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What is Air Quality Plan?

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The Air Quality Plan (AQP) contains a comprehensive analysis of geographic, demographic, climate and air quality data for an area of interest. On the basis of all available data about air pollutant concentrations and prediction of air quality in the future, the AQP provides a series of measures to improve air quality. The global objective of AQP is to ensure that the air quality meets the specified requirements and contribute to the achievement of the commitments, which the government adopted in reducing emissions of air pollutants. Some specific objectives should be as follows: reduce air pollution levels below the specified limit values and target values in areas where such limits are exceeded, keep sub-limit level of air pollution in areas where there is no crossing of the limit values and target values, etc.
During the 2012 a team composed of experts from the Republic of Serbia (Mining and Metallurgy Institute Bor) and European Union made the AQP for the agglomeration of Bor, located in the southeast of the Republic of Serbia. The area has been a major centre for mining and processing of copper and other precious metals for more than a century. Air pollution is one of the most important environmental problems in the agglomeration of Bor. The main source of air pollution with sulphur dioxide, heavy metals in particulate matter (PM) and aero sediments is the copper smelting and refining complex located close to the Bor town urban areas. This paper presents the structure of AQP for the agglomeration of Bor.

1. Introduction

The AQP describes the present state of air quality and provide measures that should be done to ensure improvement of air quality in an area (Siversten and Bartonova, 2012). The main purpose of the AQP is to establish an effective basis for reducing emissions of pollutants into the air. It prescribes short and long-term measures to improve air quality. The AQP is based on results from different kind of assessments, such as:

- Information about the area of concern (population, economy, industry, transportation, meteorology).
- Inventory of air pollution emissions.
- Information about current air quality monitoring program.
- Data about concentrations of air pollution provided by monitoring and modelling.
- Assessing exposure and health damage.

The goals of AQP are given in legislation and include identifying primary and secondary pollutants that are of concern. Information about current state of air quality should be taken from systematic monitoring and modeling (Vairo et al., 2014). Identifying the air pollution emission sources is key component of AQP. After evaluation of the current state of air quality some control measures and actions should be necessary to prescribe in order to reduce air pollution. The measures should be prescribed in details. Usually AQP contains in attached documents a detailed description for the implementation of each proposed measure. For example, one attachment should contain the list of measures to be taken to improve the air quality in the area, list of agencies and entities responsible for implementing, control of implementation and development of AQP, deadlines, planned budget, and percentage of improvement the existing state of air quality by applying the specific measures.

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2. Information about the agglomeration of Bor

The agglomeration of Bor, in fact, the municipality of Bor, is placed in a mountainous and forest area in the south-eastern part of the Republic of Serbia. It is located less than 50 km far from Bulgarian and less than 100 km far from Romanian borders (as shown in Figure 1). A large part of the municipality population live in the urban settlements in the town of Bor, while the rest of population live in the rural zones in 12 rural localities. The area has been a major centre for mining and processing of copper and other precious metals for more than a century. The main source of air pollution with SO_2, heavy metals in PM and aero sediments are the copper smelter (Dimitrijević et al., 2009). Prolonged exposure to SO_2 and PM has been associated with inflammatory processes (Camatini et al., 2010), respiratory and cardiovascular disease, and has been increased all-cause mortality (Pope et al., 2007). This indicates the need for taking appropriate action to reduce emissions of air pollutants.

2.1 Population

The agglomeration of Bor covers a mostly mountainous area of 856 km^2 and has a population density of 58.4 citizens per km^2. Majority of local population is concentrated in urban areas, especially in the town of Bor, and smaller satellite community zones (or administrative centres). The total population in the agglomeration of Bor was 50,159 persons in 2011, compared to 57,696 persons in 2002 (Census of population, 2011).

2.2 The RTB Bor Company

Main economic activity in the agglomeration of Bor comprises mining and metal processing. Mining production started in 1903 with the exploitation the only underground mine, followed by exploitation of 3 other open pits in the Bor area (as from 1912, 1979 and 1990 respectively). The first pilot plant for the preparation and concentrate was commissioned in 1929 with a processing capacity of 25-30 tons per day. After the Second World War, the Bor mine became a state company in which intensive restructuring of equipment and production facilities. In 1951 a new company was formed under the name Mine Smelting Complex Bor (RTB Bor) as a large economic system and it still operates under that name as a business entity today (EIA, 2010). RTB Bor during 1960's and 1970's went through two development stages and achieved a copper production capacity of more than 150 thousand tons per year.

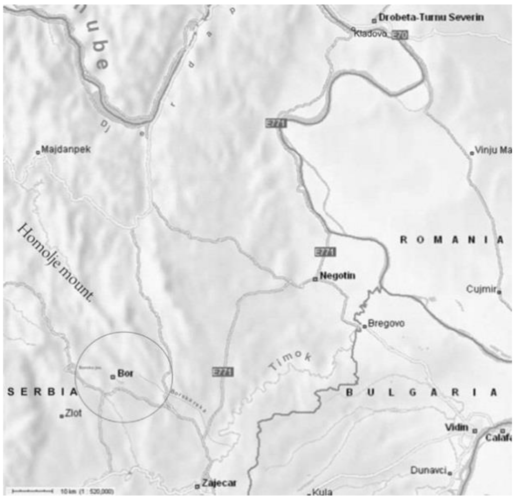

Figure 1: The location of agglomeration of Bor on the map of eastern Serbia

2.3 Impact on the environment

The mining activities have left a strong mark on the surrounding landscape, most strongly characterized by the huge open cast mines (in total accounting for some 1,800 ha). Continued immigration of workers resulted in the gradual transformation of the originally agriculturally-based village of Bor into today's town of Bor with most urban residential areas built close to and around copper smelter (the town's centre is less than one kilometer away from smelter). The industrial activities in Bor, in particular those by the mining and smelter complex, have resulted in substantive negative impacts on the environment in the region (air, water, and soil) as well as having raised serious concerns about associated health effects of the pollution at large. The fact that the main polluter is also the main employer in the area highlights the need to solve the environmental problems in a wider economic and social context.

2.4 Relevant climate data

The agglomeration of Bor is characterized by temperate continental climate, which in the highest mountain zones is transformed in mild mountain climate. The features of such climate are warm and sunny summers and cold winters with a lot of snow. The seasons are clearly recognized, the autumns being somewhat warmer, drier, with more sunny days than the springs. The summers are characterized by rather stable weather circumstances, comprising long sunny and short rainy periods. In winter, weather circumstances are characterized by low temperatures and intense snowing. The prevailing wind was from WNW direction. The average monthly wind intensities were within the range from 0.2 m/s in November to 0.7 m/s in March and April. Maximal wind gust was recorded in January. There are a significant percentage of winds blowing westwards thus pushing smelter facility emissions and particulate towards Bor town (as shown in Figure 2).

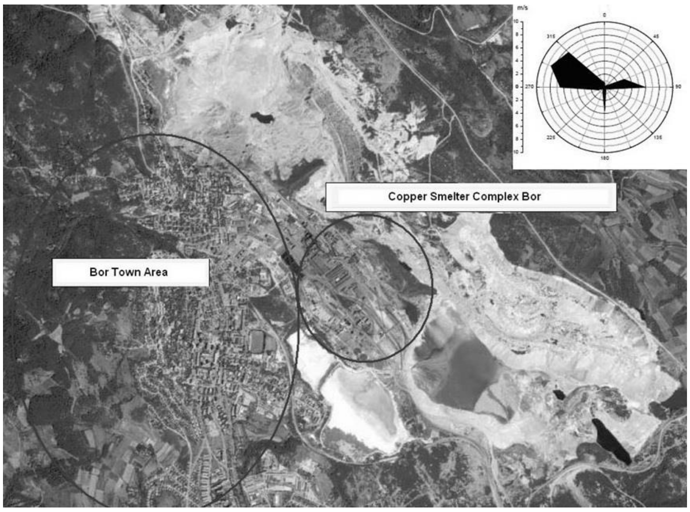

Figure 2: Map with the position of Bor town urban areas relative to the copper smelter and wind rose for 10 years period (2001-2010)

3. Inventory of air pollution emissions

The ore melted in the copper smelter plant in Bor is of chalcopyrite-pyrite type with the increased contents of arsenic, which is found in the form of FeAsS and Cu_3AsS_4. The oxidation, roasting and melting of such a mineral forms results in increased heavy metal's oxides and SO_2 gas which in certain quantities contaminate the environment. Reportedly, 170,000 to 250,000 t/y SO_2 are emitted to the atmosphere. The technology of copper production in the copper smelter in Bor is outdated which leads to the environmental pollution of higher concentrations of SO_2 and particulate matter as well as aero sediments (PM > PM_{10}). Total emissions of air pollutants (SO_x/SO_2, NO_x/NO_2 and Total Suspended Particles - TSP) in the agglomeration of Bor in 2010 are shown in Table 1 (Apostolovski-Trujić et al. 2013). Individual contribution of SO_x/SO_2 and NO_x/NO_2 and TSP in total emission of air pollutants is shown in Figure 3. More than 93 % of total SO_x/SO_2 emissions are released from the copper smelter and District Heating Plant Bor. Thus, point sources are the dominant sources of SO_x/SO_2 emissions in the agglomeration of Bor. Mobile sources are the dominant sources of emissions NO_x/NO_2 (73 %). By the intensity of total NO_x/NO_2 emissions, point sources are in the second place. Area sources are the dominant sources of TSP (86 %). By the intensity of total TSP emissions, stationary sources are in the second place with 11 %, while the mobile sources are in the third place with just 3 %.

Table 1: Total emissions of air pollutants in the agglomeration of Bor in 2010 (t/year) (Apostolovski-Trujić et al., 2013)

Types of emission sources	SO_x/SO_2	NO_x/NO_2	TSP
Point sources	85017	72.2	822
Area sources	5685	48.9	6317
Mobile sources	79.3	324.5	188.8

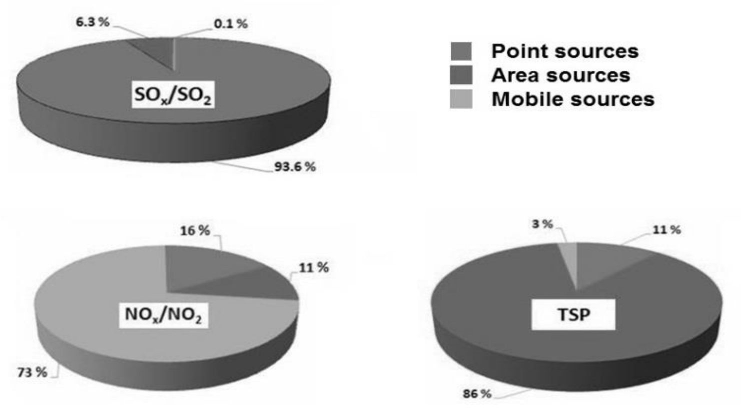

Figure 3: Individual contribution of SO_x/SO_2 and NO_x/NO_2 and TSP in total emission of air pollutants

4. Air quality monitoring program

Air quality control in the agglomeration of Bor is done through local and national monitoring networks:

- Two monitoring sites for sulphur dioxide and soot, and four monitoring sites for TSP, in a local monitoring network operated at municipal level;
- Three automatic stations as part of national network of automatic monitoring stations, operated by Serbian Environmental Protection Agency – SEPA.

Table 2: Basic information about automatic monitoring stations in the agglomeration Bor

Name / Operated by	Geographical coordinates (latitude/N/E)	Type	Measurements	
			Pollutants	Meteorological parameters
Bor-Park / SEPA, Bor Municipality	44 ° 4 ' 33.61 '' N 22 ° 5 ' 58.22 '' E	Urban/ Industrial	PM_{10}, $PM_{2.5}$, SO_2	T, RH, P, WD, WS
Bor – Institute / SEPA	44 ° 3 ' 35.72 '' N 22 ° 6 ' 5.16 '' E	Urban/ Industrial	SO_2, NO, NO_2, NO_x, CO, O_3,	T, RH, P,WD, WS
Bor – Jugopetrol / Bor Municipality	44 ° 3 ' 15.36 '' N 22 ° 7 ' 46.43 '' E	Urban/ Industrial	SO_2	
Bor-Brezonik / SEPA	44 ° 5 ' 52.96 '' N 22 ° 5 ' 30.25 '' E	Urban/ Industrial	PM_{10}, SO_2,	T, RH, P, WD, WS

Table 3: SO_2 annual averages ($\mu g/m^3$) and number of days (N) with the concentrations above the daily limit value (LV) of 125 $\mu g/m^3$ (Vahlsing and Smith, 2012)

AMS name	Average						N > LV (24h limit)					
	2005	2006	2007	2008	2009	2010	2005	2006	2007	2008	2009	2010
Bor - Park	179	229	182	127	-	171	119	155	109	69	-	111
Bor - Institute	28	56	52	63	110	76	21	25	20	22	-	65
Bor – Jugopetrol	224	198	174	146	178	94	155	144	150	126	83	77
Bor – Brezonik	60	85	50	63	86	100	8	32	51	36	18	44

According to the results shown in Table 3 the inhabitants of the agglomeration of Bor was exposed to the high concentrations of SO_2 in the time interval from 2005 to 2010.

There is only one AMS station measuring PM_{10} in the agglomeration of Bor, AMS Bor-Park. According to (SEPA, 2010), in 2010 the annual average of PM_{10} concentrations didn't exceed the immission limit, the

24 h limit was exceeded 34 times, and the concentration of 75 μg/m^3 (LV + margin of tolerance) was exceeded ones. The annual target immission limit for the $PM_{2.5}$ was not exceeded. The margin of tolerance wasn't exceeded too.

Airborne PM has been recognized with greater environmental significance as the carrier of many harmful trace metals (Moscoso et al., 2010). The annual average elemental content (Pb, As, Cd and Ni) in TSP is determined at 4 locations in the Bor town urban area in the time period 2006-2010 as shown in Table 4. Spatial variability of pollutants is mainly due to the position of the monitoring sites relative to the Copper Mining and Smelting Complex Bor and meteorological conditions (wind speed and direction, atmospheric pressure, humidity and temperature) (Tasić et al., 2013). Temporal variability and high levels of As, is due to copper smelter operation mode, type of ore and production intensity. According to the presented data, air quality in Bor was very poor in the time period 2006-2010, regarding levels of As in TSP.

Table 4: The average annual content of Pb, As, Cd and Ni in TSP at the location Bor – Park

	2006	2007	2008	2009	2010
Pb (μg/m^3)	0.2	0.2	0.1	0.1	0.1
Cd (μg/m^3)	0.003	0.002	0.003	0.002	0.008
Ni (ng/m^3)	0	0.1	0.1	0	0.4
As (ng/m^3)	38.9	25.0	19.2	8.5	6.1

5. Assessing exposure and health damage

The lack of health impact studies and useful medical records for conducting such studies in the agglomeration of Bor is obvious. Because a number of factors involved it is not easy to quantify the impact of air pollution to increase the number of people suffering from diseases of the upper respiratory tract. The same conclusion stands regarding the mortality from malignant diseases.

6. New measures for air pollution reduction

On the bases of information from different assessments listed above the fallowing three sets of measures were prescribed.

6.1 Measures for reduction of SO_2 emissions

To reduce the air pollution by sulphur dioxide gas, the following basic measures are proposed:

- Reduction of sulphur dioxide emission from the copper smelter (building of the new copper smelter and sulphuric acid factory).
- Development and implementation the energy infrastructure that does not pollute the environment (reconstruction of heating facilities and pipeline network in the district heating system, upgrading waste gas treatment system in the district heating plant, implementation the environmental friendly technologies and fuels for district heating, gasification of urban areas).

6.2 Measures for reduction of suspended particles emission

To reduce the air pollution of suspended particles, the following basic measures are proposed:

- Reduction the primary emission of suspended particles from the point and surface sources (reduction the diffuse emissions of suspended particles from open pits, dumps and flotation tailings by remediation of old dumps and flotation tailing dumps, waste sorting and remediation the inactive parts of city dump, reconstruction of heating facilities and pipeline network in the district heating system, upgrading waste gas treatment in the district heating plant, restricting the emissions from the selected dust emission sources during the adverse weather conditions, increasing the flow of road traffic).
- Relocation of dust emission sources outside the settlements (reconstruction of ring-road around town, restrictions of car traffic in the centre of town).
- Education and environmental awareness (support for energy saving in the households, education and raising the population awareness).
- Particulate pollution monitoring (air quality monitoring network optimization, permanent updating particulate emissions inventory)

6.3 Measures for maintaining low concentration level of the pollutants for which the exceeding thresholds (emissions or immissions) were not detected in the period until the adoption of the AQP

- Optimization and gasification of district heating system (refers to NO_2, CO, surface ozone, benzene)

- Modernization of transport and transport equipment (refers to NO_2, CO, surface ozone, benzene)
- Ni and Pb evaluation in the metallurgical production process

7. Conclusions

The main objective of the AQP is to serve as a document that describes all the necessary activities and measures for permanent improvement of air quality in an area. The AQP is based on results from different kind of assessments. According to the presented data, air quality in the agglomeration of Bor was very poor in the time interval from 2006 to 2010, regarding levels of SO2 and As in TSP. Thus, the proposed measures are primarily related to reduction of SO_2 emission, reduction of suspended particles emission, and reduction or prevention the re-suspension of particles. Also, the AQP prescribes measures for maintaining the low concentration levels of air pollutants that were not exceeded the limits in the period before the adoption of the AQP. In attached documents the AQP should contain detailed descriptions for each proposed measure together with the list of agencies and entities responsible for implementing, control of implementation of planned measures, activities on development of AQP, deadlines, source of funding, and percentage of improvement of air quality for each proposed measure.

Acknowledgment

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