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CONSEQUENCES OF ENVIRONMENTAL ISSUES ON SUSTAINABILITY OF METAL INDUSTRIES IN EUROPE: THE CASE STUDY OF BOR

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ABSTRACT

It is well known that the current environmental legislation put very stringent restrictions for the management of solid, liquid and gaseous wastes from industrial applications not only in Europe but also all over the world. It is also very well established through the years that the exploitation of the natural mineral resources (mining, ore processing and metallurgical activities) interacts negatively with the environment. Therefore, the development based on mineral wealth seems to be in contrast with the current environmental legislation worldwide. This paper gives an overview of European Union experiences towards sustainable development of metals industry sector.

Key words: Sustainable development, metal industries, copper metallurgy

INTRODUCTION

The World Summit on Sustainable Development in Johannesburg on 26/8/2002 – 4/9/2002 made clear that the concept of sustainable development underlines that long term efficient development, both for developed and developing countries, must be based upon three distinct pillars: environmental protection, economic development and social cohesion, both on national and global levels. These three distinct pillars are absolutely equivalent and combined actions have to be taken in order to increase simultaneously the levels of environmental protection, economic development and social cohesion in every country and in every geographical region.

A very good example for understanding the concept of sustainable development comprises the sector of metal industries all over the world. It is well known that the current environmental legislation put very stringent regulations for the management of solid, liquid and gaseous wastes from industrial applications worldwide. It is also very well established through the years that the exploitation of the natural mineral resources (coal, iron, non-ferrous metals, precious metals, industrial minerals etc) interacts negatively with the environment. Mines are very large scale digging activities on the earth surface or underground that are accompanied principally by the movement of million of tones of wasteful overburden material and million of tones of useful raw

material creating aesthetics pollution as well as chemical pollution to the environment. Chemical metallurgy is also associated with serious chemical pollution problems due to gaseous emissions in the atmosphere, wastewaters discharge to several natural receivers and solid wastes disposal. On the other hand, the development of every country all over the world is strongly dependent on the gross national product. An important part of it is always related to the exploitation of natural mineral resources constituting the mineral wealth of every country. So, the economic development and thus the related prosperity and social cohesion, the two pillars, in every country seem to follow a divergent way from the one of the environmental protection, the third pillar, which is determined with the current environmental legislation. In spite of this apparent contradiction, exploitation of natural mineral resources and environmental protection ought to follow a parallel way. That means that the exploitation of the natural mineral resources must be survived, because this is the wealth of every country, respecting the management rules providing by the environmental legislation. Although this sounds as a "philosophical scheme", in reality this constitutes the base for the sustainable development of mining and metallurgical industries all over the world.

This paper will give a short overview of metal industry in Europe. Especially, a more detailed overview of European copper industry is presented giving emphasis on the role of Balkan area. Additionally, this paper will demonstrate the way that European Union follows in order to face the problem of the balanced development among the three pillars of sustainability. At the end, this paper will take the chance of BOR industrial area in Serbia & Montenegro in order to make clear the existing interactions between exploitation of natural mineral resources and environment and to show the direction that the local industry has to follow in order to be survived in the era of European integration.

OVERVIEW OF METALS INDUSTRY IN EUROPE

The European Metals Industry has an economic and strategic importance greater than employment, capital and turnover statistics indicate. Nowadays in a globalized market, it is obvious that new poles have to be arisen and the old ones, like Europe, have to be stabilized and enforced in order for a global balance to be achieved. Moreover, the era of information society (computing, electronics, telecommunications and transport) is strongly dependent on metals industry more than ever. Therefore, it is first priority for the Europe to actuate the European Metals Industry towards sustainable development.

IRON & STEEL INDUSTRY

Iron & steel have played an important role from the beginning of the industrial revolution. A substantial change in the rate of world iron & steel production took place in the middle of the twentieth century where the production has grown exponentially reaching almost 800 million tones at the end of century. In the same period, Europe had lost steadily its share in the world iron & steel production having a production of 155 million tones at the end of century which is almost 20% of the world production [1]. Steel production in European Union is concentrated in the central Europe along to the well known coal belt. The number of employees in European steel industry decreases continuously and steadily from the beginning of 1990. This is attributed to the almost stabilized European production and to the introduction of new techniques and working practices (rationalization of steel industry) causing substantial increase in productivity. The globalization of the world economy and the market stagnation lead to a restructuring

of the European steel industry which is characterized by the developments of new concepts (e.g. mini electric still mills) and consolidation (e.g. new alliances, cooperative ventures). The environmental performance of iron & steel industry has improved substantially during the last two decades of the previous century. The most important and serious environmental problems are related with the air emissions (dust, heavy metals, organohalogen compounds, aromatic hydrocarbons, SO_2 and NO_x) and the management of solid wastes (residues, wastes and by-products). Air emissions are still remaining a serious issue not only in a European level but in a global one. Generally, the quantities of solid wastes from iron & steel industry are high enough. They are consisting of several types of dusts as well as slags. The normal practice is the recycling and reuse but still there are big amounts that are disposed of on landfills. So, there is potential for innovation in this field.

NON FERROUS METALS INDUSTRY

The total production of non Ferrous Metals industry in Europe is about 20 million tonnes per year of refined metals and semi-manufactured metallic products [2]. The total sales amount 40 – 45 billion euros per year and the profitability depends upon the current metals prices and a wide range of other economic factors. The number of employees in the European non Ferrous Metals industry is more than 200.000 people. The size of the European non Ferrous Metal industries varies from a few employing more than 5000 people and a large number having between 50 and 200 employees. The raw materials, ores, for metal production in Europe have been progressively depleted and thus, Europe is strongly dependent on imported concentrates from a variety of sources worldwide. The environmental performance and the energy efficiency of this industrial sector have been improved substantially over the last twenty five years since the adoption of Directive 84/360/EEC “on the control of pollution from industrial plants”.

EUROPEAN COPPER INDUSTRY

Copper has many important properties that made it a useful metal for many centuries. Among them the most important are its high electrical and thermal conductivities as well as its moderate corrosion resistance. Due to those properties copper has found many applications in a big variety of industrial sectors such as the electrical engineering, automobile, construction etc. In addition copper is a highly recyclable material having a closed loop-like life cycle. This means that normally a copper product at the end of its life cycle could be a good raw material for the production of pure copper or copper alloys and then for the production of new copper based materials.

The most important raw materials for the primary copper production are divided into two categories; the sulfide ores (chalcocite, covellite, chalcopyrite etc) and the oxidized ones (cuprite, tenorite, malachite etc). The world copper mine production expressed in million metric tones of Cu content for the first years of twenty first century [3] is shown in Figure 1. It is clear that there is an almost steady increase of world copper mine production from 12,8 to 14,9 million tones of Cu content in the period from the end of twentieth century till nowadays. Taking into account that the copper ore deposits in Europe are limited (the most important are found in Poland, Serbia & Montenegro, Portugal, Bulgaria, Sweden and Finland) [4], the % share of Europe on world mining production (Figure 2) is low and steady in between 6 and 7%.

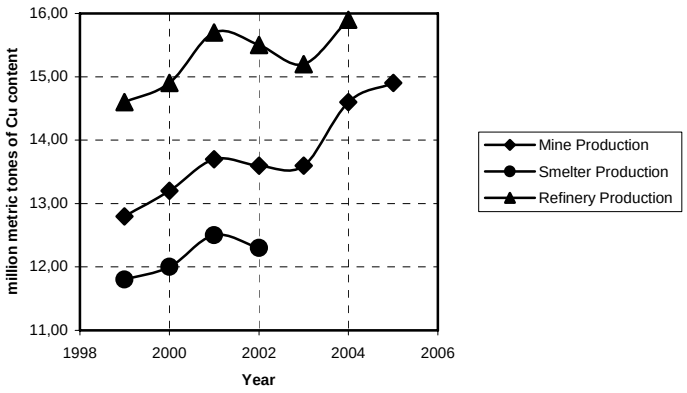

Fig. 1. World copper mine, smelter and refinery productions expressed in million metric tones of Cu content at the beginning of the new century.

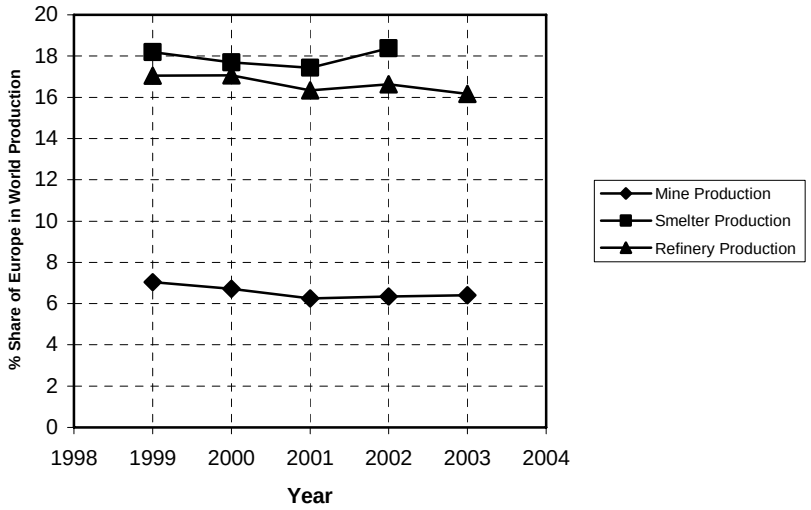

Fig. 2. % European share of world copper mine, smelter and refinery productions expressed in million metric tones of Cu content. For the estimation of given values, the EU member countries as well the Balkan countries including Turkey have taken into consideration. The European NIS countries have not taken into consideration.

In order for the Europe to satisfy the demand and keep open its copper metallurgical activities which are highly significant (Figure 2), Europe import raw materials from the international market in the form of concentrates, blister copper and anodes. As the availability of raw materials on the international market has been reduced because copper mining countries have developed their own smelter and refining facilities close to their mines in order to gain the added value on pure copper, European copper industry is dependent more on copper recycling from scrap. Indeed, almost the 50% of copper used in Europe is originated from secondary raw materials domestic or imported [2].

The role of Balkans in the European copper industry is shown in Figure 3. Almost 25% of the European mine production is coming from the Balkan area indicating the important role of Balkans as a copper raw material supplier of Europe. The % share of Balkans in European copper smelting and refining production is too low although is not insignificant. This indicates the different level of development between Europe and the Balkan area. European Industry is based on high added value products while the local Balkan industry is concentrated on the exploitation of raw materials giving less interest for their treatment in order to produce high added value products. This is better understood in Figure 4 where the absolute values of Balkan copper mine, smelter and refinery productions are given.

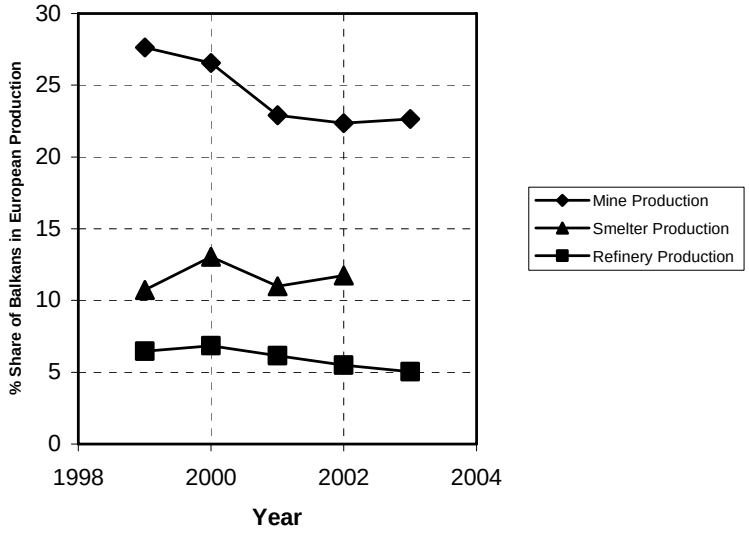

Fig. 3. % share of Balkans on European copper mine, smelter and refinery productions. For the estimation of given values, Turkey has taken into consideration as a Balkan country.

Indeed, mining and smelting productions are much higher than the refining production having also different trends with the former ones to be more or less stabilized and the latter one to show a steady decrease. A deeper look in the Balkan copper industry reveals that the most important raw material producers (Figure 5) are Bulgaria, Turkey, Serbia & Montenegro, Romania and FYROM. Bulgaria, Turkey, Romania and FYROM have an almost stabilized production while Serbia & Montenegro shows a continuous decrease. The higher smelting in relation to mine production that is shown in Figure 4, is attributed mainly to the very big increase in smelting production of Bulgaria as is seen in Figure 5. Bulgaria shows a steady increase of its refinery production in relation with the other countries that show a constant decrease. In spite of all of them, the refinery production in Bulgaria is very far from its smelting production.

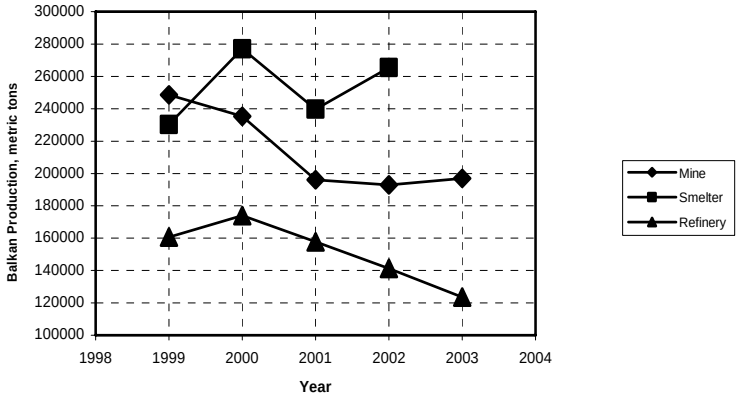

Fig. 4. Balkan copper mine, smelter and refinery productions at the beginning of the 21st century. For the estimation of given values, Turkey has taken into consideration as a Balkan country.

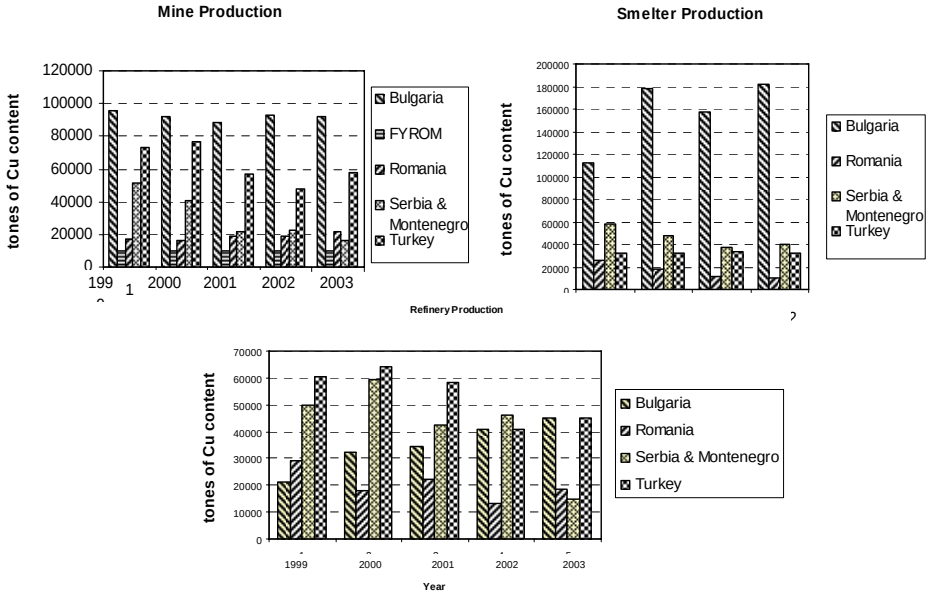

Fig. 5. Balkan copper mine, smelter and refinery productions per country.

The environmental performance of European copper industry is in a very good level. The most important environmental problem be encountered in primary copper production is the sulfur dioxide emissions to air. An effective solution of this problem is the fixation of the sulfur through the production of sulphuric acid or liquid sulfur dioxide which constitutes a common practice in European copper industry. Technologies for the treatment of wastewaters are well developed and the European copper industry has made considerable investments in order to be complied with the increasingly stringent environmental constraints.

SUSTAINABLE DEVELOPMENT IN EUROPE

Sustainable development can be realized as a successful combination of environmental protection, economic development and social cohesion in local and/or national levels [5]. The three distinct pillars of Sustainable Development are strongly interrelated and although in the past the environmental protection was of second priority parameter in designing industrial activities, nowadays it comprises the driving force.

The first Environmental legislation in European level concerning the solid wastes (Council Directive 75/442/EEC), the waste effluents and wastewaters (Council Directives 76/464/EEC and 80/68/EEC) and the air pollution (Council Directive 84/360/EEC) was inefficient [6]. The main characteristic of all the aforementioned legislative measures is the lack of flexibility, which often results from and contributes to a situation of distrust and confrontation between industry and environmental regulators. Environmental legislation that is referred generally to the industrial waste management includes specific measures prescribed by regulators regardless of whether they represent the best solution in particular circumstances. This inflexibility overcame by the 96/61/EC Council Directive concerning the Integrated Pollution Prevention and Control (IPPC Directive) [7].

The purpose of IPPC Directive is to achieve integrated prevention and control of pollution arising from highly polluting industrial activities (energy industries, production and processing of metals, mineral industry, chemical industry, waste management, etc.), leading to a high level of protection of the environment as a whole**. The Directive lays down measures for the prevention** or, where that is not practicable, the reduction of emissions in the air, water and land from the concerned industries, the generation and handling of process waste and the use of energy, taking in this way an integrated approach at the polluting and energy consuming potential of the industry. Fundamental to this approach is the general principle given in Article 3 of the Directive that operators should take all the appropriate preventative measures against environmental pollution, in practical through the application of Best Available Techniques (BAT) under economically and technically viable conditions, in order to achieve a high general level of protection of the environment as a whole. Thus, IPPC Directive sets a flexible and integrated framework for regulation for the most polluting industrial activities, including mining and metallurgical, aiming at providing the sustainable development of the concerned industrial activities.

The term “Best Available Techniques” (BAT) is defined in Article 2(11) of the IPPC Directive (96/61/EC) as “the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and their impact on the environment as a whole” [8]. Furthermore, Annex IV of the Directive contains a list of “considerations to be taken into account generally or in specific cases when determining the best available techniques bearing in mind the likely cost and benefits of a measure and the principles of precaution and prevention”. European Commission organised an exchange of information between Member States and the industries concerned on BAT and have published already the results in the well known as BREFs documents. In the case of mining and metallurgical activities, the BAT identified in the BREFs documents include techniques for resolving almost all environmental issues met within the relevant processes. A Best Available Technique

may be a way that a process is designed or operated, an operating procedure or an additional piece improving equipment. Although the choice of BAT in a plant generally depends on many factors, the implementation of a BAT is mainly influenced by the quality of raw materials used in the plant's production and the production process of the plant.

During the last twenty years, a significant improvement is noted in the environmental performance and energy efficiency of the mining and metallurgical industries in certain European Union Member States. A large number of BAT presented in BREFs documents are implemented on a large scale in a numerous of European mining and metallurgical plants. Thus, at the EU level, the European Commission is actively involved in promoting sustainability in mining and metallurgical industrial sectors while, these industrial sectors increasingly contributed in sustainable development by the successful implementation of BAT at operational level. In addition, mining and metallurgical industries recognise that sustainability may bring both short-term and long-term business benefits.

Nevertheless, during the same years important changes took place in Europe (European integration, expansion to the Balkans etc.) influencing the picture of European Union metals industry as concerns the idea of sustainable development. The new member countries, the associated countries and the future potential member countries ought to be developed rationally following the principles previously stated in EU. Political and economic stability as well as social cohesion and environmental protection are the prerequisites. Within this framework, the European mining and metallurgical industrial sectors have to address sustainability demands and afford them. Therefore, they have to develop a strategy that enables balancing of economic, environmental and social concerns through certain actions aimed their sustainable development.

THE CASE STUDY OF BOR COMPLEX IN SERBIA

Bor city is located in the eastern part of Serbia near the borders with Bulgaria and Romania. The city has a population of almost 40.000 people while almost another 25.000 people live in the geographical area of Bor. The main economic activity in the area is the mining and the metallurgical industries and about 15.000 inhabitants are working in these industrial activities. The industrial activities in this area started with the mining exploitation of copper ore in the beginning of the 20th century. Nowadays, the COPPER MINES AND SMELTING COMPLEX BOR involves all the copper industrial activities starting from the ore exploitation and mineral processing and ending to the metallurgical treatment of copper concentrates [9, 10]. The lay down of the copper industrial activities around the Bor city is shown in Figure 6.

The exploitation of copper ore is carried out with the underground mine which is the oldest one and is located near the exhausted open pit Bor mine as well as with two other open pit mines in Krivelj and Cerovo. The ore from the open pit mines is processed in the Krivelj flotation plant where the copper concentrate is produced. The flotation tailings which are by-products of the copper ore processing are transported directly by gravity to the krivelj flotation tailing ponds where they are disposed. The copper concentrate is transported directly to the metallurgical plant which is located at the border of the Bor city in order to be produced copper metal. The Krivelj flotation tailing ponds has been constructed in the natural valley of the krivelj river. The selection of this

area was based on geomorphological (naturally closed basin) and geographical (contiguity with the flotation plant and transportation by gravity) features. The current status of the flotation tailing ponds is shown in the figure 7. The valley has been divided in two fields by three constructed dams while the Krivelj river is flowing under the pond through a constructed network of pipes. The nature in Krivelj valley has been perturbed since 1982 when the flotation tailings pond was constructed and even more after its enlargement at 1990. About 1300 ha of soil have been degraded till now. The air, water and soil have been polluted in the area around the tailing dams. The ore from the underground mine is transported to the area of the metallurgical plant in BOR where the old flotation plant is located. The tailings from this flotation plant are disposed in an artificial lake nearby the metallurgical plant and the city of Bor as is shown in Figure 6.

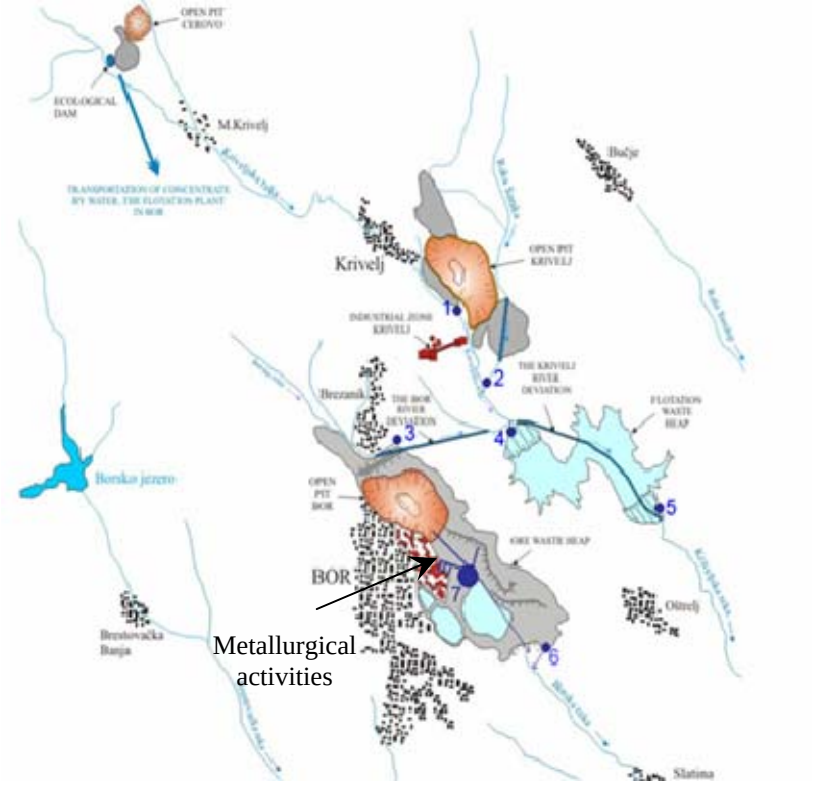

Fig. 6: Copper industrial activities in the greater area of Bor

The copper industrial activities in Bor have been characterized as an environmental hot spot in Serbia. Air, water and soil pollution are evident in the greater area of Bor. Air pollution is related mainly to the emissions of SO_2 that are originated from the copper smelter, the sulphuric acid plant, the thermal power plant and the copper and copper alloy foundry. The sulfur dioxide recovery during ore smelting is very low (20 – 30%) due to inefficient and old technology and thus a huge amount of SO_2 gas, 170000 – 250000 tons per year, are emitted into the atmosphere causing a serious risk for the human health. Dust emissions comprises an other threaten for the local society. They can reach to an amount of almost 1300 tons per years containing dangerous heavy metals like bismuth, copper, zinc etc.

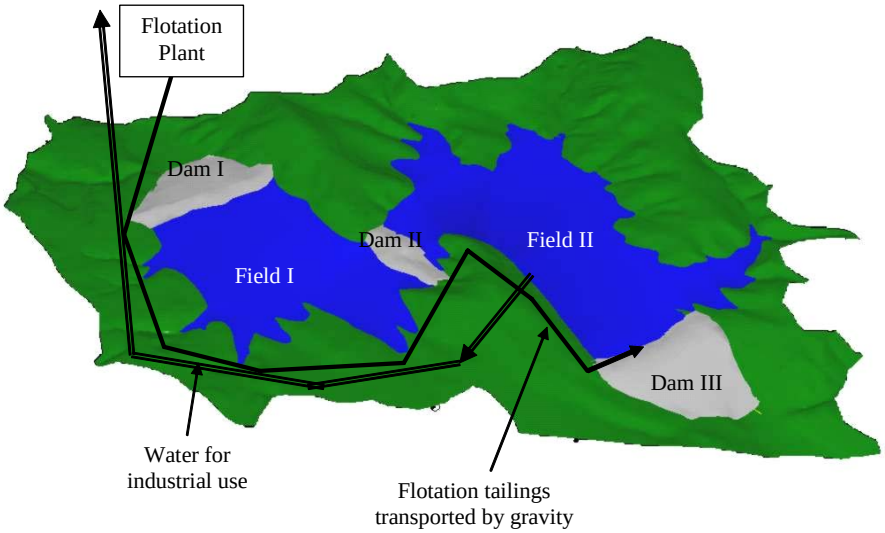

Fig. 7. The Flotation Tailings Pond in Veliki Krivelj.

The interaction between the copper industrial activities in the greater area of Bor and the natural water resources are presented in Figure 8. Seven different wastewater sources are presented in this schematic diagram originated from the mining activities, the tailing ponds, and the metallurgical activities. The wastewaters enter directly without treatment to the natural water streams of rivers Krivelj and Bor and through them to the river Timok and finally to the Danube river creating a very serious environmental problem. Almost 1285ton of iron, 502ton of copper, 1.5ton of nickel, 0.5ton of arsenic, 52ton of zinc, 2ton of lead, 300Kg of cadmium and 61ton of manganese are discharged annually in the above network of regional and international rivers.

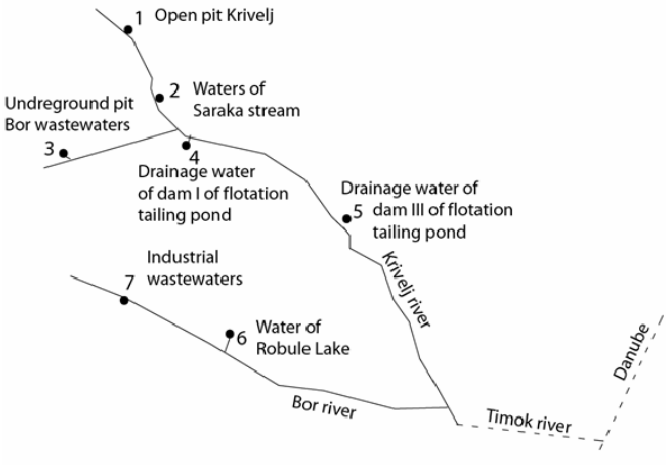

Fig. 8. Sources of natural water resources contamination

The area around the tailing dams suffers from very serious environmental degradation which is related to a) high dust concentrations in the air causing dust transportation through winds in the neighboring area and thus degradation of the soil and b) water, air and soil pollution with heavy and toxic metals such as copper, zinc, arsenic, lead etc. Another very important environmental threaten consists the possible failure of the Krivelj river collector which has obvious damages that ought to be repaired immediately. In case of the flotation dams failure, toxic leakages to the Bor river and then to the Danube river would be unavoidable causing enormous environmental consequences comparing with the ones in Spain (Aznalcollar, 1998) and Romania (Baia Mare, 2000).

It is obvious that the copper industrial activities in the Bor region are unsustainable. The three distinct pillars of Sustainable Development, environmental protection, economic development and social cohesion have to be put in a first priority strategic plan that has to be implemented immediately. Concerning the two pillars, the economic development and the social cohesion, politicians, governmental and social authorities have the responsibility to prepare this strategic plan. Scientists and especially engineers have the responsibility to prepare a reasonable strategic plan concerning the third pillar, the environmental protection. Toward this direction, there are not “magic” solutions but only reasonable solutions. The “Best Available Techniques” (BATs) can offer an efficient framework in order to be chosen the most appropriate technologies and their methods of operation that are suitable for the Bor case keeping always in mind the cost and benefits arising from their adoption. This is something that could be implemented in a short period of time and could change the picture that the copper industrial activities have in local, national and European level.

CONCLUSION

Although the European metal industry was strong in the past, nowadays has lost a part of its strength in a global basis. The depletion of raw materials in the traditionally leading European countries in relation with some inefficient decisions made in the past could probably explain this trend. On the other hand, there are European countries like those ones in the Balkan Peninsula that have substantial unexploited or unsustainable developed mineral wealth. Those countries ought to start systematic exploitation of mineral wealth or to restructure the existing unsustainable industrial activities based on the principles of sustainable development so that to fulfil the expectations of their people that simply are economical development and social cohesion. Towards this direction the European Union experiences with the IPPC directive and the BATs look like a good and efficient tool.

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