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ESTIMATION OF IMPACT OF HOME BOILERS AND STOVES ON AIR QUALITY IN SUBURBANS

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ABSTRACT
High concentration of air pollutants has significant affect on the health and the environment. Air quality researchs in Bosnia and Herzegovina is focused to urban areas but at same time lack of air quality research in suburban and rural areas is recognized. In this paper, effect of local boilers and domestic stove on air quality in suburban in Kakanj, Central Bosnia was analyzed. Most of object in the suburban are characterized by absence on any thermal insulation. It is mostly about two-sided plastered objects but not rarely there are uncompleted building (ground floor is used for living but attic is not plastered and without windows and doors). Those objects, due to high thermal conduction coefficients, require great quantity energy for heating. Heat energy sources are stoves and boilers, which are feed with brown coal and biomass.
Mathematical software AERMOD is used to forecast dispersion of sulfur dioxides arisen from fuel combustion in home stoves and boilers and surface concentration in any selected point.
***Keywords**: domestic stoves, air pollution, dispersion of pollutants*

1. INTRODUCTION

One of the most important ways of air pollution is pollution by fuel combustion for residential buildings heating. Pollutant emissions from these sources are significant if one considers the fact that the household sector accounts for 51% of total energy use in Bosnia and Herzegovina and that within this sector 66-84% of the energy used for heating [1].
Although traditionally considered to villages and suburbs areas with less contaminated air from urban areas, recent studies conducted in the countries of Central and Eastern Europe revealed that much greater air pollution in rural areas during the winter months as compared to the urban areas. The main reason for this state of air quality in the suburban areas is the pollutant emissions originated by fuel combustion for heating buildings [2,3,4,5].
For the analysis of impact of the fuel combustion for heating buildings in the house boilers on air quality was chosen as a typical suburb- Povezice. In this suburb the only way to heat buildings is by domestic stoves and local boiler fired with brown coal and firewood. The boilers in this suburb do not have catalysts or any other installation to reduce emissions of pollutants. The analysis of the situation on the site, boilers and boiler rooms inspection, and insight into firing mode it is possible to determinate a whole range of shortcomings that are primarily related to inadequate boiler volume,

inappropriate type and capacity of the boiler, the firing mode, etc. On the other hand, there are objective factors that contribute emissions of pollutants and their retention at the local level such as: low boiler chimneys which can not provide sufficient buoyancy force to eject the combustion products to the upper layers of the atmosphere, the high sulfur content in the local coal, orientation on coal as a primary fuel for affordability and accessibility. Climatic conditions are one of the crucial factors that determine the movement of pollutants in the atmosphere. The municipality Kakanj is characterized by frequent mists arising from a radiation temperature inversion. Average number of days with fog in December for 20 days in January 13 [6].

2. ENERGY ANALYSIS

The first step in determining heat consumption is calculation of the heat losses of individual objects. Povezice suburb consists of 289 buildings of residential and small commercial buildings. Detailed calculation of the heat losses is performed according to DIN 4701 and EN 12 831. The next step is to determine the required annual amount of heat energy to heat all the buildings in the village. Heat energy requirement depends on several factors: the heat losses from the building, external climatic conditions in this period, habits in terms of temperature comfort, daily duration of heating as well as the owner daily life and heating installations performance. The consumption of heat energy depends on the number of persons who permanently reside in the house, and the influx of heat from other sources such as solar radiation and etc.

To determine the annual energy consumption was used precisely defined procedure in accordance with VDI 2067 second-List [7].

The required amount of fuel is specified by a lower thermal power fuel: coal H_d = 13,000 kJ/kg, firewood H_d = 10,500 kJ/kg and assuming that 85% of users use coal and 15% biomass. Table 1. gives a summary of the number of buildings in Povezice suburb with their surface, heat loss and annual fuel requirements.

Table 1 Summary of required heat capacity, annual heating demands and fuel requirements in Povezice suburb [8]

Purpose space		Residential	Business
Usable area (m^2)		31.260	5.285
Average area (m^2)		111,25	264,25
The required heat capacity (kW)		4.403	497
Specific heat capacity (W/m^2)		140,85	94,04
The total required heat capacity (kW)		4.900	
Average annual demand for heating energy (kWh/m^2)		246.90	161,40
Total annual heating demands (MWh)		8.571	
Fuel requirements	Brown coal (t)	2.840	
	Wood (t)	620	

3. ENVIRONMENTAL ANALYZES

3.1. Emissions of sulfur dioxide

This paper analyzes the emissions of sulfur dioxide generated by the burning of fuel in a house boilers and stoves in the village of Povezice. Emission estimates was done by CORINAIR methodology-detailed mode. Emission factors are determined according to the terms of the settlement Povezice furnace (capacity boilers up to 50kW, manually firing, no advanced techniques combustion, no catalyst or other ways to reduce emissions). Annual emissions of sulfur dioxide amounts is 91,90 tons.

3.2. Modeling of sulfur dioxide distribution in the atmosphere at the suburb Povezice.

Estimation of sulfur dioxide dispersion from the house boilers in the Povezice was performed using the software package AERMOD. It is a steady-state plume model in that it assumes that concentrations at all distances during a modeled hour are governed by the temporally averaged meteorology of the hour. It is applicable in both rural and urban areas, flat and complex relief and for point and surface sources. It consists of two pre-processors and dispersion models. AERMET is the meteorological pre-processor that supplies the AERMOD with meteorological data relevant to the atmospheric boundary

layer. AERMAP is the pre-processor that provides information about the terrain and generates a receptor grid for dispersion model [9].
For dispersion modeling of ground level concentrations of sulfur dioxide is necessary to know more input parameters. Requested data can be classified into three groups:

- Climatic data (cloudiness, temperature, humidity, pressure, wind speed and direction, mixing height and horizontal global radiation)
- Data on emissions (the flow of pollutants and the height of discharge)
- Information on the terrain (loaded via the Google Earth)

For the purpose of this work the critical winter period December 2011th - January 2012th years is discussed since the period of measurement data available ground level concentrations of pollutants. Climate data were taken from the available data on the measurements in the site [10,11].
Figure 1. shows the modeled distribution of ground level concentrations of sulfur dioxide in the wider area of the village Povezice in the period December-January incurred as a result of fuel combustion for heating buildings.

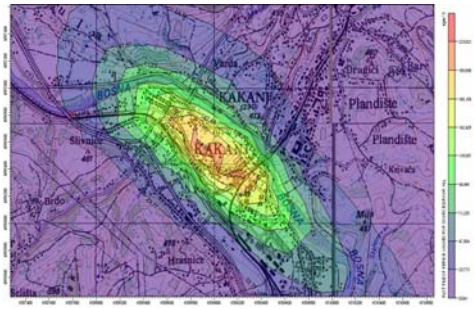

Figure 1. Mean values modeled ground level concentrations of sulfur dioxide emitted from the boiler house in the village of Povezice during decembar2010-januar2012

To assess the impact of sulfur dioxide emitted from household combustion on air quality at the site of the village Povezice should be modeled values of ground level concentrations of sulfur dioxide, which represent the influence of domestic stoves and boilers compared with measured concentrations that represent the impact of all sources of pollution on the site.
The average daily value of the measured ground level concentrations of sulfur dioxide in the reporting period is 355 μg/m^3 and average modeled values of ground level concentrations of sulfur dioxide to the closest point position mobile measurement station is 227 μg/m^3 [11]. Table 2 gives a comparative overview of the measured average daily and modeled average daily values of ground level concentrations of sulfur dioxide measured at the location of mobile measurement stations in Povezice.

Table 2 Comparison of measured and modeled average daily value of average daily ground level concentrations of sulfur dioxide measured at the location of mobile stations in the Povezice

	Sulfur dioxide [μg/m^3]
Average daily value of the concentration of sulfur dioxide obtained by measurement, taking into account all sources of pollution for the period: December 2011-January 2012th	355
Average daily value of the concentration of sulfur dioxide obtained by using mathematical modeling software AERMOD, taking into account only the emissions from the boiler house for the period: December 2011-January 2012th	227
Share modeled daily values of ground level concentrations resulting from fuel combustion in the boiler house of the total ground-level concentrations of pollutants in the village Povezice.	64%

4. CONCLUSION

Air quality modeling using software AERMOD was conducted for the most critical winter period 08.12.2011.-09.01.2012. Model covers the local area Povezice with the immediate surrounding. Selected episode includes a condition typical of a period characterized by its inversion and dense fog. Meteorological parameters were measured.

Based on the model results can be concluded that during the critical winter period house boilers and domestic stoves contribute to 64% of ground level concentrations of sulfur dioxide. This research has shown that the emission of sulfur dioxide that occur as a result of fossil fuel combustion in the homes in Povezice have a significant impact on air quality at this location.

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