Estimation of NO_2Immission Concentrations from Teko-B Power Plant and Measuring Locations Selection

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Abstract – **Thermoenergetic systems are major sources of pollution in gaseous, liquid and solid physical state. Continuous monitoring and control of the impact of energy production and processing is essential for the preservation of human health and environmental protection. In this paper data on the impact of gaseous products of combustion of coal, power plant Kostolac B (TEKO B) are presented, and air quality in the environment is analyzed. Based on the concentrations of emissionsnitrogen dioxide imission concentrations around point source of pollutionare estimated. It is proposed location of measuring stations at the place where the maximum level of pollutionis achieved, and in the direction of dominant winds.**

Keywords– **Air pollution, monitoring, power plants, immission prediction, Gaussian model.**

I. Introduction

Environmental pollution has initiated an extensive study of cross-border transfer of pollutants. The implementation of such studies is only possible international cooperation of many countries. Stockholm United Nations Conference on Environment (1972) has approved the basic principles of building a global monitoring system and recommended the organization of the cells to measure the quantity of pollutants [1]. In the framework of the United Nations on environmental issues (1973-1974) are developed basic principles of creating a global environmental monitoring system [1].

To be a part of that global environmental monitoring system, there is a need to monitor environmental quality parameters, such as air pollution, at local or regional level. By means of collaboration and data exchange among different local stakeholders, the environmental pollution problems can be more easily identified and solved.

II. Problem Description

Thermo-energetic systems are major sources of pollutantsin gaseous, liquid and solid physical condition. Continuous monitoring and control the influence of the production and processing energy is essential for the preservation of human health and the environment. There is the impact of gaseous products of combustion of coal, power plant Kostolac B (TEKO-B), on the quality of air in the local environment.

Air quality monitoring and analysis of thermal power plants on the environment is carried out according to the Regulations on limit values, methods of measuring emissions, establishing criteria for measuring points and data records [2].

Air pollution has influence on people and living species. There is also influence on buildings. The archaeological site Viminacium is in the vicinity of pollution source.On the Fig. 1 is presented the location of that archaeological placein relation to the power plant, and the Fig. 2 presents the map where is shown thermal power plant, archaeological location and nearby settlements.

Viminacium (Viminacivm) was a major city (provincial capital) and military camp of the Roman province of Moesia, and the capital of Moesia Superior. It is an archaeological site located near the power plant TEKO B (Roman baths are less than 2 km from the source of pollution, as shown in Fig. 2), which dates from the reign of Hadrian (about 117th BC), when the settlement got the status of the city, and later became a Roman colony. The city was the capital of the Roman province of Moesia Superior, and Roman legion VII was stationed there.

Fig.1. The distance between the power plant and Viminacium

Plans for future Viminacium include the idea that it becomes one of the cultural centres of Serbia. The observed area is significant from the historical and cultural standpoint, so the planned construction and future work of TEKO-B require special attention, in order to protect thenearby historicalmonument.

III. Monitoring System

Technical monitoring system consists of a set of measures and activities undertaken with the aim of monitoring and improving environmental quality. Within it there are mechanisms for keeping data on physical and chemical effects in selected samples, changes in biological processes in the surrounding environment, the level of pollution of air, water and soil and changes that occur in flora and fauna, and that are caused by anthropogenic and natural influences. The task of

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monitoring is to collect information on the state of the environment, and on the basis of these forecasts to provide quality basic elements of the environment, and to suggest the necessary prevention or maintenance measures.

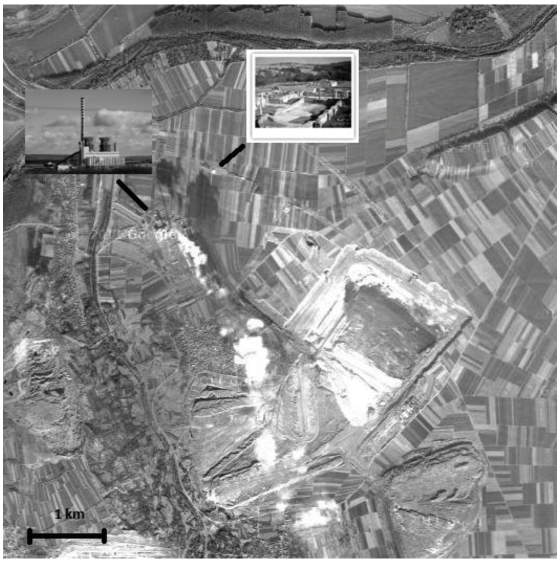

Fig.2. Location of analysed pollution source

Monitoring of air environment includes the installation of measuring points in the area where the expected maximum concentration of pollutants. The air pollutants can be found due to the accumulation of large amounts of waste water and solid waste in the country, which may make the discharge of groundwater to the surface, due to an excessive load of soil. Following the most damaging by-products of burning fossil fuels (coal and, as one of them) in thermal power plants are sulphur oxides, nitrogen and carbon, radioactive materials, soot, ash, dust and slag.

At selected measuring points is necessary to continuously measure the concentration of sulphur dioxide, carbon monoxide, carbon dioxide, nitrogen dioxide, soot and suspended particles [3].Monitoring can be carried out from time to time (occasionally) or periodically (at regular time intervals), depending on the compelling need (hourly, daily, monthly, etc.). Continuous measurement is aimed to monitor the performance of environmental protection systems at large distances.

The system for monitoring the sources of air pollution is a system designed that after sampling records and transmits the required measured values (parameters) to the destination.

IV. Calculation of Nitrogen Dioxide Immission Concentrations

By analysing the results of monitoring set out in the report of the Mining Institute - Belgrade, for the period from 2008 to 2011, it isfound that there aredays when nitrogen dioxide immission levels are above the acceptedvalue [4-6]. These conclusions formed the basis to determine the maximum value of emission and compare with the limit values.

In this paper is applied the Gaussian method for forecasting the impact of nitrogen dioxide on the air quality. Bearing in mind the pace of reaction of nitrogen oxides, their interaction and reactions with components in the atmosphere,it cannot be ignored their impact, especially if it is known that nitrogen dioxide remains in the air and up to 4,5 years. Nitrogen dioxide in the presence of moisture easily enters the reaction and form nitric acid.

Gaussian model is the most common type of model, in which is assumedthat the propagation of air pollution is based on Gaussian distribution, which means that the propagation of pollutants is normal probability distribution [7]. Gaussian models are commonly used to predict the distribution of air pollutants originating from the ground or elevated sources. The primary algorithm used for Gaussian model is based on generalized dispersion equations for a continuous point source [8].

Simplified algorithm for estimation ofimmission concentrationson certain distance from the source is shown in Figure 3, while the calculation results are shown in Figure 4.

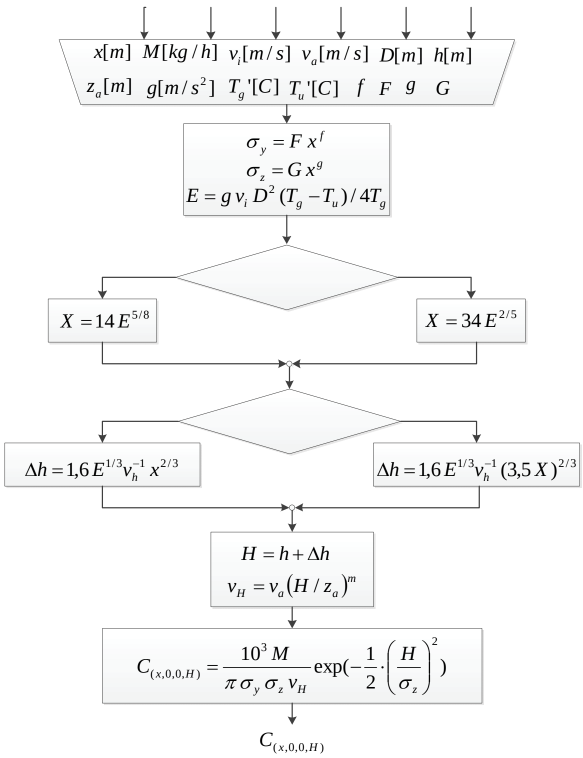

Fig.3. Simplified algorithm for calculation of immission concentrations of nitrogen dioxide

Immission concentration of pollution is determined by the following equation:

$$C_{(x,0,0,H)} = \frac{10^3\, M}{\pi\, \sigma_y\, \sigma_z\, v_H} \exp\left(-\frac{1}{2}\cdot\left(\frac{H}{\sigma_z}\right)^2\right) \qquad (1)$$

whereM isthe intensity of emission from sources (g/s); σ_y , σ_z arecoefficients which includes fluctuations in horizontal and vertical planes; v_H is thewind speed at effective height of source (m/s); and H is effective source height (m).

Calculated immission concentrations of nitrogen dioxide are shown on Table I. On this table are presented the values of immission concentrations for nitrogen oxides at a distance of 100 to 10,000 meters from sources of pollution.

TABLE I
IMMISSION CONCENTRATIONS OF NITROGEN DIOXIDE FOR FIVE DIFFERENT EMISSION MEASUREMENTS(C_1-C_5)

X (m)	C_1 (μg/m3)	C_2 (μg/m3)	C_3 (μg/m3)	C_4 (μg/m3)	C_5 (μg/m3)
100	1.1E-20	1.5E-20	1.0E-20	1.1E-20	9.5E-21
200	7.54E-5	8.68E-5	7.61E-5	5.83E-5	5.21E-5
300	0.1807	0.1992	0.1858	0.1278	0.1174
400	3.2702	3.5292	3.3914	2.2134	2.0606
500	12.7164	13.5525	13.2562	8.3876	7.8696
600	26.0879	27.5742	27.2880	16.9168	15.9534
700	39.1424	41.1303	41.0419	25.0773	23.7352
800	49.5392	51.8276	52.0370	31.4533	29.8507
900	58.6335	62.5066	61.0942	38.6478	36.2869
1000	69.3496	73.2559	72.5378	44.8677	42.3591
1100	76.4495	80.1999	80.1957	48.7720	46.2363
1200	80.4598	83.9572	84.5913	50.7764	48.2909
1300	82.0710	85.2779	86.4378	51.3512	48.9613
1400	81.9304	84.8432	86.4124	50.9108	48.6404
1500	80.5699	83.2032	85.0763	49.7840	47.6430
1600	78.3987	80.7752	82.8633	48.2168	46.2068
1700	75.7187	77.8638	80.0952	46.3866	44.5044
1800	69.6363	71.3928	73.7546	42.3990	40.7525
1900	72.7470	74.6860	77.0043	44.4187	42.6580
2000	66.4920	68.0872	70.4597	40.3858	38.8454
2500	52.0281	53.0583	55.2274	31.3386	30.2175
3000	40.8787	41.5919	43.4344	24.5075	23.6636
3500	32.6685	33.1907	34.7318	19.5282	18.8720
4000	26.6004	26.9998	28.2918	15.8700	15.3455
4500	22.0407	22.3566	23.4488	13.1318	12.7029
5000	18.5478	18.8044	19.7368	11.0397	10.6823
5500	15.8214	16.0344	16.8382	9.4099	9.1073
6000	13.6563	13.8362	14.5357	8.1175	7.8577
6500	11.9099	12.0640	12.6780	7.0761	6.8506
7000	10.4814	10.6152	11.1583	6.2251	6.0274
7500	9.2985	9.4158	9.8996	5.5209	5.3460
8000	8.3079	8.4117	8.8454	4.9315	4.7757
8500	7.4701	7.5626	7.9538	4.4333	4.2934
9000	6.7551	6.8382	7.1927	4.0082	3.8820
9500	6.1400	6.2150	6.5379	3.6427	3.5281
10000	5.6068	5.6750	5.9704	3.3259	3.2215

For the purpose of immission concentration prediction it is created an application TEKO-Air, in which are used the following basic parameters: emission speed (g/s), the amount of pollution sources (m), inner diameter of pollution sources (m), temperature of gas at the source (K), and ambient temperature (K). It is considered a point source of pollution, and it is taken into account the coefficient of dispersion for rural areas. It is a simple site, without the influence of wetlands, and it is considered of all the weather condition information(stability class and wind speed). For further calculation of immission concentration is used Eq. (1), and other equations presented in Fig. 3.

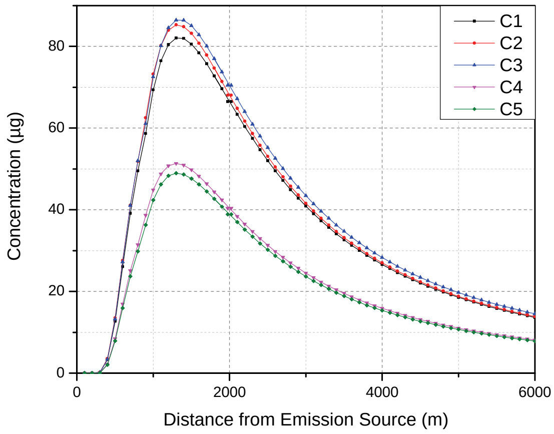

Fig.4. Calculated immission concentration of nitrogen dioxide

Fig.5shows the wind rose for the area of Požarevaccity, according to measurements of nearest hydro meteorological station Gradište. This wind rose is used during the consideration ofair pollution propagation.

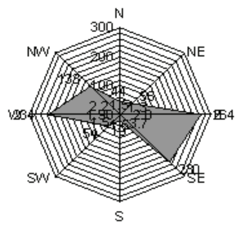

Fig.5. Wind rose for the city of Požarevac

In this area the dominant wind direction is the east and southeast, and the second one is west and west-north west direction. The strongest winds are from the east (27%), with mean speed values over 4 m/s.

Based on the presented results, the problem of increased emission levels of pollutants is solved thanks to the setting up proper chimney height, but there are still occasionally increased concentrations of nitrogen dioxide. Serbian Air Protection Act defines daily limit for concentrations of nitrogen dioxide for non-urban areas (0.07 mg/m^3) and urban areas (0.085 mg/m^3) [9].

V. MEASURING LOCATIONS

Monitoring stations can be stationary (for systematic and long-term measurements), semi-mobile (for continuous monitoring using mobile laboratories to cars) and mobile (for monitoring the current concentration of emission sources, under the smoke plume).

Based on the results obtained by measuring the immission concentrations of nitrogen dioxide, to increased levels of pollution are occasionally exposed surrounding small towns: Kostolac, Bradarac, Klenovik and Petka.

Based on the calculation of immission concentrations of nitrogen dioxide it is necessary to set the measuring points at approximately 1300 m (the radius of the circle presented) from the source of pollution in the direction of dominant winds, as it is shown in Fig. 6.

Fig.6. Distance where is calculated maximum immission concentration in the vicinity of the thermal power plant

As it is previously mentioned, Roman baths are less than 2 km from the power plant and the air pollution has strong influence on thosearchaeological remains.

VI. Conclusion and Future Research

In this paper is calculated immission concentration of nitrogen dioxide near thermal power plant TEKO-B. For that purpose is used Gaussian model of atmospheric dispersion. It is concluded that the maximum immission concentration is approximately 1300 m distant from the source of pollution, measured in the direction of dominant winds, and that is proposed location for measuring point.Daily limit for concentration of nitrogen dioxide can be exceeded, and all small towns that are in the range of 3 km can be exposed to that increased pollution. All these locations are potential measuring points in the future functional network, in order to create the real view on the state of the environment. Monitoring should take place in several stages: data collection, transmission of measured values using the network, data processing, decision making, alarm activation and taking certain measures. Among all the phases there should be communication, thus the system should be interoperable.

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