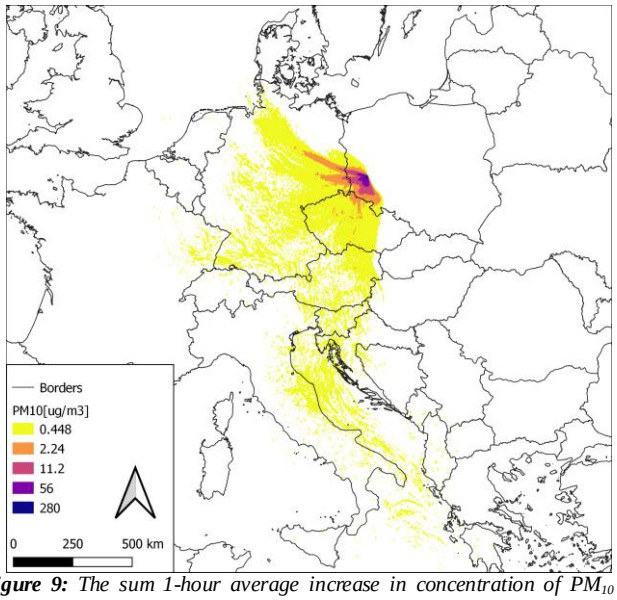

Figure 9: *The sum 1-hour average increase in concentration of PM_{10} in layer 0-100 m above ground level emitted during waste fire at 24 July 2018.*

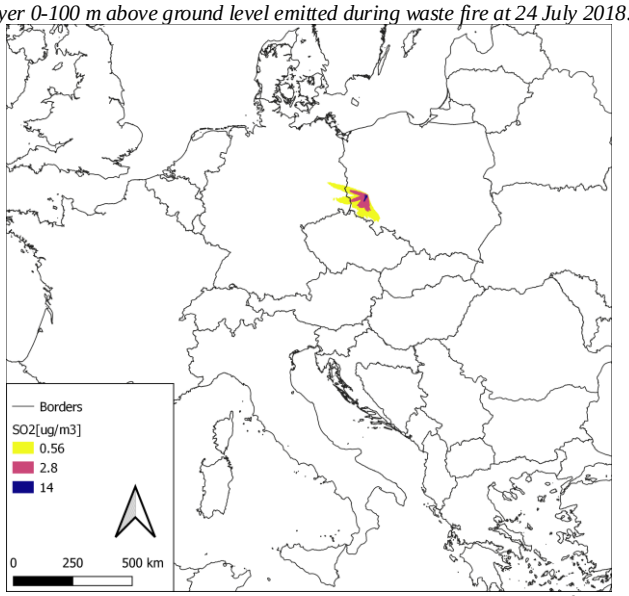

Figure 10: *The sum 1-hour average increase in concentration of SO_2 in layer 0-100 m above ground level emitted during waste fire at 24 July 2018.*

4. Discussion

The emission of the substances during the landfill fires is a significant problem with international impact. The 1-hour average CO concentration increase in waste fire covered much bigger area than in case of tire fire while the increase concentrations of CO_2 were observed on similar areas. The impact of tire fire on concentration of PM_{10} in layer 0-100 m above the ground level was significant to air quality in many countries. PM_{10} is substance which has negative health impact without threshold value [18]–[20]. The range of impact of emission of SO_2 from waste fire (measured as range of increase in 1-hour average concentration) is much lower (only national, regional) while tire fire has subcontinental impact.

Although the concentrations seem to be low in relation to the permitted yearly levels, however, the discussed concentrations are additional concentrations caused by single landfill fire. In Poland, in 2018, 23 very big landfill fires occurred and hence, the impact of all fires is important for air quality in Europe.

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