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SIMULATION OF POLLUTANT TRANSPORT AND ASSESSMENT OF IMPACTS ON HUMAN HEALTH

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ABSTRACT
This article deals with the analysis the obtained values of indicators of air quality in the Tuzla area on the basis of results measurements of the established systems for air quality monitoring. The indicators of the risk of polluting are substances whose values exceed the limit values and alert thresholds and alarm threshold values, and represent a potential hazard to human health. Using a mathematical model Airmod View that simulates propagation of pollutants in the atmosphere we made an assessment of the participation of sulfur dioxide emissions from thermal power station in Tuzla that is the Thermo Power Plant contribution to the total pollution by SO2. Based on the characteristics of the initial discharge pollutants obtained concentrations of pollutants at a particular receptor location and the ability to map the spatial distribution of concentration of these substances. A significant correlation between daily variation of the measured pollutants in the air and the attribution of cases of mortality and hospitalization due to respiratory and cardiovascular diseases has found. The greatest increase in the number of deaths and hospitalized persons has been caused by the diurnal variation of concentrations of SO2 and PM10.
Keywords: Air pollution, Modeling, Health and Consumption.

1. INTRODUCTION
The state of air quality in the area of Tuzla Canton affects pollution emitted from industrial and power plant, small power plants installed in the undertakings, individual furnace and boiler house, and transportation. Unsuitable terrain, spatial deposition of major pollutants, climate and meteorological conditions, weak winds, unsuitable temperature inversion also contributes to the higher load.
Completed the processing, analysis and interpretation of measurement results of the established systems for monitoring air quality, which consists of five fixed automated measuring station at which the register the following indicators of air quality: sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, dust and sludge-PM2,5. Indicators of target values, limit values, threshold alerts, and alarm thresholds were calculated. 98-percentiles of daily values for the years 2003 to 2006 are also calculated at all measure stations.
Tuzla power plant with total installed capacity 715 MW, use brown coal and lignite. The most significant air emissions during coal combustion are sulfur dioxide (SO2), nitrogen oxides (NOx), carbon monoxide (CO), carbon dioxide (CO2) and particulate matter. Other compounds such as heavy metals, fluoride, halogenated compounds, hydrocarbons incombustible, non-methane volatile organic compounds are emitting in smaller quantities but can have a significant impact on the environment due to their toxicity and persistence. In most of the emission of particles are particles with an aerodynamic diameter smaller than 10 microns (PM10). Much of the particulate matter, sulfur and nitrogen oxides

are removed from flue gases, while the lower part, depending on the efficiency of equipment for cleaning of flue gases emitted into the environment. [2]

Regulations on limit values for air quality determine limit values and the air quality target values as indicators of air quality planning in the area, and warning thresholds and alert thresholds for timely action in case of transient unauthorized air pollution. [3] This values are given in the Table 1.

Table1. Limit values and the air quality target values – GV[3]

Pollutant	Period of sampling	Limit value – year's average (μg/m³)	High limit value (μg/m³)	Target value – year's average (μg/m³)	High target value (μg/m³)
sulfur dioxide	1 hour	90	500 [1)]	60	350 [1)]
sulfur dioxide	24 hours	90	240 [2)]	60	160 [2)]

[1)]: must not be exceeded more than 24 times in a calendar year

[2)]: must not be exceeded more than 7 times in a calendar year (98-percentile)

For sulfur dioxide SO2 the warning thresholds and alert thresholds for 1 hour action in case of transient unauthorized air pollution for high values are between of 400 and 500 μg/m³.

The system for air quality monitoring in Tuzla canton region, which performs automatic monitoring of air quality includes: five measuring stations equipped with measuring devices as concentration of the basic indicators of air quality and meteorological data and a central unit (server) for collecting, storing and processing of measurement results. Measuring stations are installed at the location Skver (MS1), BKC (MS2), Bukinje (MS3), Bektići (MS4) and Cerik (MS5), all in thermal power plant environment. The values of 98-percentile daily concentration based on measured air quality for the years 2003-2006 are given in the Table 2.

Table 2. Values 98- percentiles daily concentrations

Year/Station	MS1-Skver	MS2-BKC	MS3-Bukinje	MS4-Bektići	MS5-Cerik
2003	171,6	133,8	184,4	251,6	79,7
2004	162,9	225,96	179,7	153,3	132,8
2005	203,7	272,1	228,4	148,2	203,9
2006	*	329,3	90,6	*	246,4

To assess the impact of pollutant' sources to the quality of the air must be known some characteristics, like: the level of emissions of pollutants, chimney height from point source and height of discharges, gas temperature, internal diameter of chimney, exit velocity of stack gas, topography data for each point source, a detailed description of all structures in the vicinity of the chimney and similar information from other relevant sources in the vicinity of the subject.

After ICST (Industrial Complex Short Term) model, American Association of meteorological and environmental agencies has introduced a new 'plume' model in stable condition-AERMOD (AMS/EPA Regulatory Model). The Input data for Aermod are: Information about the source of emissions (emission parameters: mass flow, velocity and temperature of waste gases); Geometric characteristics of sources; The parameters for the calculation of "building downwash" effect for particular chimneys; Meteorological data, and mean hourly values of the wind speed and direction, air temperature, relative humidity, pressure, altitude mixed layer, stability class of atmosphere (by Pasquill Giford); network of receptors or discrete receptors.

The methodological studies and practical analysis is usually to determine the propagation of harmful substances using Gaussian models (see [3]).The use of these models is easy for understanding and show relatively good agreement with physical experiments. AERMOD model with some corrections and adaptations includes a wide range of possibilities for modeling the impact of pollutants on air pollution. Models are more reliable to estimate the average concentration during longer periods of time than shorter than for a specific location. The models are reasonably reliable in estimating the value of the highest concentrations occurring somewhere in observed region at given instant of time.

2. PRESENTATION AND ANALYSIS OF MODELING REULTS

Modeling was performed for sulfur dioxide for the years 2003 and 2006, based on meteorological data obtained from the Federal Hydrometeorology Bureau and parameters obtained from thermal power plants Tuzla. The hour's values of wind speed have not been available for 2005 and 2006. Three

chimneys with a height of 100 m and one 165m have almost the same internal up diameters. Flue gases have a standard chemical composition of all components such as N_2, O_2, H_2O, CO_2, CO and Nitrogen oxides. The waste gases contain the dust particles (fly ash, which "fails" electrostatic separator (filter) and had the temperature of 160-180 ^{0}C. The waste flue gases that are emitted into the air the next pollutants: sulfur dioxide SO_2, Carbon monoxide CO, nitrogen oxides $NO+NO_2$ and dust.
Annual emission of pollutants is determined by multiplying the average emission concentrations with an average volumetric flow of flue gases emitted. The flow of flue gases is determined computationally (stechyometric combustion equation) on the basis of the established monitoring of the mass and heat value of coal consumed for each block. [2]. Based on the measured values (SO2 emission data for Tuzla3, Tuzla4, Tuzla5 and Tuzla6 plant blocks, [2]) 98-percentile value of daily concentrations of sulfur dioxide were calculated and compared with values of 98-percentiles of daily concentrations of the same pollutant that are obtained by modeling.

Table 3. Results of analysis

2003 (98 percentile)	MS1	MS2	MS3	MS4	MS5
Measured values	171,6	133,8	184,4	251,6	79,7
Model values	36,0	51,00	66,00	58,00	44,00
percentage	21,0	38,1	35,8	23,1	55,2
Percentage share-total	**34,6**				

2006 (98 percentile)	MS1	MS2	MS3	MS4	MS5
Measured values		365	140	479	278
Model values		75	125	107	35
percentage	21,0	38,1	35,8	23,1	55,2
Percentage share-total	**36,19**				

As can be seen from the Table 3 set, the thermo power accounts for 34.6% of the total sulfur dioxide pollution in 2003.and for 36,19 % in 2006 year.
The Figure1-left shows the distribution of hourly concentration of SO2 in 2003, when the maximum hourly concentration range is above 624 µg/m^3. The highest average concentrations of pollutants are found in the north north-east direction. On the same Figure – right the distribution of hourly concentration values is given for 2006. The distribution of hourly concentration shows concentric arrangement surround the thermoelectric power plant, with the highest values above 600 µg/m^3 (from the Figure 1 – right).

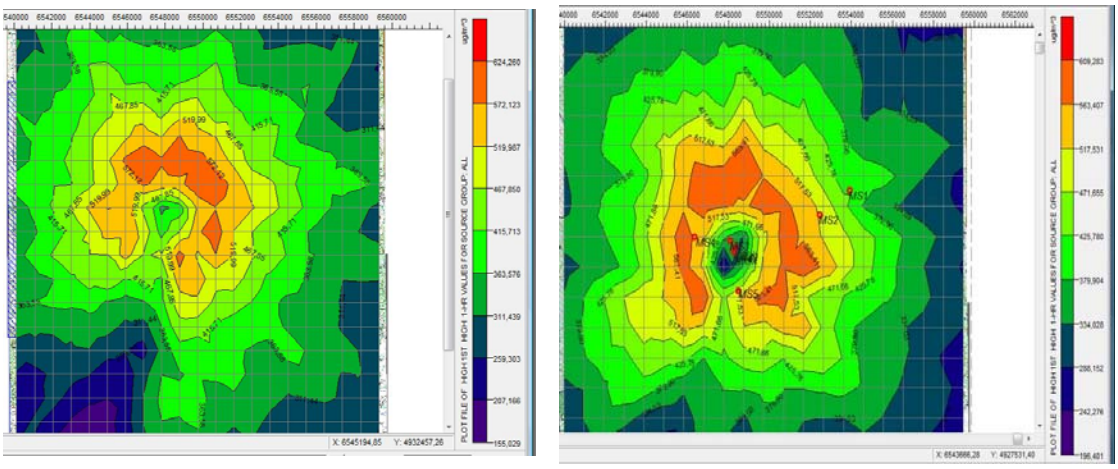

Figure 1. Results of modeling SO2, concentration of hourly values: left for 2003; right for 2006.

Results for 98-percentiles one-hour intervals for SO2 obtained by modeling show the highest values north from the stations MS3, MS4 and MS5 /above 252 µg/m^3 in 2003, and 180 µg/m^3 in 2006/. Maximum hourly concentrations of the range are above 624 µg/m3. The highest average concentrations of pollutants are found in the north and north-east region. The highest concentration of sulfur dioxide load in all cases reported to the measuring stations Bukinje, Bektici and Cerik.

3. IMPACT ASSESSMENT OF POLLUTANTS TO THE POPULATION HEALTH

A research impact of air pollution on the health of the population of Tuzla was conducted during the 1981 when was proven high incidence of acute respiratory illnesses directly related to the SO2 present in the air. High rates of patients with respiratory and cardiovascular illnesses, and their significant participation in the overall morbidity and a significant percentage of cardiovascular and respiratory diseases in mortality in the area of Tuzla, indicating the presence of risk factors originating from the environment.[1]

Within the study included 11 553 patients (4349 patients hospitalized for respiratory disease and 4020 patients hospitalized for cardiovascular disease), and 3184 subjects died (of which 217 persons died due to respiratory illnesses and 1702 deaths due to face cardiovascular disease), in the period 03.01.2003-28.02.2006. Assessment of potential impacts on human health from exposure to pollutants from the air was done by defining health indicators: mortality, population mortality, respiratory mortality, cardiovascular mortality, expressed in number of deaths, hospital morbidity, hospitalization due to respiratory disease, cardiovascular disease, expressed in number of patients. The significant connection of daily variation of the measured pollutants in the air and the attributive cases of mortality and hospitalization due to respiratory and cardiovascular diseases were found in the Tuzla Canton region. The greatest increase in the number of deaths and hospitalized persons is caused by the diurnal variation of concentrations of SO2 and PM10. Health outcomes attributable to the exposure of pollutants: diurnal variation of SO2 significantly correlated with daily cardiovascular and respiratory mortality; annual hospital admissions for respiratory and cardiovascular illnesses, according to the attributable risk of SO2 registered an increase in the investigated period; diurnal variation of SO2 in the winter season significantly correlated with daily hospitalizations for asthma, COPD-a (Chronic Obstructive Pulmonary Disease) and acute myocardial infarction.

In the winter season, the concentrations and daily variations caused by SO2 (on average), doubling the total deaths, deaths from cardiovascular and respiratory diseases. Hospitalization for COPD is slightly higher in the winter seasons, but hospitalization for asthma and acute myocardial infarction register throughout the whole year. During the study period, the number of deaths due to respiratory diseases in the area of Tuzla ranged 62-85 persons per year, with a significant proportion of older persons. During the study period, died a year between 556 and 583 people for cardiovascular disease in the Tuzla area. Hospitalization due to respiratory and cardiovascular disease shows an increase in the examined period. High rates of hospital respiratory and cardiovascular morbidity and an increase in their study period are indicators of risk to human health in the municipality of Tuzla.

4. CONCLUSION

AERMOD model includes a wide range of possibilities for modeling the impact of pollutants on air pollution. The model contains algorithms for the analysis of the aerodynamic flow near and around buildings, which should be included in future budgets in modeling, and would thus give a more precise value of the concentration of certain pollutants. The paper is accompanied by the impact of sulfur dioxide from power plants, where the influence of other pollutants, nitrogen oxides, dust and particulates, mercury, heavy metals has neglected. Emissions of sulfur dioxide are more harmful in areas where the concentration of ammonia in the atmosphere is higher, due to the formation of ammonium sulfate. Using the model, it was concluded that the effect of pollutants from power plants is about 35% of the total air pollution in the area of Tuzla Canton. Calculating total health care costs caused by air pollution and applying same percentage obtained results are greater than previous calculation method. The total investment cost in the cost of sulfur reduction is much smaller than the total estimated cost of medical expenses for one year, arise from power plants contribution.

Tuzla power plant still made high sulfur dioxide emissions. If compared with the new power plants, Tuzla plants all major pollutants has exceeded, but it’s level of energy conversion is about 30 percent less power than today's most advanced clean coal power plants.

5. REFERENCES

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