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Air pollution

TRANSBOUNDARY AIR POLLUTION BY MARITSA-EAST THERMAL POWER STATIONS

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Abstract. Maritsa-East mining and electricity producing complex is one of the largest on the Balkan Peninsula. High sulphur lignite's coals are the raw material for energy generation. Burning processes of some units are several decades old and only limited cleaning systems are implemented. This is the reason for high emissions of acidic oxides and dust in the atmospheric air. Because the chimneys are over 325 m high distribution and transfer of air pollutants cover large areas, affecting not the Bulgarian, but also other territories. The annual amount of acidic oxides emissions is about 50% of the country emissions. The computer simulation of the pollutant dissipation is based on the PLUME and PHOENICS computer packages. Pollutants distribution is simulated at different conditions and it is confirmed that relatively high concentrations of acidic pollutants may remain in long distances.

Keywords: air pollution, thermal power stations, transfer, acidic oxides.

AIMS AND BACKGROUND

Thermal Power Stations (TPS) are using law quality coals and are the major generators of air pollutants. Open mining of lignites in the region of the energetic complex Maritsa-East is the natural base for about 38-40% of energy production in Bulgaria. This complex is situated in South-Eastern Bulgaria and the distance to Turkey is 55-70 km and to Greece – 85-100 km. TPS Maritsa-East 2 is the biggest TPS on the Balkan Peninsula with a total capacity of 1450 MW power. The same complex includes TPS Maritsa-East 1 with 200 MW power and TPS Maritsa-East 3 with 840 MW power. As a result of TPS operation in the region anually about 33 202 × 10^6 Nm^3/year waste gases are generated, with high concentrations of sulphur and nitrogen oxides and particulate. As it was mentioned in our previous publications[1] the level of pollution in the region is much higher then the average not only in the country, but all over Europe. Air cleaning systems have been already introduced in a large scale in the associated countries[2-4]. Bulgaria became a party of several international agreements[5,6] and took the obligations to reduce the air pollutants like acidic oxides and particulate, transferred in a long distances. In this paper we have studied the tendencies of the emissions

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from Maritsa-East TPS and estimate the risk for local population and transboundary transfer. Influence of the measures taken is also subject of discussion. Because Maritsa-East 2 is the main energy producer, major attention is given to this TPS.

EXPERIMENTAL

Data used were obtained in different ways. Firstly, the results from TPS and National Environmental Monitoring System were used as the basic source for all models and simulations. Measurements included regular samplings and analysis, according to the methods approved and measurements in a real time with monitoring systems working in a real time continuously, like mobile OPSIS system and stationary environmental station from the national system. Polski Gradetz environmental station was used for comparison and assessment of the tendencies. For verification balance method was applied and calculations were made for the annual total emissions on the base of sulphur average distribution and the total content of sulphur in the lignite. Thus measurements of sulphur content in the solid wastes were also taken into account.

RESULTS AND DISCUSSION

TPS in the studied region uses lignite from open mines Troyanovo 1, 2 and 3. Annual production of lignite varies, but it should be stressed that for a number of years it was over 30×10^6 t, during transition period it is less by 15-30%. The quantities and average content and characteristics of lignite used in Maritsa-East 2 are given in Table 1. New unites are planned to be installed in TPS Maritsa-East 1 and 3 and after their construction the consumption of lignite in the region will be over 21×10^6 t. So it is obvious that the main environmental problem is related to the desulphurisation of waste gases. The same time nitrogen oxides, carbon oxides and particulate have to be considered and monitoring is needed, according to the conventions mentioned above. On the base of analysis made it is confirmed that in the solid wastes remains from 16 to 19% of the sulphur from the raw fuels. Analysis made have shown that the total content of sulphur in lignite is in the range 4.62-6.39% and water content – 46.9-52.7%. Ash generated is in the range 32.1-42.2%. On the base of average data obtained sulphur distribution for years 1995 and 1999 are given in Table 2.

Table 1. Specific properties of fuels, used in TPS Maritsa-East 2 for the period 1992-1999

Property	1992	1993	1994	1995	1996	1997	1998	1999
Quantity (t)	10 629 653	9 862 759	11 094 519	12 553 950	12 498 083	13 048 759	12 776 958	10 993 194
Heat capacity (kcal/kg)	1543.16	1550.47	1562.59	1519.32	1510.18	1506.37	1504.6	1531.75
Water content (%)	51.89	52.48	52.36	52.49	52.71	52.48	51.97	51.90
Ash (%)	34.71	33.92	33.87	35.04	35.09	35.56	35.16	35.52
Sulphur – total (%)	5.13	5.12	5.12	5.14	5.14	5.14	5.15	5.14
Sulphur – burned (%)	2.19	2.16	2.17	2.17	2.16	2.17	2.20	2.20
Carbon (%)	19.7	19.76	19.83	19.33	19.23	19.14	19.12	19.39
Hydrogen (%)	1.66	1.67	1.67	1.63	1.62	1.61	1.61	1.63
Oxygen (%)	5.97	5.98	6.00	5.86	5.82	5.80	5.80	5.87
Nitrogen (%)	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34
Volatile (%)	1.53	1.48	1.48	1.53	1.52	1.55	1.59	1.53

Table2. Sulphur distribution for years 1995 and 1999 in Maritsa-East 2*

	Sulphur quantity (t)	
	1995	1999
Sulphur – total	272 286	241 850
Sulphur – in waste gases$_2$	190 695	168 908
Sulphur emitted as SO_2	5857	5223
Sulphur – emitted as SO_3	24 518	21 766
Sulphur in waste waters	51 760	45 953

* For comparison in 1990 sulphur calculated emissions from the same TPS are 339 162 t.

According to Oslo protocol of Long-Range Transboundary Air Pollution Convention for this TPS the quantity should be reduced to 118 376 t for 2010. Waste gases from this TPS are released from staks with characteristics given in Table 3.

Table 3. Operation characteristics of the stacks

Parameters	Stack No 1	Stack No 2
Height (m)	325	325
Diameter inner (m)	12.4	9.5
Flow-rate (m^3/s)	2100	880
Velocity (m/s)	17	6
Temperature (°C)	140	140
Power connected (MW)	1020	430

Measured emissions from the stacks are in the range 14 000-21 000 mg/N m^3. Dust cleaning systems (electrical precipitators) with efficiency 99.4-99.9% decrease significantly dust emissions, whereas $DENO_x$, $DESO_x$ cleaning systems are not effectively used yet. Content of particulate in the emissions is in the range 5-50 mg/m^3. It is obvious that the high concentrations of sulphur oxides, when the stacks are 325 m high, is a precondition for affecting a large area. Units with total power of 200 MW from Maritsa-East 1 and 840 MW from Maritsa-East 3 also contribute to the emissions in the region. Climatic conditions are important factor for pollutant distribution. The main directions of the winds in the area are from west-east to south-north and the annual average value of winds is close to 0.7 m/s. For certain short periods the wind's velocity may come close to 10 m/s.

ECO-1 monitoring station (OPSIS system) in the production area of TPS of Maritsa East-2 produce data for sulphur and nitrogen oxides. ECO-2 monitoring station in Polski Gradez gives information about landed concentrations of sulphur dioxide, nitrogen dioxide and particulate. Some of the results are presented in Tables 4 and 5. From the data presented it is seen that for few days per month the maximum measured concentrations exceed limits, when the monthly average of pollutants is within the limits.

Table 4. Measured concentrations (mg/m^3) of SO_2 at stations ECO-1 and ECO-2 for 1999 and 2000

Month	ECO-1 SO_2a*	ECO-1 SO_2m**	ECO-2 SO_2a	ECO-2 SO_2m
		1999		
July	0.016	0.100	0.023	0.992
August	0.029	0.078	0.045	1.106
September	0.033	0.079	0.032	1.986
October	0.025	0.194	0.018	0.751
November	0.025	0.263	0.020	1.165
December	0.028	0.077	0.022	0.299
		2000		
January	0.031	0.093	0.037	0.252
February	0.018	0.106	0.028	1.006
March	0.024	0.056	0.024	0.764
April	0.015	0.116	0.011	0.936
May	0.019	0.330	0.014	0.559
June	-	-	0.031	1.110
July	-	-	0.032	0.603
August	-	-	0.023	0.667
September	0.042	0.091	0.028	0.986

* Average value; ** maximum value.

Table 5. Measured concentrations (mg/m^3) of NO_2 at stations ECO-1 and ECO-2 for 1999 and 2000

Month	ECO-1 NO_2a*	ECO-1 NO_2m**	ECO-2 NO_2a	ECO-2 NO_2m
		1999		
July	0.006	0.100	0.025	0.066
August	0.009	0.078	0.031	0.119
September	0.010	0.079	-	-
October	0.010	0.194	-	-
November	0.011	0.263	-	-
December	0.011	0.077	0.002	0.033
		2000		
January	0.010	0.093	0.004	0.070
February	0.008	0.106	0.002	0.088
March	0.007	0.056	0.002	0.117
April	0.014	0.116	-	-
May	0.016	0.330	-	-
August	-	-	0.063	0.204
September	0.013	0.091	0.033	0.163

* Average value; ** maximum value.

Analysing the data from Tables 4 and 5 one can see that the average and maximum concentrations of the pollutants in the production area are less than in the area outside of the station. Maximum concentrations demonstrate better the differences and the landed concentrations in Polski Gradez are much higher than the limits for those pollutants. The same conclusion could be derived from the distribution curves obtained for the pollutants using the Phoenix program package (Figs 1-5).

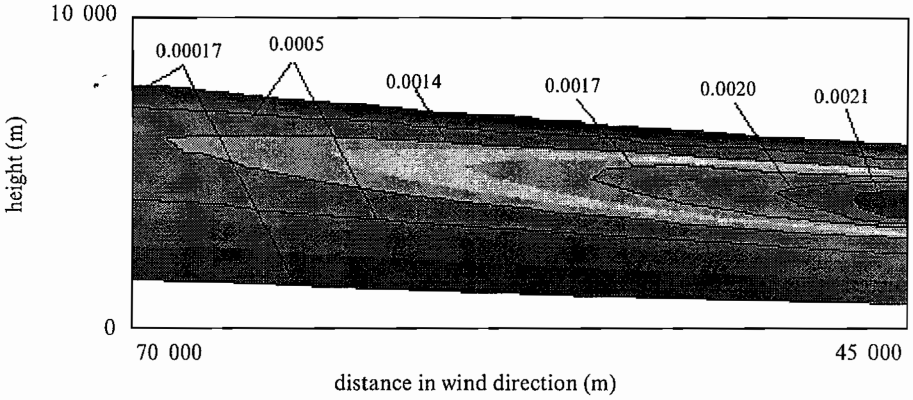

Fig. 1. Vertical profile of SO_2 concentration (SO_2 concentration, value × 5500 mg/m^3)

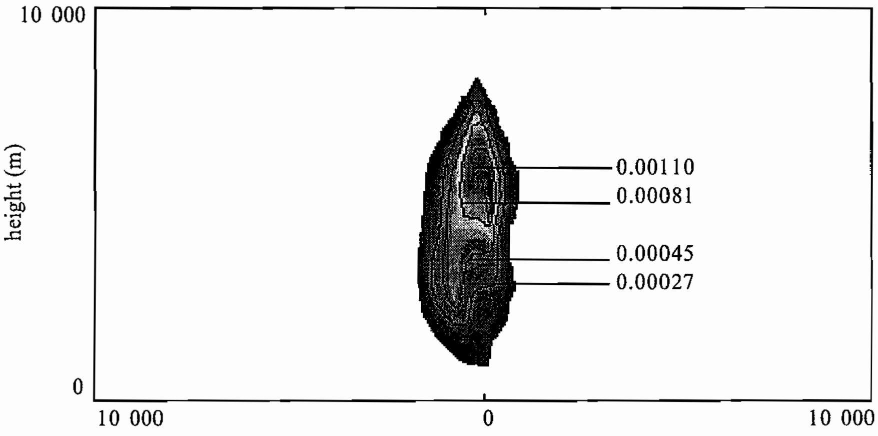

Fig. 2. Vertical profile of SO_2 concentration at 70 km downwind (SO_2 concentration = value × 5500 mg/m^3)

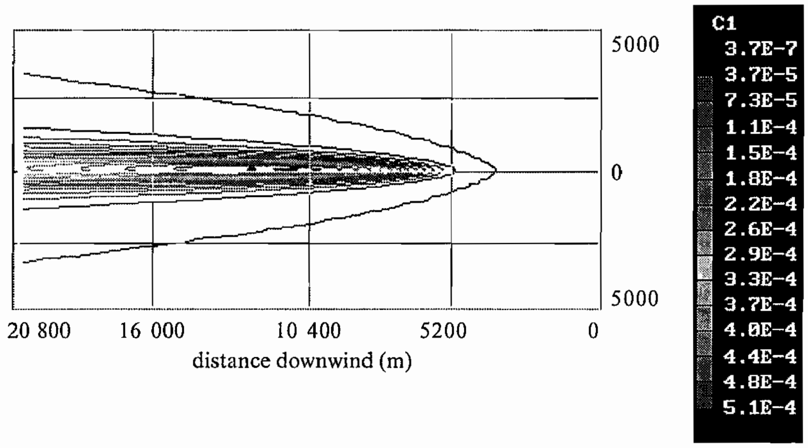

Fig. 3. Ground level concentration of gas pollutants (C1 = 1.00 corresponds to the initial (max) values of the pollutant concentrations, wind velocity 3.0 m/s)

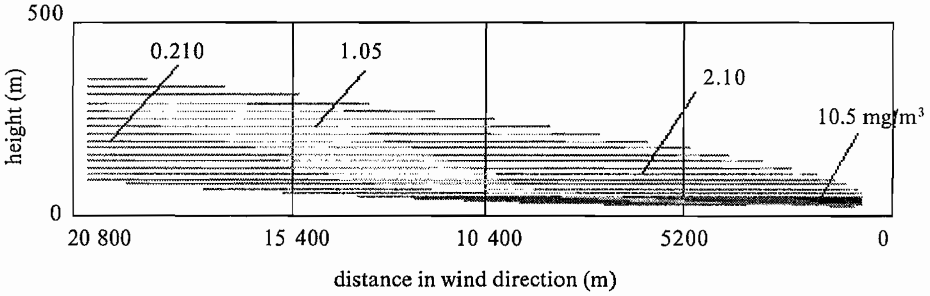

Fig. 4. Vertical profile of dust concentration (dust concentration in a vertical plane oriented to the wind direction)

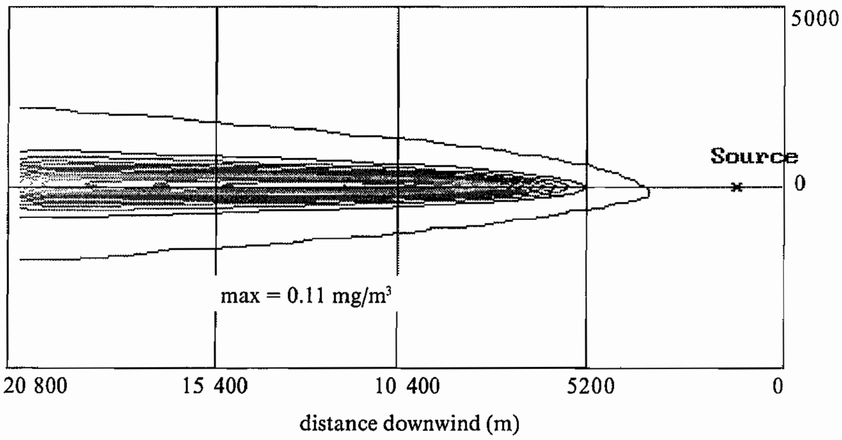

Fig. 5. Ground level dust concentration

CONCLUSIONS

On the base of the studies made conclusions could be derived as follows:

- Acidic oxides from TPS in Maritsa East region are distributed in a far distance and they have to be considered as a transboundary pollution.
- Without implementation of desulphurization cleaning systems for at least 80% of the TPS units in the region it would not be possible to come in compliance with the requirements of Oslo protocol.
- Selection of desulphurization cleaning systems should take into account secondary pollution problems, related with releasing of carbon dioxide, wastewaters and solid wastes generation.

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