

Geographical Consequences of the Surface Exploitation of Coal on the Area of Tuzla Basin (Bosnia and Herzegovina)

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Abstract

The paper analyses, from a geographical aspect, consequences of the surface exploitation of coal on the area of Tuzla basin, and offers the comparison of the results achieved in the revitalization of exposed territories with some examples (the Rhine basin, Lusatia region etc).

The surface exploitation of coal caused significant geomorphological and anthropogenic changes on the area of the Tuzla basin. They can be noticed particularly in the change of scenery by the creation of landforms (open pits, slag heaps etc). Coal surface exploitation also includes the relocation of water flows, destruction of drinking water springs, soil and vegetation degradation, air pollution above the exploitation areas and in their surroundings, etc. Anthropogenic changes can be seen primarily in the relocation of settlements or parts of them, depopulation, relocation of roads, etc. For example, coal surface exploitation in the Tuzla basin so far resulted in the following: 785 million m³ of waste material, 150 million tons of coal, 4400 ha of degraded land, 20 relocated villages or parts of them, 20 new anthropogenic lakes etc.

The Law on Mining of the Federal Republic of Bosnia and Herzegovina and the Statute on long-term programs and mining projects (which broadly covers the exploitation of mineral resources and the environment protection) have obliged coalmines to re-cultivate the degraded surface. According to these legal regulations the re-cultivation of the degraded soil on the territory of the Tuzla basin started at the end of 1970s and so far around 800 ha have been re-cultivated.

Key words: surface exploitation of coal, geographical consequences, physical-geographical and anthropogenic changes, Tuzla basin.

Introduction

The coal exploitation on the territory of today's Tuzla basin has lasted from the Austro-Hungarian period onwards. The underground mining gradually became unprofitable and the production in these mines was constantly decreasing. That was the reason why many mines with underground exploitation were closed. The main reasons for that were increasingly unfavorable mining and geological conditions of the exploitation due to the position of the carboniferous layers at increasing depth. This initiated the surface exploitation of coal in the Tuzla basin. This type of coal exploitation started in 1946 in Banovići and

Đurđevik basins and in 1967 in the Kreka basin. The exploitation in these basins was organized on several dozens of open pits. Today, exploitation is organized on open pits "Šikulje" and "Dubrave" (Kreka basin), "Potočari" and "Višća" (Đurđevik basin) and "Grivice", "Turija", and "Čubrić" (Banovići basin). For comparison, at the beginning of the 1990s there were between 50 and 60 open pits in Scotland, England and Wales and only a few of them are still open (Hughes, Clarke, 2002). Since 1950, in the Rhine carboniferous basin the number of open pits has decreased from 22 to 5, while, in the same period, coal production has been increased by 100 percent (Goedecke, 1978). The above mentioned mining investment projects

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have generated immense changes on the territory of the Tuzla basin in both: scenery and the relocation of settlements and parts of them. That caused the depopulation of rural areas affected by surface exploitation since their inhabitants mainly moved to urban areas of closest municipalities or near them. This is also one of the main factors which influenced the structural changes of population in Tuzla, Lukavac, Živinice and Banovići. Ever since the beginning of surface exploitation, these urban areas have become larger in terms of their territories and their population. Besides these effects of the coal surface exploitation on the geographical environment, which are of the primary importance in this case, there are also indirect effects which endanger geographical environment such as coal separation and combustion. During the combustion of this energy source, the power plant *Tuzla* emits a large quantity of harmful pollutants which significantly pollute the environment and whose consequences have been evident for more than 40 years. For example, the negative effects of coal exploitation in Poland are particularly evident in the region of the Upper Silesia Coal Basin where coal has been intensively exploited for 160 years (Rybicka, Rybicki, 2002). At the end of 1970s the re-cultivation of the degraded soil was started in the Tuzla basin mainly by seeding grass; in the mid 1990s the agricultural production started. The author of the paper mainly used the method of analysis and synthesis, statistical, comparative and cartographic methods and field research.

Geographical position and borderlines of the investigated area

The Tuzla basin lies in the north-east of Bosnia between the Pannonian plain in the north and the Dinarides in the south. This basin lies between 44°18' N (Konjuh) and 44°33' N (Banj Brdo) and between 18°06' E (at the mouth of the river Spreča into the river Bosnia) and 19°03' E (Velja glava). The basin has an irregular shape, the longer axis goes in the south-east - north-west direction and is 83.6 km long, while the shorter axis goes in the south-west - north-east direction and is 42.6 km long. Geomorphologically, this basin is situated in the inner Dinarides among the mountains Trebavac (692 m) in the north-west, Ozren (918 m) in the west, Konjuh (1327 m) and Javornik (1019 m) in the south and south-east and Majejica (915 m) in the north and north-east (Figure 1). In its entirety, the basin belongs to the Spreča river basin, which includes the area of 1947.7 km² or 3.81% of the territory of Bosnia and Herzegovina. The economic, administrative, education and cultural center of this basin is Tuzla which is situated at the crossroad of regional and international roads. By standard railways in the Bosnia valley Tuzla is connected via Doboj, while the railway Banovići-Tuzla-Brčko connects it to Croatia and Serbia. The Tuzla basin is known for its wealthy natural resources, especially from salt and coal deposits. Economically important coal deposits on the territory of the Tuzla basin emerged in the Neogene (pit coal mainly in the lower and mid Pliocene - 10 to 15 million years old and lig-

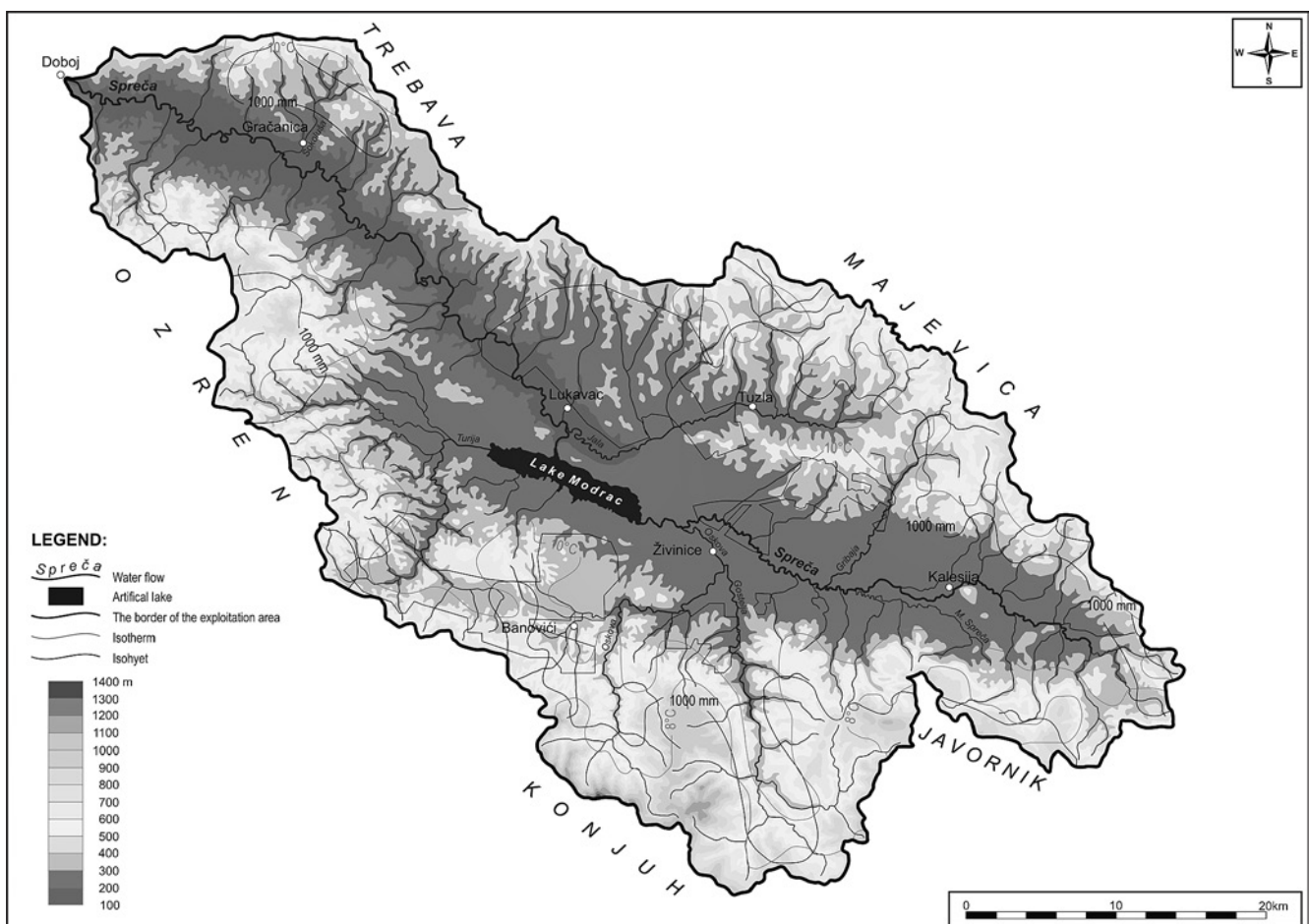


Figure 1 A physical-geographical position of the Tuzla basin

nite in the upper Miocene and the lower Pliocene - 5 to 8 million years old). In the southern part of the Tuzla basin, there are significant reserves of coal in the fresh water-lake basins of Seona, Banovići and Đurđevik. The deposits in these basins are in the range of 100 m in Seona, 400 m in Đurđevik to over 700 m in Banovići. Kreka lignite is from the lower Pliocene period. During the lower Pliocene the basin was connected to the open sea in the north through a tectonic channel which is now a course for the river Tinja. By its raising, the mountain Majeвица formed a natural dam in the Tinja channel. In that way, the Kreka bay was turned into a shallow lake and later into a peat land and swamp forest. During the lower Pliocene, the link in the Tinja channel was broken at least four times. Thus four coal layers were formed in the Kreka basin (Isaković, 2003). The Tuzla basin is mostly leveled, mildly wavy and hilly up to 500 m above sea level (Topographical map 1982). This hypsometric range includes 1533.77 km² or 78.75% of the territory of the Tuzla basin, and the largest part of that basin is between 200 to 400 m above sea level (1100.3 km² or 56.5%) (Smajić, 2007). Open pits in the Tuzla basin are mainly up to 500 m above sea level.

The consequences of the surface exploitation of coal in the Tuzla basin

Total geological reserves of coal in the Tuzla basin are around 1,399 billion tons. They are exploited mainly on the open pits (about 80 percent) and mostly combusted at the local power plants. The surface exploitation of coal on the territory of the Tuzla basin has generated extreme changes

in the scenery as well as in the relocation of settlements and their parts (Figure 2). Due to the surface exploitation of coal in the Kreka basin (200 square kilometers) the following settlements have been relocated: Prline, Lukići, Potočari, Perušići, Salkičići, Milići and Perići. The relocation in the Banovići basin (35 square kilometers) included the settlements Podgorje, Grivice, Avdići, Mekići, Banovići Selo and others. In the area of the Đurđevik basin (13 km²) some settlements have been relocated while others have completely vanished: Odžak, Havići, Galovići, Lug, Kažalj and Sakići. Besides these, settlements were partially relocated: Salkići, Požar, Kupjerusi, Husinovići and Panjik (Figure 3). The inhabitants of these villages have mainly moved to suburban parts of Živinice: Litva, Ciljuge, Sjever, Šarenjak and others. A large number of them moved to Đurđevik along the main road Sarajevo-Olovo-Kladanj-Živinice-Tuzla. That is the reason why one can notice an intensive suburbanization process in this part of Živinice municipality.

Very frequently, the activation of the open pits required a complete or partial relocation of local water flows. Therefore, in the area of Šikulje, the flow of the river Spreča was relocated (5 km in length), the flow of Šikuljačka rijeka also (1.5 km in length) as well as the railroad (5.5 km in length) (Kulenović, 1991). There were some requirements for the coal exploitation at the open pit Lukavačka Rijeka: a tunnel was used to lead the water flow of Lukavčić into Smolučka rijeka, and a part of the flow of Lukavački potok has also been relocated. Its new water basin is situated further west compared to the previous one. In Višća the following items were relocated: the water flow of Oskova and a part of the railroad as well as the regional road (1.4 km in length), while



Figure 2 A detail representing the open pit Grivice (Banovići basin); Author: S. Smajić, October, 2006

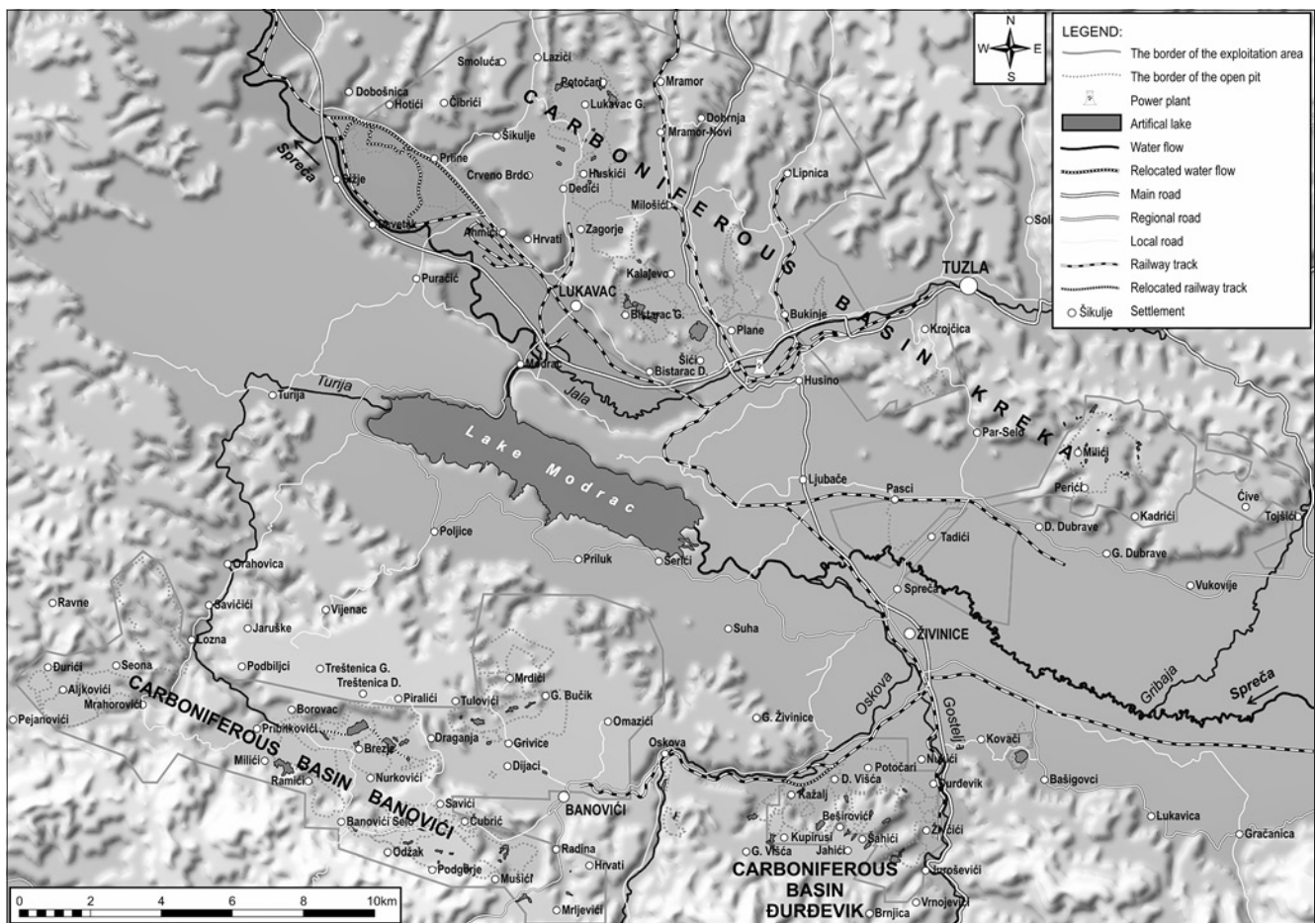


Figure 3 The placement of open pits on the territory of Tuzla basin

a considerable number of smaller water flows was cut and disorganized by open pits (Brestovica, Brnjica, Meminovac and others). Similar, but more extensive changes happened in the Rhine carboniferous basin in Germany, where 24000 people who lived in 55 settlements were moved to a new location. The roads, railways and rivers were also relocated and moved 7 km from the working area of the coalmine to its outer deposit place (Goedecke, 1978).

In the period from 1946 to 2007 the surface exploitation of coal in the Tuzla basin resulted in the production of approximately 49.4 million tons of lignite and 98.6 million tons of coal with more than 785.2 million m³ of waste material. The production in the basins is as follows: in the Kreka basin 49.4 million tons of lignite, in Banovići 68.3 million and in Đurđevik 30.3 million tons of coal. During that period the data for the removed waste material are: in the Kreka basin 213 million m³, in Banovići 371.5 million m³ and 200.7 million m³ in the Đurđevik basin. In the period 1992-1995 the production of coal in the Tuzla basin as well as in the entire Bosnia and Herzegovina was considerably reduced, and after the Dayton Peace Agreement was signed it was slightly increased. Bosnia and Herzegovina belongs to the group of eleven countries which are the most important producers of lignite in Central and Eastern Europe. Its yearly production is around 8 million tons, with 56 percent share of lignite in a total production of energy (Drebenstedt, 2002). In 2007, around 10 million tons of coal was produced in Bosnia and Herzegovina (that is 54 percent of the pre-war production), out of

which 3.3 million tons by surface exploitation on the area of the Tuzla basin.

Surface exploitation destroys large areas of land since coal is under the roof materials which can be several dozen meters deep. The production of one ton of coal requires digging, transporting and depositing to a better location an average of 5.14 m³ of soil (open pit Dubrave), 6.6 m³ at the open pit Višća up to 8.6 m³ (open pit Čubrić). Large areas in the Tuzla basin have been turned into deposit places whose landscape significantly differs from its original (including physical, geological and chemical features). For example, coal waste from the open pit Dubrave is deposited to an outer deposit point "West", which is located in the Spreča field, in the south-west from this open pit. The projected capacity of this deposit place is 396.26 ha, and so far, 28 million m³ (or 25 percent) of the planned soil has been placed. The depositing started at 224 m above sea level and now it is 249 m above sea level. This caused the degradation of 170.9 ha of mainly alluvial carbonated sand soil and brown (meadow) non-carbonated soil with some ash-colored barren pseudogley valley and terraced soil (Smajić, 2007). The waste material on many deposit places in this region includes carbonated and sulfur soil which contains large quantities of sulfide, pyrite and other harmful solids which oxidize when they are in contact with oxygen. This process leads to the mobilization of free base minerals, large quantities of sulfate and bivalent iron, which then causes extremely substandard environment conditions of soil. They are characterized by low pH value, high electric conductivity and increased proportion of heavy metals

Table 1 Degraded soil in the Tuzla basin

Basin	Soil types	ha	%
Basin Kreka	Ash-colored barren pseudogley terraced soils	195.7	8.6
	Yellow-brown soils on sandstone	380.6	16.7
	Alluvial carbonated sandy soil on sand	183.3	8.0
	Brown degraded soil on clay	384.9	16.9
	Brown ash-colored soil on clay	69.0	3.0
	Alluvial non-carbonated sandy soil	66.5	2.9
	Lythochromathogenous red soil on clay	151.7	6.7
	Brown noncarbonated soil on clay	24.0	1.1
	Ash-colored barren pseudogley slope soil	106.2	4.7
	Grey-brown deep marsh soil	3.2	0.1
	Brown non-carbonated soil	65.5	2.9
	Mineral-marsh clay non-carbonated soil	28.0	1.2
	Brown degraded clay soil	86.5	3.8
	Brown non-carbonated clay soil	79.8	3.5
	Brown carbonated soil	136.9	6.0
	Ash-colored barren pseudogley valley soil	89.7	3.9
	Yellow-brown soils on sand	230.0	10.1
Total	2281.4	100.0	
Basin Đurđevik	Ash-colored barren pseudogley slope soil	70.4	8.9
	Brown acidic soil on sandstone	78.5	9.9
	Leaf mold silicate soil (rankers) on serpentine rocks	2.1	0.3
	Brown shallow or medium deep soil on serpentine rocks	6.5	0.8
	Ash-colored barren pseudogley terraced soil	635.3	80.1
	Total	792.8	100.0
Basin Banovići	Humic Cambisols	255.4	19.2
	Calcic Vertisols	1074.3	80.8
	Total	1329.7	100.0

and aluminum. Such geological and chemical structure of soil has an extremely negative influence on the quality of water and plant growth.

Over 20 thousand ha of land has been degraded by surface exploitation in Bosnia and Herzegovina. Only 5 percent of that land has been reclaimed (Ibreljić, Kulenović 2005). Surface exploitation of coal in the Tuzla basin has so far degraded over 4400 ha of land: around 2281 ha in the Kreka basin, around 1330 ha in the Banovići basin and around 793 ha in the Đurđevik basin. For comparison, until 1980s, the Rhine lignite mining industry took and used around 175 km² of land and around 120 km² of the degraded land was recultivated. About 60 km² was used for agriculture and the rest was afforested (Goedecke, 1978). In the Kreka basin the degraded types of soil mainly include: yellow-brown soils on sandstone and on sand (610.61 ha or 26.76%), brown degraded soil on clay (384.91 ha or 16.87%), ash-colored barren pseudogley terraced soils (195.72 ha or 8.6%), alluvial carbonated sandy soil on sand (183.26 ha or 8.03 %) etc. The surface exploitation of coal in the Đurđevik basin degraded mainly ash-colored barren pseudogley terraced soil (635.3 ha or 80.1%), and in the Banovići basin Calcic Vertisols (1074.3 ha or 80.8 %) (Table 1).

The surface exploitation caused the development of lakes: seven lakes with the total area of approximately 37 ha in the Kreka basin, four lakes (22.5 ha) in Banovići and eight lakes (14.7 ha) in Đurđevik. On the territory of the Southern Kreka sinclorium the lake *Zmajevac* appeared, with the surface of 1.15 ha and 334 m above sea level. This lake appeared after the waste material from the open pit *Dubrave* filled the flow of the river *Zmajevac*. The lake is 264 m long, 70 m wide and 30 m deep. The lake *Suhodanjsko* has a larger surface (2.58 ha) but its depth is smaller (5.5 m). This lake is 315.7 m above sea level, it is 512 m long and the mean width is 86 m. The water surface of the lake *Mušičko* (at the open pit *Čubrić* in the Banovići basin) is at 357 m above sea level. The border slope, 420 m long, of the west deposit place is immediately above it. The largest anthropogenic lake in the Đurđevik basin is *Ćenda*, whose surface is 5.12 ha. This lake is at 269.2 m above sea level and it is located among *Ćenda* hamlet in the south, *Jahići* hamlet in the east, *Beširevići* hamlet in the north and the deposit place of the closed open pit "Višća I" in the west, which is 330 m above sea level (Figure 4). These lakes have existed at these open pits for a long period of time and they even formed their own water regime (Smajić, 2007). There are many lakes in



Figure 4 Anthropogenic Lake Ćenda (Đurđevik basin); Author: S. Smajić, September, 2007

the Rhine basin, which all give exquisite charm to the re-cultivated land. Some of the largest lakes cover the area up to 70 ha (Goedecke, 1978).

The surface exploitation of coal in the area of the Tuzla basin degraded 4417.24 ha of forest vegetation (The map of actual forest vegetation of R BiH, 1980). In the Kreka basin, 2281.41 ha of plant cover were degraded: beech forest (51.25 ha or 2.25%), oak and Turkey oak forest (4.10 ha or 0.18%), oak and hornbeam forest (979.04 ha or 42.91%), while agricultural land, settlements, bare countryside and other elements cover 1247.02 ha or 54.65%). The exploitation of coal in the Đurđevik basin caused the degradation of 792.76 ha of plant cover: common oak and hornbeam forest (13.24 ha or 1.67%), oak and hornbeam forest (82.84 ha or 10.45%) while the agricultural land, settlements, bare countryside and other elements cover 696.68 ha or 87.88 %). In the Banovići basin the surface exploitation caused the degradation of 1343.07 ha of plant cover: beech forest (175.20 ha or 13.05%), beech and fir forest (140.30 ha or 10.45%), common oak and hornbeam forest (526.23 ha or 39.18%), while the agricultural land, settlements, bare countryside and other elements cover 501.33 ha or 37.33% of the territory (Smajić, 2007). The data clearly show that, in the Tuzla basin, agricultural land, settlements and bare countryside were mostly degraded in the Kreka basin, significantly less in Đurđevik and the least in the Banovići basin.

More than 90 percent of the coal from the open pits of the Tuzla basin is transported to the power plant *Tuzla* where it is combusted. The Kreka lignite has an average of 38.7% moist, 13.06% ash, 0.61% sulfur, etc. Lignite combustion results in large quantities of slag, which

presents a mechanical issue to the environment and poses a problem for its transport, deposition, water protection and soil cover. The Đurđevik coal has 9.42% moist, 25.77% ash, 2.30% sulfur, etc. A higher percentage of sulfur causes problems during combustion. Aggressive sulfur and nitrogen compounds, which appear during combustion, cause corrosion and degeneration of materials in contact, while the gases pollute the environment. During the processing of this energy source the plant emits harmful gases, mainly sulfur dioxide, nitrogen dioxide, carbon monoxide and dust. During coal combustion at the power plant *Tuzla*, the plant emits large quantities of pollutants which, with weak wind (1.6 m/s) and temperature inversion, decrease the environmental quality. The power plant *Tuzla* is situated west from the city center, which is a serious problem, since the western wind frequency on this territory is on the third place (9.1 percent). The Tuzla basin has an average of 75.5 foggy days a year (Smajić, Ahmetbegović, 2008). The average yearly concentration of sulfur dioxide in the air is in the range of 52.5 $\mu\text{g}/\text{m}^3$ registered in 2004 and 17.3 $\mu\text{g}/\text{m}^3$ in 2006. The average yearly concentration of nitrogen dioxide was 12.4 $\mu\text{g}/\text{m}^3$ and 50.5 $\mu\text{g}/\text{m}^3$ of dust. The average yearly concentration of carbon monoxide in the air was 885.8 $\mu\text{g}/\text{m}^3$ in 2004 and 223.7 $\mu\text{g}/\text{m}^3$ in 2006 (Kulenović et al., 2007). In the period 1963-2006 over 100 million tons of coal was combusted and over 100 billion of KWh of electricity was produced. This resulted in the dumping of approximately 25 million tons of slag and ash (over 40 million m^3) and 250 million m^3 of technological water used in the transport of slag and ash to the dump-site. Similar problems are evident in cen-



Figure 5 Agriculture production on the recultivated soil (Kreka basin); Author: S. Smajić, August, 2007

tral Europe, in the so called “The Black Triangle” region among the Czech Republic, Poland and Germany where ten power plants combust around 80 million tons of lignite and thus emit around 3 million tons of sulfur dioxide and around one million tons of nitrogen oxide (Manczyk, 1999). This means that this region participates with 30 % in the total emission of sulfur dioxide in Europe. Every day, about 20 thousand m³ of waste water are released from the coalmines (screening) into the river Spreča. Coal dust and other suspended materials, caused by the erosion of open pits dump-sites, fill the bed of the river Spreča and its tributaries. That causes frequent floodings in their inundated areas.

The dumping of slag and ash from the power plant *Tuzla* on the dump-sites near the city of Tuzla has so far caused the degradation of approximately 149 ha of land: brown degraded soil on clay (126.09 ha or 84.78 %), yellow-brown soil on sandstone (6.45 ha or 4.34 %), yellow-brown soil on sand (5.85 ha or 3.95 %) etc (The Map of Soil, 1969). There is some available space for slag dumping on the dump-site “Divkovići I”; while the dump-sites “Jezero I” and “Drežnik” have been used up to the projected elevation and they cannot be used for dumping slag and ash. As a comparison the Electric-power industry of Serbia possesses around 1200 ha of dump-sites for ash, on which they dispose around 6.5 million tons of ash per year (Čanak-Nedić, 2007). The planned yearly consumption of coal in the *Tuzla* power plant in the period 2006-2020 will be approximately 4 million tons, while the production of slag and ash will be 991 thousand tons per year (Ibreljić, et al., 2007).

The activities related to the re-cultivation of degraded soil at the open pits in the Tuzla basin started in the 1980s. So far the re-cultivated area covers 470 ha in the Kreka basin, 75 ha in the Đurđevik basin and 300 ha in the Banovići basin (Smajić, 2007). In the USA, for example, up to the mid 1970s, the re-cultivation covered around 250 thousand ha of land and another 250 thousand was included in the so called self-reclamation. The largest part of the reclaimed land is covered with forest and pasture ground while “agricultural” re-cultivation is intensively applied. Around 50 thousand ha of land degraded by open pits were re-cultivated by the end of the 1970s in Great Britain and around 60 thousand ha were re-cultivated by the beginning of the 1980s in Germany (Knežiček, et al., 2006). Economically useful cultures were used in the direct biological re-cultivation in the Tuzla basin. With the appropriate fertilizers these cultures had a pioneer role. The re-cultivated land of the open pits usually includes a mixture of Alfalfa and grass, on the plane ground and mild slopes there are fruit cultures (plum, walnut, apple, pear, etc) while pine-trees and locust are on steep slopes and unstable terrain. Autochthonous species and sorts have been chosen and they are adapted to this climate. Clover (Alfalfa, *Lotus corniculatus* and *Melilot*) has a deep root and it bonds the substratum and fitomelioration in the deeper layers. Spike grasses (*Dactylis glomerata*, turflin and French ryegrass) have a shallow root and they bond surface layers of soil. In the German region of Lusatia, systematic re-cultivation of land started in 1920s mainly with seedlings of oak-tree, pine-tree and other species of trees which all improve the biochemical structure of soil. In the period from 1960 to 1975

oaks, pines and other species were planted on 8600 ha of land while in the period 1970-1990 pine-trees were planted on 7700 ha (Häge, 1996). After 1970s planting trees decreased and it was mainly changed by agricultural re-cultivation. The results of four-year measurements of hay yield (alfalfa and grass compound) on the re-cultivated land in the Kreka basin showed that the yield from the 16% slope terrain is 8516 kg/ha, while the yield on the plane ground is 9464 kg/ha (Knežiček, et al., 2006).

According to the data issued by the Central Bureau of Statistics of the Federation of BiH, average hay yield (alfalfa and grass compound) on natural land in the municipality of Lukavac in the same period was 3670 kg/ha. That means that in the same period yields from the slopes of the re-cultivated terrain were 2.3 times higher, and from the plane ground 2.6 times higher than from the natural land. When it comes to the aspect of the quality of re-cultivated land very good results were achieved in Great Britain, where the level of re-cultivation was brought to the standard used for nature parks, and in Germany, which has good results in agricultural re-cultivation. Out of 29.672 ha of the used terrain, 19.514 ha were re-cultivated until 1984 (8.417 ha/43% were returned to agriculture, 7.841 ha/40% were returned to forestry, 1.899 ha/9% to water flows, 1.423 ha/8% to traffic, enlarging settlements and other purposes). It is predicted that in the north part of the Rhine basin, almost 80% of the used land would be re-cultivated into agricultural land. Nowadays, open pits for the exploitation of lignite in the Rhine region cover 30 to 50 km². In the Rhine basin around 300 ha of land are taken for the mining industry every year and approximately the same quantity is re-cultivated. In the last few decades, 18 000 ha of land were re-cultivated (9300 ha for agriculture and 7000 ha were afforested) (Merten, 2006).

In 1993 in the Kreka basin the cultivation of potatoes started. Two years later other cultures were included, such as wheat, corn, oats, tomato, pepper, cucumber, etc. For example, the re-cultivated land in the Kreka basin was used for sowing 10-15 ha of corn, 10-15 ha of wheat, 10 ha of grass, 5 ha of barley, 1 ha of potatoes, etc. per year (Figure 5). The yield of wheat on the re-cultivated soil of the Kreka basin is 27 to 30 tons per 10 ha, corn 70 to 80 tons per 10 ha, pepper 2.5 kg per branch, tomato 5-6 kg per branch etc.

In the period 1995-2006 the re-cultivated soil in this basin was used for the production of 826.9 tons of various agricultural products: 322 tons (39%) of hay and grass-clover mixture, 343.7 tons (41.6%) of crops, 140.8 tons (17%) of vegetables, 4.2 tons (0.5%) of meat and 16.2 tons (1.9%) of other crops (Kulenović et al., 2006). The greenhouse cultivation of vegetables exists only in the Kreka and Banovići basins and the yield is satisfying. There are 6.5 thousand trees of plum "Mađarica", 100 apple trees and 500 walnut trees on the re-cultivated land in the Banovići basin. The plum yield per one tree ("Mađarica") is 60 to 80 kg ("Stanley" 80-100 kg) while the hay yield per acre of this land is around 1000 kg. The yield on the re-cultivated soil in the Kreka basin is better than in other two basins due to a better quality of soil.

European legislative on environment contains the principles of sustainable development and international envi-

ronment norms. Bosnia and Herzegovina is expected to adjust its laws to the European legislative. Not much has been done in this field. In the Federation of BiH the Law on environment protection is applied (Official Gazette of F BiH, number 33/03). This law also includes the exploitation of natural resources and environment protection in that field. On the basis of that document and the Statute (Official Gazette of F BiH, number 19/04) the decisions are brought on the issuing of environment approval for the function of facilities. Since the coal surface exploitation in the Tuzla basin was not accompanied by re-cultivation, there are still 3600 ha of degraded land.

Conclusion

The surface exploitation of coal on the territory of the Tuzla basin has a long tradition and it started at the end of the 19th century. Ever since the first exploitation procedures up to now around 49,4 million tons of lignite and 98,6 million tons of coal was produced, with more than 785 million m³ of slag. The areas affected by this type of exploitation are considerably degraded and disturbed by mining, so the morphology of the terrain represents a combination of natural relief and artificially formed strata, craters, surface damp-sites, excavations, etc. During the surface exploitation of coal in this basin 19 anthropogenic lakes have been formed with a total area of 75 ha. The surface exploitation of coal caused the degradation of 4417.24 ha of forest vegetation: 226.5 ha of beech forest (5.1%), 140.3 ha of beech and fir forest (3.2%), 13.2 ha of common oak and hornbeam forest (0.3%), 4.1 ha of oak and Turkey oak (0.1%), 1588.1 ha of oak and hornbeam forest (36%) and 2445.03 ha (55.3%) of agricultural land, settlements, bare countryside and etc. The relocation of settlements away from the exploitation areas caused the change in the inhabitant structure in the towns of Tuzla, Lukavac, Živinice and Banovići.

The Tuzla basin is characterized by small land reserves. The ratio of agriculture and cultivable land per person has reached the acceptable limit. This problem is the most evident in Banovići where the ratio is 0.04 ha of cultivable land per person and in Tuzla and Živinice with 0.09 ha and 0.12 ha per person. That clearly shows that present negative trends of land degradation in the basin should be stopped and that re-cultivation should be intensified with the usage of European experience in this field. So far, around 800 ha have been re-cultivated on this territory, out of which 470 ha in the Kreka basin. As it has been mentioned, 3600 ha of land is still degraded in the Tuzla basin. The open pit slopes should be terraced and afforested for the decrease of surface soil erosion. The lowest levels should be turned into anthropogenic lakes which might be used for agriculture, recreation and other purposes in future.

In the future, owing to its geographical position and coal reserves, the Tuzla basin (1.399 billion tons) and Bosnia and Herzegovina (5.763 billion tons) might supply all the energy needs of neighboring countries. In order to achieve this, the state energy companies would have to be transformed and the investments should be made into coal and thermal energy capacities, taking into account all the ecological standards.

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