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Influence of pyrometallurgical copper production on the environment

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ABSTRACT

In this paper the influence of pyrometallurgical treatment of copper sulphide minerals and pyrite on the environment from the aspect of ambient air pollutions is considered. Results of emission of SO_2 and particulate matter from the location with the most pollution are presented. According to the results it could be seen that the Bor's citizen were exposed to the high concentration of SO_2 and arsenic which were found to be multiple over the Serbian legislative limits during 2007. Also, the reasons and consequences of this pollution were analysed.

1. Introduction

Copper is one of the most important raw materials in modern society. During the past years, world copper production has risen from 8.7 Mt in 1988 to 13.2 Mt in 2000. In particular, the industrialization of developing economies in Asia, and the drive to improve standards of living in the region, fuelled the demand for copper over the last 10 years. There will be appreciated further market copper risen until 2010 [1].

Copper is most commonly present in the earth's crust as copper-iron-sulphide and copper sulphide minerals, e.g. chalcopyrite ($CuFeS_2$), bornite (Cu_5FeS_4) and chalcocite (Cu_2S). The concentration of these minerals in an ore body is low. It is now rare to find a large copper deposit averaging more than 1 or 2% Cu. Copper ore containing down to 0.5% Cu (average) are being mined from open pit while ores down to 1% (average) are being taken from underground mines. Pure copper metal is produced from these ores by concentration, smelting and refining. About 80% of the worldly copper production from ores has its origin in Cu–Fe–S minerals. Cu–Fe–S minerals are not easily dissolved by aqueous solution, so the vast majority of copper extraction from these minerals is pyrometallurgical. More than 67% of the world copper production originated from porphyry copper ores [1,2]. These ores present a pyrite copper deposits in which the content of pyrite is 90–95%, and much more. The Bor Copper Mine belongs to this type of deposit and is located in the Eastern Serbia. Serbia is country in the Balkans (a historical and geographical region of south-eastern Europe) and in the Pannonian Plain (a region of central Europe). It shares borders with Hungary, Romania, Bulgaria, Macedonia, Montenegro, Bosnia-Herzegovina and Croatia (Fig. 1).

Mining production in Bor started in 1903 by underground mining. The open pit operations started in 1912 and were performed until 1986. There are two more copper mines in the municipality—at Veliki Krivelj (opened in 1979) and Cerovo (opened in 1990). The Bor Copper Mine, that is, the town of Bor is situated in eastern Serbia, 220 km away from Belgrade and about 30 km away from the Bulgarian border. The mine is located on the north-eastern rim of the town so that the open pit, metallurgical smelting complex and the flotation tailings pond make a boundary between the urban and the industrial zone. Owing to the fact that the town was built in the near vicinity of the mine, as well as the location of the copper smelting plant and two more mines nearby, which are comprised by RTB Bor (the Copper Mining and Smelting Complex Bor), the town itself represents a serious environmental hot spot of Serbia and Europe.

One of the main directly/indirectly pollutant in the mining and metallurgy production of copper is certainly pyrite—FeS_2. Pyrite is one of the most spreaded sulphide mineral and one of the most spreaded mineral in general. It is present in many valuable mineral raw materials mostly as impurity that disturbs their mineral processing and treatment. Thereby, FeS_2 is inevitable present in copper sulphide ores as well as in the smelting copper concentrates.

Oxidation of FeS_2 and its negative effect on living and working environment is, first of all, related to mining. Exploitation of copper sulphide minerals which contain ore are associated with FeS_2, lead to uncontrolled oxidation under the influence of weathering. Due to oxidation of FeS_2 and associated minerals, in underground mines, open pits, overburden dumps and flotation tailings, acid

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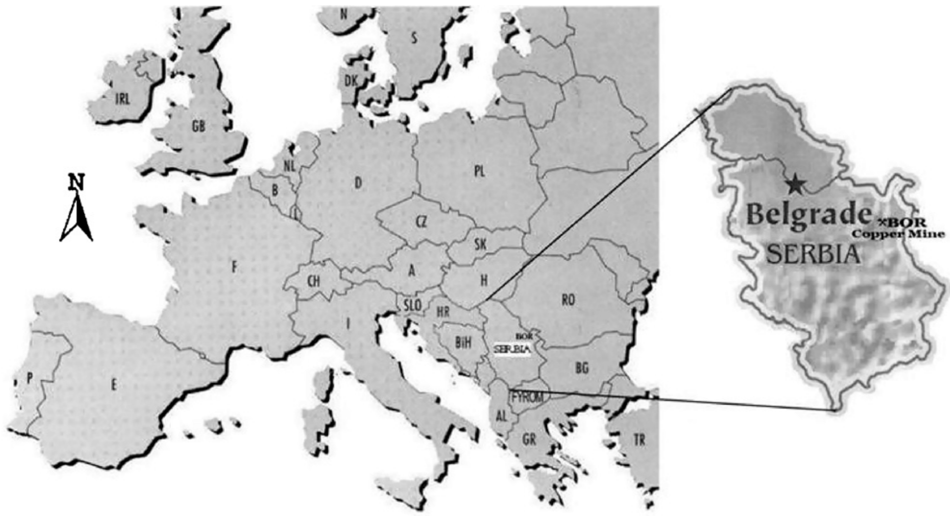

Fig. 1. Location of Serbia and the Bor Copper Mine.

solutions are produced, enriched with heavy metal ions, solution salts and other substances, which through piercing, percolating and overflowing waters come to underground and surface waters and pollute nearer and wider areas. FeS_2 oxidation itself is mostly a bacterial-chemical process which produce follow: Fe^{2+}, Fe^{3+}, $SO_4{}^{2-}$, S^0 [3].

All products obtained in such process may be very harmful. Dissolved ions pollute mine and underground waters. Fe^{3+} and H_2SO_4 may cause additional autocatalytic FeS_2 oxidation. Also, Fe^{3+} in acidic medium causes oxidation of Cu and other sulphide minerals while heavy metals are released into solution [4].

Degradation of a huge soil area, huge volume of the soil waste as well as the pollution of underground and surface water, are the main attribute for the most of activated or closed mines of copper exploration from sulphide ores. However, beside the soil and water pollution by oxidation of copper minerals and FeS_2 during the metallurgical treatment, the air pollution by SO_2, if it is not adequately transform into the sulphuric acid or sulphur, is presented. The most important source of air pollution is certainly the half century old technology of pyrometallurgical production of copper in the RTB Bor.

Namely, combustion of FeS_2 and $CuFeS_2$ releases SO_2 which is partly or completely emitted into atmosphere. SO_2 is, along NO_x, main constituent of acid rain, which is a global problem since it also pollutes soil and waters. SO_2 emitted from smelter and thermal power and heating plant mostly originate from FeS_2 [5].

Among SO_2, the citizen of Bor is also exposed to the high concentrates of As in particulate matter. As naturally occurs in over 200 different mineral forms. But, it is common in FeS_2, PbS, $CuFeS_2$ and less common in ZnS. The most common As mineral is FeAsS [6]. In the reaction of concentrate smelting obtained from the most spreaded arsenical pyritic copper deposits [7], As_2O_3 has been released according to the equations [8,9]:

$$3FeAsS + 7.25O_2 \rightarrow Fe_3O_4 + 1.5As_2O_3 + 3SO_2 \quad (1)$$

$$4Cu_3AsS_4 + 13O_2 \rightarrow 6Cu_2S + 10SO_2 + 2As_2O_3 \quad (2)$$

The main source of As emission is copper smelting, coal-combustion, herbicide use and Pb- and Zn-smelting. Sixty percent of the anthropogenic As emissions can be accounted for by only two sources: Cu-smelting and coal combustion [7]. Unfortunately, both sources are presented in Bor town.

Having in mind the fact that the citizen of Bor has been exposed to the high concentrations of SO_2 and particulate matter this paper represented the results of continuous measurement of those parameters during 2007 at the locations where the most pollution was detected. Also, the reasons and consequences of this pollution as well as the course of their control are analysed.

2. Experimental

Bor's municipality is located in the central part of Eastern Serbia on the territory of 856 km^2. Degree of settlement is 67.2 inhabitants per km^2. The altitude of town Bor of 378 m is low comparing with surrounding tall mountains (Stol 1.156 m, Veliki Krs 1146 m and Crni Vrh 1043 m). Bor is located in the valley of the homonym river. The wood soil cover the 45% of the Bor's municipality area, the rest of 49% refer to the agriculture soil and 6% to the infertile soil. The climate is moderate continental. The average mean of annual amount of rainfall is around 469.2 mm/m^2, the snow overlay retains about 60 days and the annual average temperature is 11.7 °C. The annual average mean of relative air humidity is 73% while the atmospheric pressure is 971 mbar. W-NW wind prevailing wind velocity with an average of 0.5 m/s with the period without wind of over 50%.

In Mining and Metallurgy Institute Bor, Department for Chemical and Technical Control, there is a group for measuring of meteorology parameters and air quality control over 30 years. By UNEP (United Nations Environment Protection) donation, two fixed stations for SO_2 monitoring (Environment SA), mobile station for ambient particulate matter concentration monitoring (PM10—particles less than 10 μm in diameter), and dust sampler for heavy metal concentration analyses in deposited matter had been arrived in Bor during summer 2003. One fixed station for SO_2 concentration monitoring was situated in "Town Park", and other at "Jugopetrol warehouse" (see Fig. 2).

The station in Town Park is equipped with meteorology sensors. The measuring of particulate matter concentration (PM10) is done in eight locations distributed in the town and its nearly surrounding. In addition, these measurements are realised occasionally, depending on the wind direction and meteorology conditions [10]. The concentration of SO_2 in the open air has been monitored in many measuring points present in the Bor town.

However, we will discuss in this paper those which are highly exposed to SO_2. They are "Town Park" and "Jugopetrol warehouse". Monitoring stations are placed on those points and continuous

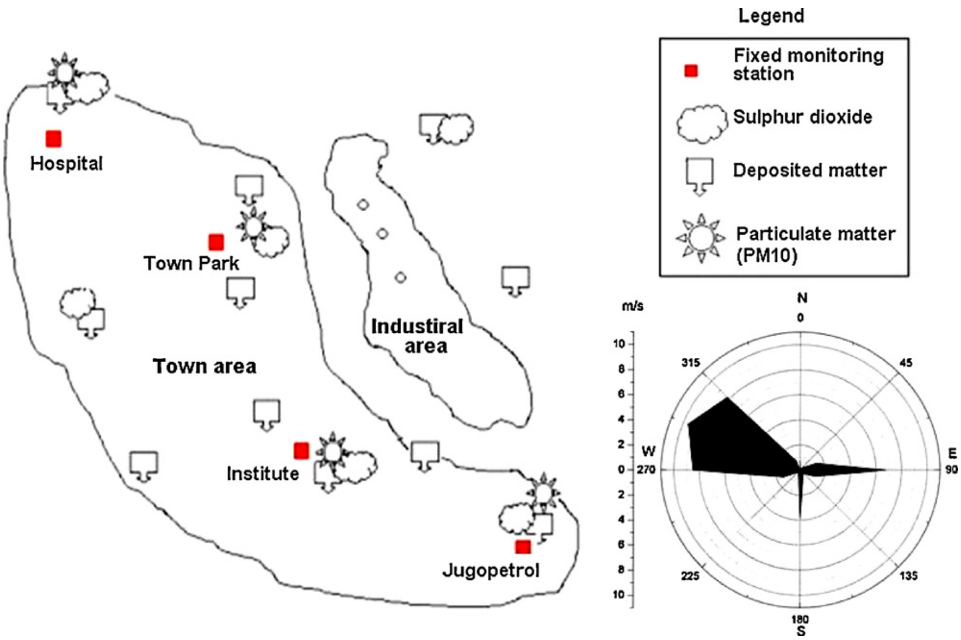

Fig. 2. Locations for taking of samples and placing measuring stations during 2007 together with the wind rose.

measurement has been given. Date transfer is by modem at every 15 min from the stations to the control centre in Mining and Metallurgy Institute Bor. SO_2 concentration determination in air is provided by UV-fluorescence after excitation to higher energy level and light emission measurement. It is possible to perform automatic analysis of measuring the concentration of SO_2 in ambient air in the concentration range from 0 to 10,000 $\mu g/m^3$ according to ISO 10498 standard with this method. Sampling instrument for the determination of airborne particles consists of a sample inlet, photometer, collection medium and a flow regulated pump. Photometer uses a light scattering technique to determine the concentration of particulates in the size range from about 0.4 μm to about 20 μm in diameter. The particulate is retained by the filter which can be removed for subsequent analysis of quantities of heavy and volatile metals by ICP-AAS (Spectro Ciros Vision) and GFAAS (PerkinElmer) techniques.

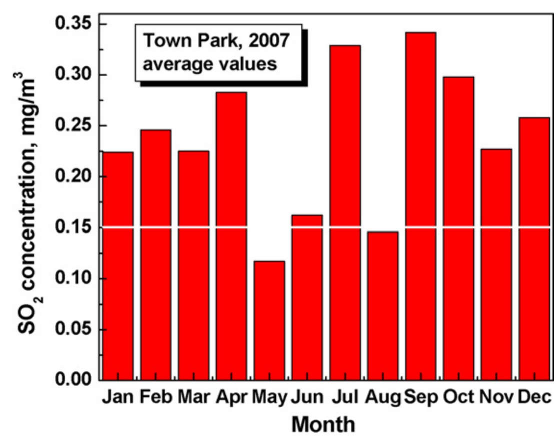

Fig. 3. Average monthly values of SO_2 emission during 2007 on measured location "Town Park".

3. Results and discussion

The SO_2 produced by man is due to the combustion of sulphur containing fossil fuels (principally coal and heavy oils) and the smelting of sulphur containing ores. The largest SO_2 pollution is from Copper Smelting Plant, because sulphuric copper based ores with high content of FeS_2 (mainly $CuFeS_2$) are smelted. Results of measured emission of SO_2 during 2007 are given in Figs. 3 and 4.

The results showed average monthly values of emission based on daily mean values. According to analysed results from the measured location "Town Park", the average annual value for SO_2 is 238 $\mu g/m^3$ and during 142 days of 2007 the concentration of SO_2 was higher than 24-h limit value of 150 $\mu g/m^3$. The average annual value of SO_2 at the measured location "Jugopetrol" was 196 $\mu g/m^3$, and during 176 days of 2007 concentration of SO_2 was higher than 24-h limit value [11,12]. Calculated to the month it could be seen that the concentration of SO_2 was higher in 5–6 months during 2007. According to the regulation on ambient air quality for urban areas (Official Gazette of the Republic of Serbia, No. 54/92; 30/99; 19/2006) annual average concentration of SO_2 is 50 $\mu g/m^3$. It means that the concentration of SO_2 was four to five times above the limited value. Additionally, the citizen of Bor town was occasionally

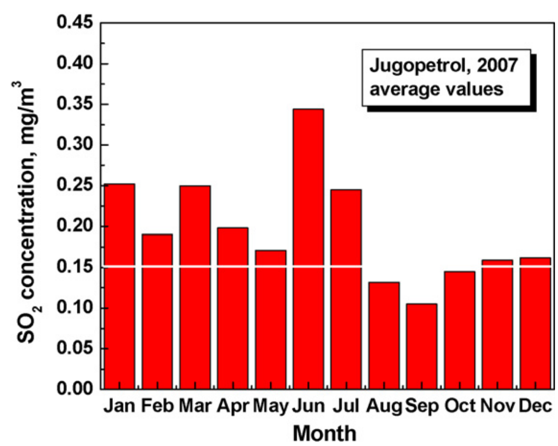

Fig. 4. Average monthly values of SO_2 emission during 2007 on measured location "Jugopetrol".

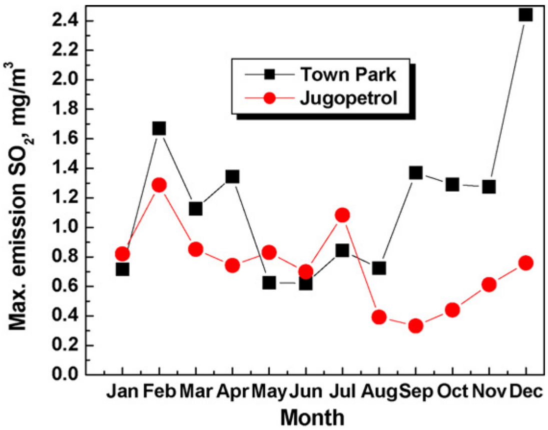

Fig. 5. Measured maximum monthly values of SO_2 emission during 2007.

exposed to rarely high concentration of SO_2 (5000–8000 μg/m^3). It could be kept in mind that those pollutions could last 1 h and could be repeated during the month, sometimes during the day. From Fig. 5 it could be seen the maximum values of the emission of SO_2 through the months. According to Figs. 3 and 4 it could be seen that only 3 months during 2007 the values over the emission limit were not noted at the location of Town Park and Jugopetrol, respectively.

Air pollutions with SO_2 are everyday matter in Bor town. It is very rare to note the day without pollutions. It could only be noted when Copper Smelter Plant stop working or the weather conditions are favourable (high atmospheric pressure, low humidity, W-NW wind). Under this condition the minimum concentrations of SO_2 in the open air in Bor is 10–20 μg/m^3. The wind is the most important factor for the transport of pollutants, the highest values of SO_2 concentrations diffuse horizontally to wind direction. In the annual distribution of frequency of wind direction the W-NW wind dominated (approximately 28%), the rest refer to E-SE wind (approximately 11%).

When W-NW winds are blowing only eastern part of town and two villages downstream (Ostrelj and Slatina) are exposed to the air pollution, it is noted at the Jugopetrol measurement point. The unfavourable situation for the citizen of Bor town is the period when E-SE winds are blowing; nevertheless the most dangerous are the periods without winds. The annual frequency of periods without winds during 2007 was 53.6%, varying in the range from 42.7% to 77.2%. In the periods without winds, in the period of absence of air circuit, all the polluted matter emitted from chimney remains in town. It means that the industrial zone and town centre are the most threaten area. Those weather conditions are typical for late autumn, winter and the beginning of spring. It is in agreement with maximum detected values for emission of SO_2 at the measuring point “Town Park” in that period of year.

The distance between town centre and the first smelter chimney with SO_2 emission is about 500 m. This is very unfavourably for the inhabitants in Bor, because the old town centre has the largest population. It is also an administrative, trade and business centre, with four primary schools, two nursery and kindergarten, town market, university and hospital.

The main reason of the air quality of Bor town is certainly the half century old technology of copper smelting. All gaseous products (up

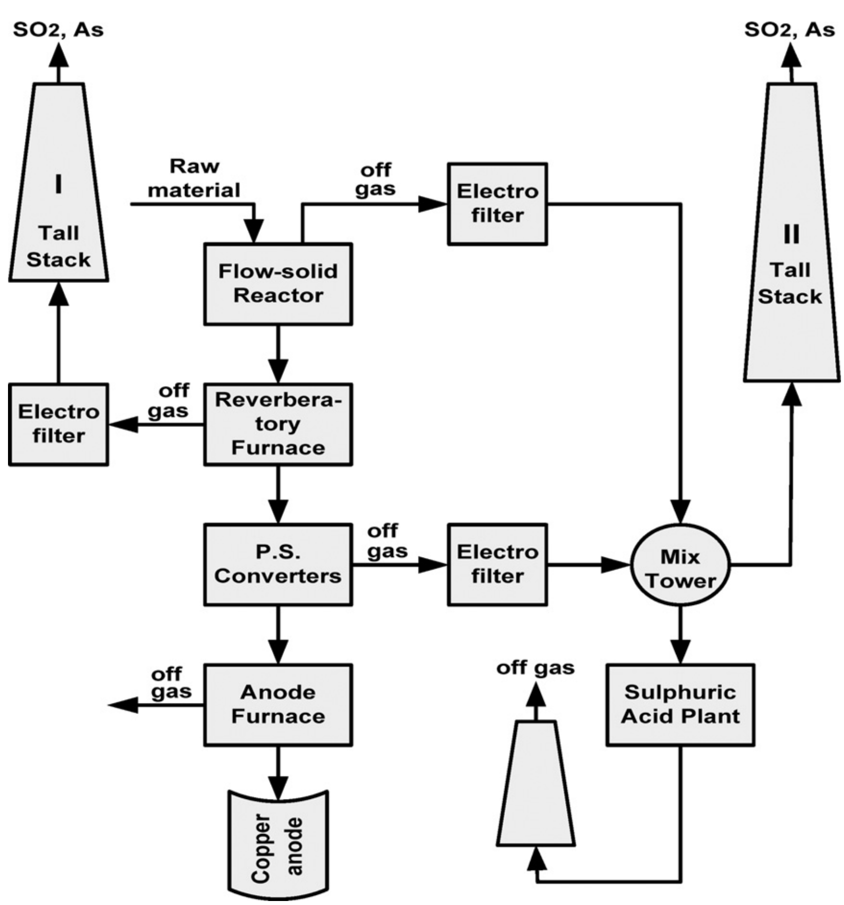

Fig. 6. Block scheme of the smelting process in Bor Smelter Factory.

to 1% SO_2) from reverberatory furnace through chimney (H 120 m, D 3.0 m) release into the atmosphere collecting the particle of dust which is not deposited in an electro-filter (Fig. 6).

Gaseous products from the processes of roasting and converting are collected in mix tower, refined and send to the Sulphuric Acid Plant or to stack 150 m high (D 3.5 m) if the Sulphuric Acid Plant is out of service or if the flow rate is higher than the maximum treatable in the plant. The Sulphuric Acid Plant does not work very often due to impossibility to sell sulphuric acid on the market and full capacities of the storage tank (max. 30,000 t H_2SO_4). As a consequence, this more concentrated SO_2 (about 5–6%), is emitted through tall stack II into the atmosphere. It could be seen from Table 1 that the emission of SO_2 from copper smelting process is too high. Additionally to the air pollution in Bor town and its nearly surrounding, it also could cause an international or transboundary dimension to the air pollution problem as winds reportedly carry emission to nearby Bulgaria and Romania and perhaps even further. The total emission of SO_2 from Bor Smelting Plant during 2007 was 370 t SO_2 per day, i.e. about 140,000 t per year, which corresponds to the average values from several years of 170–250,000 t [13]. In some modern Smelter Plant, for example Harjavalt copper smelter (Finland), during 2006 only 3300 t SO_2 were emitted toward the annual production of 160,000 t of copper anode [14]. One of the top 10 world pollutant is Mining and Metallurgical Company Norilsk Nickel (Russia). Their annual average atmospheric concentration of SO_2 in 2005–2006 was at the maximum allowable level of 500 $\mu g/m^3$ for populated area [15]. Knowing the value of 238 $\mu g/m^3$ for the annual average concentration of SO_2 in the most polluted part of the Bor town ("Town Park") it could be evaluated the dimension of air pollution in Bor town.

The Copper Smelting Plant did not stop working during 2007 and about 4000 t of anodic copper per month were produced. Difficulties associated with production of copper based on the concentrate refer to the fact that copper concentrate (domestic and imported) comprise the high content of sulphur (>30%), see Table 1. It could be mentioned that the technology of copper smelting which have been used in Bor town demand the concentrate rich in sulphur and pyrite. FeS_2 present in the copper concentrates is one of the heat sources into the autogenously smelting processes.

The Thermal Power Plant could be mentioned as one of the pollutant which emitted SO_2, smoke and dust as a result of coal combustion process (approximately 50,000 t) through its stack (H 100 m, D 3 m) during 6 months of working. The content of sulphur in used coal is approximately 1–3%. The location of the mentioned tall stacks related with the urban surrounding is shown in Fig. 7.

Nevertheless, the fact is that the Copper Smelting Plant is the major SO_2 source. The recovery of sulphur (about 60% in 2007) is very low if compared to modern copper smelting standards, which aim for over 95% recovery of sulphur. The emission of SO_2 depend of the amount of the content of refined copper concentrate as well as of the production in the Sulphuric Acid Plant where the part of waste gaseous product from Smelting Plant have been used for the production of H_2SO_4. As previously pointed out, the Sulphuric Acid Plant finds difficulties in operation due to the low market demand for H_2SO_4. Therefore, the flue gas from the converter furnaces and from the roasting furnace goes directly to the emission on stack II. Moreover, the average values of particulate content in the flue gas both from the smelting furnace and from the converters furnaces are high meaning that the electro filters do not work as they should. The efficiency of the removal of dust in electro filters was 61% on smelting streak and 80% on converting streak during the period associated with problems in working process in Sulphuric Acid Plant noticed in the third quartet of 2007. Instead, exhaust gases from the electrostatic precipitators of the converters and smelting furnaces contain higher values of particulate, as well as volatile

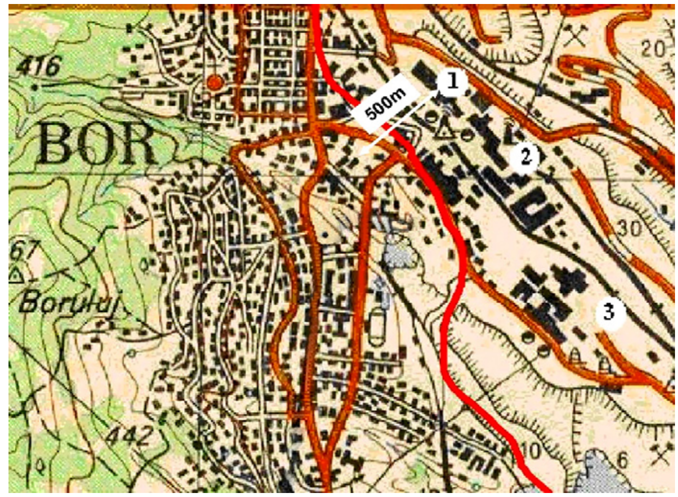

Fig. 7. Tall stacks locations from RTB Bor metallurgical complex: (1) tall stack H 120 m (Copper Smelting Plant), (2) tall stack H 150 m (Copper Smelting Plant), (3) tall stack H 100 m (Thermal Power Plant), a red line presents pseudo rim between urban and industrial zone.

metals such as As, Pb, Cd, Hg, Se and fluorides. In a modern smelter these would be removed in the gas washing and cooling section of the Sulphuric Acid Plant; at the Smelter and Refinery Plant Bor they are very often discharged to atmosphere [11,13].

Cu concentrates (imported/domestic ratio is 55-60/45-40) refined during 2007 beside the higher content of sulphur were comprised values for the content of As and Cd what is the serious problem for the Bor's citizen. Table 2 shows the annual average concentrations of heavy metals in airborne particulate matter collected from several measuring points in the town and its surroundings. The highest concentrations of As were reported at "Town Hospital", than at "Jugopetrol" and "Town Park", respectively. The higher concentrations of Cu were found at "Jugopetrol", "Town Hospital" and "Town Park". According to the average annual level the higher content of Cd was not reported. The real situation could be seen from Table 3 where the concentrations of Cd over the limit through months are bolded. It means that annual average values generate the real picture only of permanent air pollution. From the same table the extremely high values for the content of As measured in October and December at the "Town Hospital", "Town Park" and "Jugopetrol" are highlighted and underlined. The concentrations of As are so far above the limited value. Calculating to the annual level, at the three most polluted locations of the town, the concentrations of As were eight time above the limited values. Calculating to the monthly level, the highest measured concentrations of As were 20–30 times more above the limit. According to the data from Table 3 for the measured concentration of As through the month's graphic chart (Fig. 8) represent the real situation of the air pollution with As in Bor town. The content of As in air were measured in 21 towns in Europe, the highest concentration of 24.7 ng/m^3 was noticed in Verona, Italy in winter period [16]. Comparing with the value for the concentration of 193 ng/m^3 of As in Bor town noticed in December at the "Town Hospital", it could be seen that this value is about eight times higher. It could be concluded that Bor is one of the most polluted town in Europe in accordance to the data that 5.3–19.6 kg of As per citizen were emitted during past years [17].

Thermal Power and Heating Plant in the process of coal combustion emitted SO_2 and As. According to Matschullant [7] and Subramanian et al. [18] the average content of As in coal vary from 0.34 to 130 mg/kg and from 5 to 45 mg/kg respectively, assuming that half the As is volatilized during combustion. It could be the reason of the highest As concentrations during winter period.

Table 1
Base data for copper production in 2007

Month	Mass of treated concentrates (t)	%Cu in concentrate	%S in concentrate	Mass of produced anode (t)	SO_2 emission[a] (t/day)
January	18,429	19.54	31.89	3953.24	346
February	15,356	17.82	34.75	3231.58	346
March	20,900	22.61	32.31	5009.84	415
April	19,656	22.11	32.95	4806.56	360
May	12,306	19.77	33.93	3001.84	318
June	18,379	20.05	34.57	4073.34	339
July	18,533	18.97	31.90	4080.38	419
August	16,492	20.33	32.60	4037.42	499
September	14,387	20.16	33.48	3464.48	438
October	18,069	20.00	33.82	4165.28	432
November	17,293	18.67	32.81	3524.52	287
December	15,403	19.16	36.02	3421.38	284

[a] Mean daily values of SO_2 emission per months.

Table 2
Annual average concentrations of heavy metals in airborne particulate matter (PM_{10}) during 2007

Monitoring point	Number of sampled[a]	Pb (μg/m^3)	Cd (μg/m^3)	Cu (μg/m^3)	Ni (ng/m^3)	As (ng/m^3)
Hospital	9	0.2	0.006	0.4	–	59.3
Town Park	8	0.2	0.003	0.3	–	38.9
Jugopetrol	10	0.2	0.005	0.4	–	41.3
Copper Institute	10	0.01	0.003	0.2	–	15.5
Ostrelj	5	0.0	0.002	0.2	0.2	20.6
Krivelj	1	0.0	0.001	0.1	–	7.0
Brezonik	6	0.0	0.002	0.1	–	4.7
Slatina	2	0.2	0.007	0.2	–	5.3
Legislative limits		1.0	0.01	0.2	2.5	6.0

[a] Time of one sampled is 7–8 days.

According to the shown results, it could be noted that the citizen of Bor town were exposed to the high concentrations of SO_2 and As, and not so rare to the extremely high concentrations during 2007. Both have the negative effect to the whole human health, especially to the health of children and older person. The most pollutant parts of the town are shown in Fig. 9. It could be seen that 55% of populations were exposed by those pollutants almost everyday [19].

Table 3
Monthly average concentrations of arsenic and cadmium in particulate during 2007

Month	Hospital (ng/m^3)		Town Park (ng/m^3)		Jugopetrol (ng/m^3)		MM Institute (ng/m^3)	
	As	Cd	As	Cd	As	Cd	As	Cd
Jan	28.4	0.001	17.5	0.0	39.4	0.002	36.0	0.001
Feb	25.1	0.005	20.4	0.001	19.4	0.002	–	–
Mar	–	–	0.0	0.0	40.2	0.0	3.4	0.0
Apr	–	–	–	–	4.7	0.001	22.6	0.004
May	5.0	0.0	–	–	13.6	0.0	0.7	0.0
Jun	33.6	**0.012**	–	–	–	–	–	–
Jul	14.8	0.001	30.2	0.002	59.8	0.005	–	–
Aug	49.4	0.005	–	–	–	–	6.7	0.0
Sep	–	–	10.6	0.001	24.2	0.006	13.8	0.002
Oct	133	0.010	170.0	**0.014**	0.0	0.003	0.0	**0.015**
Nov	51.9	0.009	10.0	0.002	63.9	0.010	0.0	0.003
Dec	193.0	0.012	52.3	0.007	148.0	**0.018**	75.7	0.009

Health effects of SO_2 gas are irritation to the eyes and respiratory system, reduced pulmonary functions and aggravation to respiratory diseases such as asthma, chronic bronchitis and emphysema [20,21].

As is a toxic element for human health and is considered a carcinogen. The major hazard associated with inhalation of arsenic compounds is lung cancer. Risk assessments have been based on studies around US smelters. The data indicates a linear lifetime risk level v arsenic exposure. Because of this linear relationship the World Health Organization (WHO) published in 2001 the WHO 2nd edition of the Air Quality Guidelines for Europe indicating that

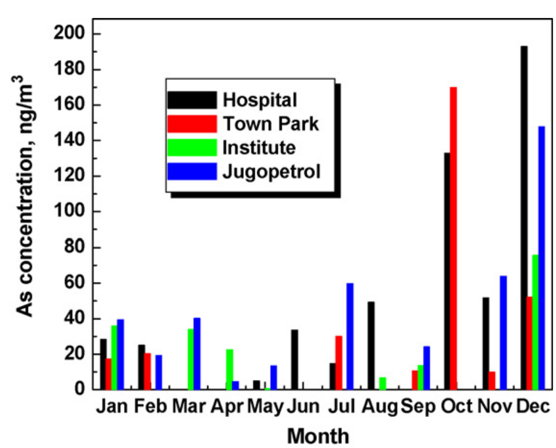

Fig. 8. Monthly average concentration of arsenic at four measured locations with the highest emission.

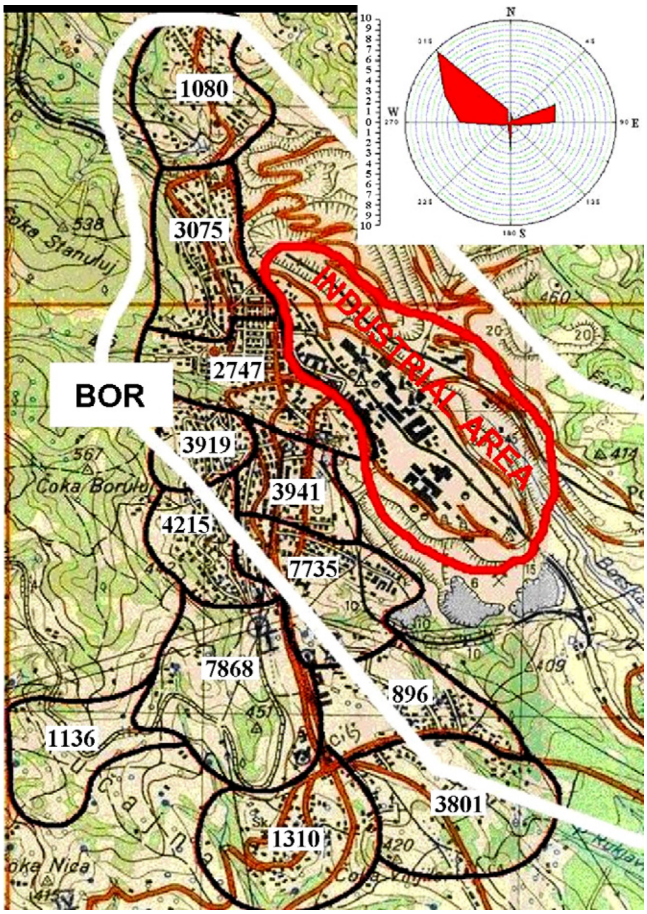

Fig. 9. Regions of the town most exposed by air pollutions (area limited by white line), digits with numbers of habitants per urban zone (black lines) and wind rose (approximately in 10 years).

a safe level for inhalation exposure cannot be recommended, but established a unit risk of 1.5 ng/m^3 [22–24].

Trasande and Thurston [25] cite the following effect of PM10 to the children population: enhanced allergen response; infant deaths, principally from respiratory illness, sudden infant death syndrome; leukemia and central nervous system tumours; lymphoma (especially Hodgkin's) incidence.

According to all results it could be elucidated the effect of pyrometallurgical production of copper to the air quality and to the humans health. During the 1970s the smelter was partially modernised with the construction of new roasting technology, oxygen enrichment of smelting and new emission control system. However, since than there has been minimal investment and the environmental performance is now far below the one expected in the modern smelters.

The technical study undertaken by SNC Lavalin confirms discharge of emission to air noncompliance with Serbian regulatory standards due to high concentrations of SO_2. In order to reduce environmental impact deriving from the smelter and gradually achieve environmental compliance of emitted flue gases, a modernisation plant for the smelter was prepared by SNC Lavalin. This modernisation plan would be developed through two main components: a first step would consist of improvement of the converter gas handling system and of the Acid Plant named K2 in order to enable the entire flue gases frothed converter to be treated together with the roaster plant. The second component would require replacement of the reverberate furnace with an electric smelting which would offer a relatively low cost alternative involving minimal change to current operations and satisfying Best Available Techniques criteria. The modernisation plan would also include refurbishment of Acid Plant named K3, currently out of operation, which would be available to treat wastewater effluents from the smelter characterized by high content of metals (including As) and acidic pH (namely the acid plant weak bleed and the refinery bleed liquor). Expected outcomes of the overall modernisation plan would therefore include operating rates up to 125,000 t copper fixation of SO_2 up to 90–95% and compliance of flue gases from the smelter with Serbian regulatory limits both with regard to SO_2 and dust. Total investment for the proposed modernisation plant is estimated to be about 63 million euros and timeline for implementation is about 2 years. The second option is replacing the old units with new ones constructed with modern technology. An indicative cost for this replacement is estimated by IMC Due Diligance study to be around 250–300 million euros [11].

4. Conclusion

According to the shown results it could be concluded that quality of ambient air in Bor was very poor during 2007. The citizen of Bor town was exposed to the high concentrations of SO_2 and As which were found to be multiple over the Serbian legislative limits. The most exposed part of the town was old town centre, "Town Hospital" and industrial zone where about 55% of populations live and work. It is a consequence of meteorology parameters, especially the periods without winds as well as the period with I-SI winds. Also, the reason could be bed chosen town location which is in the direct neighbourhood of Copper Mining and Smelting Complex (RTB Bor), as well as the old technology of copper concentrate smelting. Besides the everyday informing of citizens about air pollution in town and some action in the accident situation nothing were done. The solution for the lot of ecological problems is attached to the help of Government, European Union and adequate privatization of RTB Bor. The new owner ought to invest a notable means for building the modern Smelting Plant respecting the ecological standards of European Union, or to choose the other mode for the production of copper. The Bor's citizen will be the hostage of the present mode of the copper production at least 3–4 years in a best case. The pollution of air, soil and water through many years leads to the constant increase of the number of diseased, especially those with lungs cancer. Also, a number of invalids are notable.

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