

Review article

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OCCUPATION AND LAND DEGRADATION DUE TO MINING WORKS – EXAMPLE OF THE “KOLUBARA” MINING BASIN

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Abstract: The subject of this scientific-research paper is the occupation and land degradation due to mining works in the “Kolubara” mining basin. The aim of the research is to determine areas exposed to degradation and to display devastated areas along with the possibility of conditions’ improvement through the revitalization of certain areas. Additionally, the aim would be the proposal of measures for solving other ecological problems, such as waste, tailings sites and activities to reduce the level of environmental pollution and to conduct the proper monitoring.

Key words: occupation and land degradation, “Kolubara” mining basin, environmental protection.

Introduction

For the purpose of the scientific-research, the relevant literature have been used by the following local authors who have dealt with the problem of managing degraded areas due to mining operations - Dragicevic S. et al. (2017), Milanović M. et al. (2017), Dragicevic S. et al. (2012), Djukičin S. et al. (2012). The area of the “Kolubara” lignite basin has been the subject of the analysis of various strategic documents in the recent years (the Energy Development Strategy of the Republic of Serbia until 2025 with indications until 2030 (2015),

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(defines the development of energy in the Republic of Serbia), Spatial Plan of the Exploitation Area of the Kolubara Lignite Basin (2008), (the purpose of space defined)), studies (Preliminary design - Development of thematic maps of the agricultural land use in the GIS environment in the deposol area of the "Kolubara" basin (2012), (land use for agricultural purposes), Report on Agricultural Land Survey of the "Kolubara" surface mines in accordance with the Law on Agricultural Land, (2010), (land quality), Cadastre of the degraded areas in the municipality of Lazarevac (2013), (analysis of degraded surfaces with detailed cartographic display), publications of relevant ministries and the Environmental Protection Agency, as well as the environmental reports published by the relevant state institutions: Public company "Elektroprivreda Srbije", Branch "RB Kolubara", Sector for environmental protection (2016), City Institute for Public Health Belgrade, Center for Hygiene and Human Ecology, the City of Belgrade - City Administration of the City of Belgrade, Secretariat for Environmental Protection (2017), (2016) which show the quality of the environmental media. Internal data has been used by the Statistical Office of the Republic of Serbia, Secretariat for Environmental Protection of the City of Belgrade and from the City Institute for Public Health Belgrade.

The starting hypotheses of the research are: ecological conflicts between the need for lignite exploitation and the occupation of arable land have not been removed; occupation and land degradation in the zone of surface mines is intense; solving of the secondary environmental problems would improve the state of the environment. The aim of the research is to determine the areas that are exposed to degradation and to display devastated areas along with the possibility of conditions' improvement through the revitalization of certain areas (revitalization and proposal of measures for solving secondary environmental problems that would lead to an increase of the quality of environmental media).

The following research methods have been used: methods of analysis and synthesis, classification method and cartographic method. The research has included two phases: analysis of the existing documentation and literature, and field research. The special emphasis has been on the field research and determination of the possibility for revitalization of degraded areas with the overview of the already revitalized areas, as well as to the areas that are planned for the expansion of the surface mine.

Existing condition and endangering factors of soil quality

The conflict between environmental protection and the need to exploit lignite from the open mines is one of the biggest political, economic and environmental challenges in the Republic of Serbia. The fact that the Republic of Serbia has the majority of electricity exactly from this energy source, suppresses the topic of environmental protection. Therefore, investments in this field are necessary. The “Kolubara” lignite basin is the main link in the functioning of the country’s energy system, but the fact is that exploitation affects the land occupation (surface mines, disposal of land, tailings and ashes), displacement of settlements and emigration, increased levels of air, water and soil pollution, as well as the displacement of river banks, erosion, landslides and ecosystem changes.

Geological reserves of lignite in comparison with the geological reserves of all coal types in the Republic of Serbia make up 97% (Strategija razvoja energetike Republike Srbije do 2025. sa projekcijama do 2030. godine, 2015). The “Kolubara” mining basin is located mostly within the administrative area of Belgrade and is the dominant producer of coal in Serbia (about 70%) (Regionalni prostorni plan administrativnog područja Beograda, 2004).

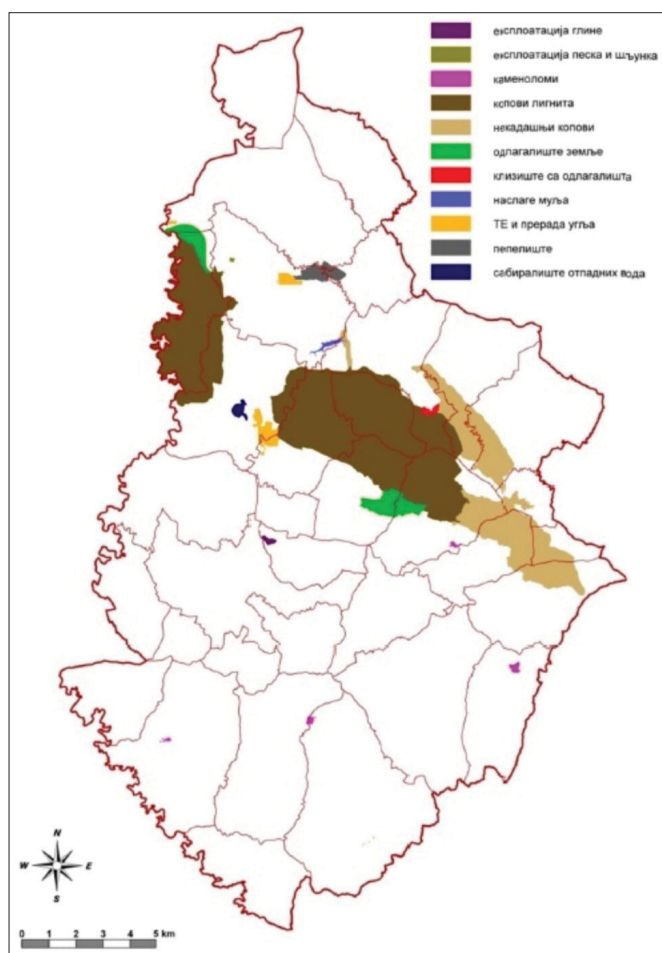


Figure 1 - Viewpoint in Medoševac Polje „D“

The largest part of the “Kolubara” lignite basin is located in the municipality of Lazarevac (smaller part is in the municipalities of Ub and Lajkovac)



and it covers the entire cadastral municipalities Vrbovno, Leskovac, Stepojevac, Veliki Crljeni, Junkovac, Arapovac, Mirosaljci, Sakulja, Vreoci, Šopić, Medoševac, Zeoke, Baroševac, Strmovo, Prkosava, Rudovci, Mali Crljeni, Bistrica, Lukavica, Petka, Stubica, Šušnjar, Dren and Burovo, which is 70% of the municipality of Lazarevac, with more than 85% of the total population (Prostorni plan područja eksploatacije Kolubarskog lignitskog basena, 2008).



Map 1 - Degraded areas in the municipality of Lazarevac
(Legend (ascending): clay exploitation, sand and gravel exploitation, stone pit, lignite surface mines, formerly surface mines, soil landfill, landslide at landfill, sludge deposits, TPP and coal processing, ash site, wastewater collector)
Source: Katastar degradiranih površina, 2013.

In the “Kolubara” lignite basin, the exploitation is performed on the surface mines: “Tamnava zapadno polje”, “Polje B”, “Polje D” and “Veliki Crljeni” (Извештај о стању животне средине за период јануар-јун 2016. године, 2016). The surface area of agricultural land in the municipality of Lazarevac amounted to 23,066 ha in 2011 (Zavod za statistiku Republike Srbije, internal data), while 31% of the total surface area of the municipality, which is 383.54 km², has been degraded (Katastar degradiranih površina, 2013).

Degradation of agricultural land² in the “Kolubara” lignite basin is the consequence of the specific exploitation of lignite at the surface mines (but also the consequence of landslides, erosion, exploitation of gravel, sand and stone, the use of pesticides in agriculture, etc.) where space occupation is necessary for the surface mine and for storage of soil, tailings and ash.

According to Dragicevic S. et al (2017) in the period 1967-2010, 39.6 hectares of arable land in the lower course of the Kolubara River was lost, and the total loss of land amounted to 80,560 US dollars by 2010, while the total loss in agricultural production was 634,240 US dollars.

Milanović M. et al. (2017) state the change of land use as the reason for erosion in the area of the “Kolubara” lignite basin, which was caused by the anthropogenic factor (mining activity, industrialization, construction works and agriculture).

The process of mines expansion requires the occupation of a new space which, besides the ecological (occupation of fertile soil, relocation watercourses) has also the social component. This refers to the relocation of the population and the destruction of created values (settlements, cemeteries, religious objects, etc.).

The surface mine “Tamnava Zapadno polje” has occupied the area of three settlements: Mali Borak (whole village evicted – the municipality of Lajkovac), Kalenić (almost half of the village evicted – the municipality of Ub) and Radljevo (the municipality of Ub). The surface mine “Tamnava Istočno polje” was in operation in the period 1979-2009 (235.4 million tons of coal was produced and excavated 211.7 million cubic meters of soil layers) (Локални еколошки акциони план општине Лазаревац, 2006), and during the exploitation, the settlement of Svetovac was completely evicted. The surface mine “Polje D” has occupied the area of the evicted settlement

² Law on Agricultural Land („Sl. glasnik RS“, br. 62/06, 65/08, 41/09) defines the planning, protection, development and use of agricultural land, while the Law on Land Protection („Sl. glasnik RS“, br. 112/15) regulates land protection, systematic monitoring of the condition and quality of land, measures for remediation, recultivation and inspection control.



Sakulja, the parts of the settlements Vreoci and Medoševac, while the surface mine "Polje B" has jeopardized greater part of the settlement Baroševac.



Figure 2 - Evicted residential buildings and space intended for the expansion of the surface mine in the settlement Vreoci

The water analysis of the Kolubara River with its tributaries indicates that not only the mining activity is the cause of poor water quality. Water sampling has been done upstream from the surface mines and the causes of the poor water quality are the discharge of municipal wastewater directly into watercourses, waste dumps near river beds and the excessive use of agrochemicals in agriculture.

In the period 2012-2016, none of the 46 tested samples of the Kolubara River did not correspond to the second class of surface water quality, while from 9 tested samples of the rivers Beljanica, Turija and Peštan, none of them corresponded to the second class of water quality (Gradska uprava Grada Beograda Sekretarijat za zaštitu životne sredine, internal data; Gradski zavod za javno zdravlje Beograd, internal data; Kvalitet voda reka i kanala na teritoriji Beograda u 2016. godini, 2017; Kvalitet životne sredine u Beogradu u 2012, 2013, 2014. i 2015. godini, 2016).

For the needs of the development and expansion of the surface mine, the regulation of river beds has been performed several times and the water accumulation "Cvetovac" has been built. "The consequences of these interventions

are numerous and often lead to the expansion of the riverbed and the undermining of the concave sides of the river banks” (Dragicevic S. et al., 2012).

The analysis of air quality³ show high concentration of pollutants as the consequence of pollution from TPP “TENT A”, TPP “TENT B” and TPP “Kolubara A” with accompanying facilities. Other factors affecting the air quality are traffic, industry, individual heating units, as well as dump sites, burning of dry grass and craft workshops.

Soil sampling done in the previous years, shows the increased levels of pollution in the immediate vicinity of surface mines and even the presence of heavy metals. Individual values of the existing forms of tested elements, such as copper, iron and manganese, have very high values (Idejni projekat – Izrada preglednih tematskih karata poljoprivrednog korišćenja zemljišta u GIS okruženju na području deposola Kolubarskog basena, 2012).

Wastewater and process water from agricultural land, as well as landfill, areas where the exploitation of mineral resources and areas under forests is carried out, is burdened with nutrients, sediments, pesticides, herbicides, microbial agents and heavy metals (Побољшање система за процену дифузног загађења вода у Србији – студија случаја за слив Колубаре, 2013). The land conditions of the surfaces formed after the excavation of the ore, which need to be recultivated, are followed by numerous problems such as soaking, lack of nutrients, poor functional activity, compaction and destruction of the land texture (Izveštaj o ispitivanju poljoprivrednog zemljišta na Površinskim kopovima „Kolubare“ u skladu sa Zakonom o poljoprivrednom zemljištu, 2010).

“The decades-long and intensive exploitation of coal has pushed agricultural production to the background, although the territory of the CM Lazarevac is characterized by favorable ecological conditions for the production of biologically valuable food” (Katastar degradiranih površina, 2013). By expanding the surface mines, arable land and pastures are permanently lost.

In addition to the stated problems, difficulties are in the waste management system which further degrades this area. The problem of dump sites is present throughout the territory of the municipality of Lazarevac (Локални еколошки акциони план општине Лазаревац, 2006), but also in the neighboring municipalities Lajkovac and Ub. As a rule, the most endangered ar-

³ Measuring points of the pollutants originating from stationary sources: Obrenovac, Vojvode Mišića 231; Lazarevac, S. Kozareva 1; Obrenovac, M. Milanovića 3; AMS Veliki Crljeni, 7. Jula 19; Obrenovac, S. Kovačevića bb and Vreoci (Gradska uprava Grada Beograda Sekretarijat za zaštitu životne sredine, internal data).



areas are those near watercourses, on public green areas, along the road routes (especially Ibarska highway) as well as around the agricultural areas.



Figure 3 - Dump site nearby the Beljanica River

Measures to improve the state of the environment and reduce the harmful effects of mining works

“The exploitation area of the “Kolubara” basin is a dynamic environment in which space changes due to the development of mining activities” (Đukićin S. et al., 2012). From that reason, the measures to improve the state of the environment and reduce the harmful effects of mining works are related to the recultivation of surface mines with completed exploitation of lignite, solving the problem of tailings and ash dump sites, along with the activities to reduce the level of environmental pollution and implementation of proper monitoring.

The implementation of these activities is under the jurisdiction of the Public Enterprise “Elektroprivreda Srbije”, which performs works, monitoring, recultivation, etc. throughout its sectors and services.

The solution for large quantities of ash generated in thermal power plants is to use them in the construction industry, especially in the civil engineering. Therefore, the decade-long ash dumps would be used for the construction of roads, where ash is used to form the lower horizon of the road.

The process of phytoremediation implies biological methods of greening and landscape management, and also the functional transformation of space (industrial tourism (viewpoints), construction of artificial lakes, golf courses, hippodromes, etc.). The examples of the executed phytoremediation are “Kipa in Mirosaljci”, which represents the forested tailings of the surface mine “Polje D” (the forest complex area is around 800 ha). Also, there is the soil amphitheater made of the tailings from the surface mine “Tamnava Istočno polje”, which has been built for the needs of social activities, while the northern part of the tailings has been re-cultivated by afforestation and with agricultural surfaces. Quality phytoremediation slows down or completely eliminates the erosion processes and stabilizes landslides.

Recultivation, in order to renew the agricultural production, implies the preparation of the soil substrate, cultivation of crops, soil processing, fertilization and care. In the very first years, the surfaces are usually planted with grasses that contribute to the stabilization and increase of organic matter and nitrogen in the soil. It is possible to cultivate fruit in later stages.

A significant improvement of the state of the environment is possible by introducing green technologies in thermal power plants (filters, wastewater treatment, etc.), as well as the regulation of the river beds, preventing the formation of landslides and erosive processes.

Water analysis carried out in the previous years, indicates that surface mining is not the main cause of water pollution, but rather the municipal wastewater. The removal of watercourses has been necessary in the function of continuing mining operations. The air quality is endangered by pollution from thermal power plants and associated facilities, while the analysis of soil quality samples shows the deviations in certain parameters.

The pollution of soil would be reduced by improving the waste management system and eliminating the creation of dump sites, as well as by completing of the planned regional sanitary landfill “Kalinić” which would significantly contribute to the improvement of the waste management system.

Conclusion

Environmental conflicts between the need for exploitation of lignite and the occupation of new arable land have not been eliminated, due to priority of the Republic of Serbia for meeting the needs for heating and electricity. The specificity of exploitation in the “Kolubara” lignite basin refers to the



occupation of large areas where environmental changes are necessary (soil and substrate removal up to lignite), which also implies the removal of built objects. The stated examples of revitalization have insufficient surfaces, if we take into consideration the entire area of the "Kolubara" lignite basin and the performed environmental changes. In the following period is necessary to increase the areas that are revitalized.

Likewise in the previous years, the land occupation and degradation in the area of surface mines has been continued. The expansion of surface mines is intensified, which has led to new emigration of the population and complete devastation of the environment.

However, apart from the problem of the occupation of space and agricultural land due to the exploitation of lignite, it is noticeable that secondary ecological problems such as wastewater, dump sites, ash sites and technological processes in thermal power plants are not resolved. By solving these problems, the state of the environment would be significantly improved: the construction of a waste water collection system in the settlements would improve the water quality of the Kolubara River and its tributaries; by improving the flood protection system (building retentions and river dykes, regulation of river channels), a part of the problem of the rivers' discharge would be solved; better conditions for solving the problem of dump sites would be created by improving the waste collection system and completing the regional sanitary landfill "Kalenić"; the use of ash in the construction industry would reduce the existing ash and slag dumps; the increasing of areas under the greenery would contribute to the improvement of air quality; while by improving the monitoring system conditions (new measuring points), conditions for more efficient monitoring of the state of the environment would be created.

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References

- CONSECO GREEN d.o.o. (2013). *Katastar degradiranih površina na teritoriji opštine Lazarevac*. Obrenovac, Beograd: CONSECO GREEN d.o.o.
- Gradski zavod za javno zdravlje Beograd, Centar za higijenu i humanu ekologiju, Grad Beograd – Gradska uprava Grada Beograda, Sekretarijat za

- zaštitu životne sredine. (2017). Kvalitet voda reka i kanala na teritoriji Beograda u 2016. godini. Beograd: Gradski zavod za javno zdravlje Beograd, Centar za higijenu i humanu ekologiju, Grad Beograd – Gradska uprava Grada Beograda, Sekretarijat za zaštitu životne sredine.
- Grad Beograd, Gradska uprava, Sekretarijat za zaštitu životne sredine. (2016). Kvalitet životne sredine u Beogradu u 2012, 2013, 2014. i 2015. godini. Beograd: Grad Beograd, Gradska uprava, Sekretarijat za zaštitu životne sredine.
- Dragicevic S. et al. (2017). Economic Consequences of Bank Erosion in the Lower Part of the Kolubara River Basin, Serbia. *Environmental Engineering and Management Journal*, 16(2), 381-390.
- Dragicevic S. et al. (2012). Land Use Changes and Environmental Problems Caused by Bank Erosion: A Case Study of the Kolubara River Basin in Serbia. *Environmental Land Use Planning*, Seth Appiah-Opoku (Ed.), ISBN: 978-953-51-0832-0, InTech, pp. 3-20.
- Djukićin S. et al. (2012). Spatial and social changes caused by the continuous exploitation of lignite in the Kolubara lignite basin, the Republic of Serbia. *Acta geographica Slovenica*, DOI:103986/AGS54102, UDC: 913:622.332(497.1), COBISS: 1.01.
- Institut za zemljište Beograd. (2012). Idejni projekat – Izrada preglednih tematskih karata poljoprivrednog korišćenja zemljišta u GIS okruženju na području deosola Kolubarskog basena. Beograd: Institut za zemljište Beograd.
- Institut za zemljište Beograd. (2010). Izveštaj o ispitivanju poljoprivrednog zemljišta na Površinskim kopovima „Kolubare“ u skladu sa Zakonom o poljoprivrednom zemljištu („Sl. glasnik RS“, br. 62/06), po čl. 21. (ukupno 117,9 ha). Beograd: Institut za zemljište Beograd.
- Milanović M. et al. (2017). Land degradation analysis of mine-impacted zone of Kolubara in Serbia. *Environmental Earth Sciences*, 76(16), online ISSN 1866-6299.
- Službeni glasnik Republike Srbije. (2015). Strategija razvoja energetike Republike Srbije do 2025. sa projekcijama do 2030. godine („Službeni glasnik RS“, br. 101/15). Beograd: Službeni glasnik Republike Srbije.
- Službeni glasnik Republike Srbije. (2015). Zakon o zaštiti zemljišta („Službeni glasnik RS“, br. 112/15). Beograd: Službeni glasnik Republike Srbije.
- Službeni glasnik Republike Srbije. (2008). Prostorni plan područja eksploatacije Kolubarskog lignitskog basena („Službeni glasnik RS“, 122/08). Beograd: Službeni glasnik Republike Srbije.



Službeni glasnik Republike Srbije. (2006). Zakon o poljoprivrednom zemljištu („Službeni glasnik RS“, br. 62/06, 65/08, 41/09). Beograd: Službeni glasnik Republike Srbije.

Službeni list grada Beograda. (2004). Regionalni prostorni plan administrativnog područja Beograda („Službeni list grada Beograda“, br. 10/04, 57/09, 38/11). Beograd: Službeni list grada Beograda.

*** Grad Beograd, Sekretarijat za zaštitu životne sredine, internal data.

*** Gradski zavod za javno zdravlje Beograd, internal data.

*** Zavod za statistiku Republike Srbije, internal data.

ГО Лазаревац. (2006). Локални еколошки акциони план општине Лазаревац. Београд: ГО Лазаревац.

Јавно предузеће Електропривреда Србије, Огранак РБ Колубара, Сектор за заштиту и унапређење животне средине. (2016). Извештај о стању животне средине за период јануар-јун 2016. године. Лазаревац, Београд: Јавно предузеће Електропривреда Србије, Огранак РБ Колубара, Сектор за заштиту и унапређење животне средине.

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