Quantifying the impact of Tamnava - West field drainage system of the surface pit on groundwater regime of Kalenić regional landfill

Dušan Polomčić, Dragoljub Bajić, Vesna Ristić Vakanjac, Tomislav Šubaranović

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Editors:
Slobodan Vujić
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THE CONTENT

MINERAL RESOURCES AND MINING GEOLOGY

MINERAL PROCESSING, FLOTATION TAILS, ASH AND SLAG

GEOMECHANICS AND ROCK MECHANICS

WATER PROTECTION

ECOLOGY, PROTECTION OF THE LIFE AND WORKING ENVIRONMENT

MANAGEMENT, ECONOMY, EDUCATION

A WORD ON THE CONGRESS

The coming of age of the idea of organizing a congress of mining experts from Balkan countries, was followed by successful execution. Initially I presented the idea for the congress 20 years ago to prof. Dr. Vencislav Ivanov, at his proposal I presented the idea to Dr. Tzolo Voutov and prof. Dr. Peter Daskalov, and all three of them wholeheartedly supported it. Implementation began soon after, the name "Balkan Mining Congress", the Congress logo, the Statute and the Congress Coordination Committee was formed by: prof. Dr. Slobodan Vujić – Serbia and Montenegro, Dr. Tzolo Voutov – Bulgaria, prof. Dr. Nikolae Ilias – Romania, prof. Dr. Stojan Zdravev – North Macedonia, Tomo Benović, Master Eng. – Republic of Srpska B&H, Marjan Hudej, Master Eng. – Slovenia, prof. Dr. Jani Bakallbashi – Albania, H. Canellopoulos, Master Eng. – Greece, Nejat Tamzok, Master Eng. – Turkey. According to the original plan, the bearer of the organizational function of the congress was supposed to be the Balkan Association of Mining Experts (acronym: BALKANMINE). This has been abandoned, and the reason is the operational inefficiency of such a concept. The congress monitoring and control function was already assigned to the Coordination Committee, so in the spirit of efficiency, the organizational function was left to the national organizational committee of the country in which congress is held. The acronym BALKANMINE was spontaneously adopted as a permanent synonym of the Balkan Mining Congress. The suggestion was that the 1st Balkan Mining Congress be held in Serbia, because of great obligations regarding the preparation of the XXXI Symposium on Operational Research (2004), they decided to hold the Congress in Bulgaria.

The idea of the necessity to bring together scientists and mining engineers and organize a scientific conference of mining experts from Balkan countries, came from negative consequences that were already visible at the time in the mining industry, generated by geopolitical turbulence and other destructive tendencies. The fragmentation of state-owned areas and colonial transition, weakened and destroyed the potentials of mining science, engineering and the economy of most Balkan countries. Such circumstances indicated the need for a scientific conference like the Balkan Mining Congress which would, on a scientific and pro-

fessional basis, ease the negative influences of time, bring together and connect experts, and ensure an effective flow and exchange of scientific, expert and economic information. Despite occasional doubts and problems, a well-defined and motivated course, has provided the "Balkan Mining Congress" ship successful sailing in the past 17 years, with ports in:

2005 – Varna, Bulgaria
2007 – Belgrade, Serbia
2009 – Izmir, Turkey
2011 – Ljubljana, Slovenia
2013 – Ohrid, North Macedonia
2015 – Petroșani, Romania
2017 – Prijedor, Republic of Srpska B&H

At seven congresses, 697 papers in seven books on 4457 pages were announced and published. Participants came from 47 countries from all continents. These quantitative indicators are an undeniable confirmation of the justification of the implementation of the visionary idea of organizing the Balkan Mining Congress. They are a confirmation of the scientific and professional importance of the Congress that surpasses the geographical framework of the Balkans, the needs and motives of mining experts. Undoubtedly, they are also a testament to the art of successful organization of a top-ranking international scientific conference.

Preparatory meeting of the founders of Balkan Mining Congress at the office of Geotechmin, Sofia, 2004.

Sailing into port no. VIII which was planned for 2020 and entrusted to the Mining Institute of Belgrade in recognition of six decades of successful creativity, scientific and professional contributions, was delayed for two years because of the pandemic. Hoping that Covid – 19 will not regain its evil power, the intention is to hold the VIII Balkan Mining Congress on 28 – 30 September in Belgrade.

A significant event related to the V Balkan Mining Congress is the establishment of the Balkan Academy of Mining Sciences. On my initiative, at the proposal of the Chairman of the Congress Organizing Committee MSc. Sasho Jovchevski, on September 21st in Ohrid, 2015, 257 participants of the Congress, representatives of all Balkan countries, made the decision to establish the Balkan Academy of Mining Sciences. In accordance with the adopted Statute of the Balkan Academy of Mining Sciences, at the proposal of the Chairman of the Congress Organizing Committee the following were elected as members of the Academy's Presidency: prof. Dr. Slobodan Vujić, Serbia; prof. Dr. Tzolo Voutov, Bulgaria; prof. Dr. Bahtiyar Unver, Turkey; prof. Dr. Zoran Panov, Macedonia; Assoc. prof. Dr. Ranko Cvijić, Republic of Srpska B&H; prof. Dr. Nikolae Iliaş, Romania; Assoc. prof. Dr. Željko Vukelić, Slovenia; Dr. Miodrag Gomilanović, Montenegro; Emeritus prof. Konstantinos Panagopoulos, Greece and prof. Dr. Jani Bakallbashi, Albania.

Prof. Dr. Slobodan Vujić was elected president of the Academy, and as vice president prof. Dr. Tzolo Voutov.

The President and the Presidency are under obligation by the Congress to, in accordance with the Statute, organize a selection of members and work of the Balkan Academy of Mining Sciences as a scientific association of mining and other experts from similar fields, citizens of Balkan member states of the United Nations Organization, with the aim of encouraging and nurturing scientific and professional cooperation in order to improve science, engineering, scientific and professional information and education in the field of mining.

At the 2017 elections for full members of the Academy, the following were elected: from Serbia – Academician prof. Dr. Aleksandar Grubić, Emeritus prof. Dr. Nadežda Ćalić, Dr. Milinko Radosavljević and Dr. Svetomir Maksimović; From Bulgaria – prof. Dr. Venzislav Ivanov, Dr. Iliya Garkov and prof. Dr. Lyuben Totev; from Slovenia – Dr. Marjan Hudej; from North Macedonia – prof. Dr. Zoran Despodov and prof. Dr. Dejan Mirakovski. As honorary members the Academicians of the Russian Academy of Sciences prof. Dr. Nikolai Nikolayevich Melnikov and prof. Dr. Valentin Alekseevich Chanturia were elected. Blagoje Spaskovski, mining engineer, Serbia and Dragomir Draganov, mining engineer, Bulgaria became associate members.

At the 2020/2021 elections for full members of the Academy, the following were elected: from Romania – prof. Dr. Iulian Offenberg and prof. Dr. Sorin Mihai Radu; from Republic of Srpska B&H – prof. Dr. Vladimir Malbašić; From Turkey – prof. Dr. Güven Önal, prof. dr. Abdullah Fişne and prof. Dr. Bayram Kahraman; From Albania – prof. Dr. Edmond Goskolli. As honorary members: from Russia – Academician prof. Dr. Mikhail Vladimirovich Kurlenya and prof. Dr. Elena Leonidovna Chanturia; prof. Dr. Omar Lanchava, Georgia; and prof. Dr. Carsten Drebenstedt, Germany were elected. MSc. Sasho Jovchevski, North Macedonia was elected as an associate member.

This summarizes the results of the Balkan Mining Congress achieved during its coming of age in the past 19 years, illustrating its value and importance for mining science, engineering, education and the mining economy of the Balkans, and beyond.

All that is left for us is to wish the Balkan Mining Congress
continues its successful mission in the future!

Belgrade, July 2022

Academician prof. Dr. Slobodan Vujić,
president of the Scientific Council of the 8th BMC

QUANTIFYING THE IMPACT OF TAMNAVA- WEST FIELD DRAINAGE SYSTEM OF THE SURFACE PIT ON GROUNDWATER REGIME OF KALENIĆ REGIONAL LANDFILL

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Abstract: *The paper analyzes one of the alternative solutions that emerged after the calibration of the hydrodynamic model of the wider area of the "Tamnava - West Field" surface pit. The main objective of the predictive calculations was to analyze the change in groundwater levels in the floor aquifer and to predict the effects of the level maintenance systems at the projected levels with the aim of protecting the body of the designed regional landfill. In this case, the effect of moving the drainage system of the "Tamnava-West Field" surface pit away from the location of the "Kalenic" regional landfill on the groundwater regime in the landfill zone was simulated and quantified.*

Key words: HYDRODYNAMIC MODEL, PREDICTIVE CALCULATIONS, GROUNDWATER REGIME

INTRODUCTION

Kolubara ore mine is the most powerful link in the Electric Power Industry of Serbia. In the postwar period alone, over 580,000,000 tons of coal was produced. Every other kilowatt of electric energy in Serbia is produced from the Kolubara lignite. Daily exploitation of up to 100.000 tons of coal, enables the reliable operation of the Nikola Tesla and Veliki Crljeni thermal power plants. The Kolubara basin has been the subject of numerous researches. The most significant hydrogeological studies were presented by: Bajić & Polomčić (2012); Buhač et al. (2012); Polomčić et al. (2014); Bajić et al. (2019).

Wider area of the "Tamnava-West Field" surface lignite pit belongs to the coal-bearing Kolubara basin which covers an area of approximately 600 km^2.

The geological structure of the "Tamnava-West Field" deposit is composed of the Paleozoic and Mesozoic sediments within the paleo -relief, while the basin itself is composed of quaternary and tertiary (Neogene-Pliocene) sediments. The coal-bearing series consists of two major coal layers which contain sporadic interlayers of laterally extending sand and coal clay of varying thickness. The thickness of the productive coal series varies a lot increasing from East to West and from North to South. The average thickness of the coal-bearing layer spreading over the entire bearing is about 33 m.

On the wider area of the investigative terrain three aquifers were formed: immediate roof, interlayered, floor. Within all of the aquifers a compressed type of aquifer under pressure was formed with a sub artesian level of groundwater. Concerning some of the important researches on the"Tamnava-West Field" surface pit the following should be singled out: Kitanović (2010); Đinđić et al. (2016); Ratković et al. (2016); Polomčić et al. (2017); Polomčić et al. (2018a).

The entire area of the"Tamnava-West Field" surface pit is characterised by complex hydrogeological and hydrodynamic conditions which require complex drainage methods. The designed groundwater protection system consists of facilities for direct drainage and facilities for pre-drainage of the immediate roof, interlayered and floor aquifers. The main task of these facilities is the protection of the working shape of the pit from the water in order to provide adequate conditions for exploitation as well as the formation and development of an internal landfill.

On the other hand, it was planned that the regional landfill should be located on the site of the"Tamnava-West Field" surface pit and the intended area for the future regional landfill amounts to around 60 hectares. The construction of the landfill would entail sanitary disposal of non-hazardous waste in eleven cities and municipalities which participated: Ub, Lajkovac, Ljig, Mionica, Osečina, Valjevo, Koceljeva, Vladimirci, Obrenovac, Lazarevac i Barajevo. The features of the regional landfill are shown in detail in a paper written by Polomčić et al. (2018b).

After the creation of the hydrodynamic model, the whole concept of the predictive calculations is based on the dynamic of the construction and functioning of the „Kalenic" regional landfill along side with the advancement of the coal exploitation mining activities within the "Tamnava-West Field" surface pit.

METHODOLOGY

The basic usage of the hydrodynamic model is to simulate the assumed conditions of the groundwater regimes. Therefore, the usage of the hydrodynamic model for predictions for various purposes represents the final phase of the entire endavor to consrtuct it and is carried out on a calibrated and verified model. The

solution of the calibrated and verified model most frequently represents the inital state for all planned predictions (Polomčić et al., 2019).

Most often, the prediction of the future groundwater regime or a prediction based on the weather forecast done in advance is carried out. The process consists of entering the initial parametars into the model and getting the values of the groundwater regime parameters, mostly groundwater levels and flows, as a result. The degree of reliability of the predictive calculations depends on the period of time for which they are carried out and the manner in which the boundary conditions are set. As the prediction period increases the degree of reliability of the results of the predictive calculations decreases, because it is usually impossible to define the parameters through the calibration process in a wider area of terrain affected by longterm exploitation. The transition from the calibration and verification of the hydrodynamic model phase to the predictive calculations of the alternative solutions represents an extrapolation of the conditions for which the calibration was carried out for some other conditions which are related to changes or the establishment of new boundary conditions. During the predictive calculation phase, geometrical characteristics remain unchanged, unless changes are made in the predictive calculations due to anthropogenic or natural activities. Filtration characteristics remain unchanged as well. Predictive hydrodynamic calculations of the groundwate regime under new conditions yield a much greater advantage compared to other interpretations and predictive methods. Solving the given problem using the predictive hydrodynamic analysis, several alternative solutions are usually obtained.

RESULTS AND DISCUSSION

For the purposes of creating the hydrodynamic analysis of the groundwater regime, a threedimensional hydrodynamc model of the study area (Polomčić et al., 2017) was developed, based on the final increment method using the MODFLOW code (Harbaugh et al., 2000) with the graphical user interface Groundwater Vistas Advanced version 64-Bit 6.74 b.24 (Rumbaugh and Rumbaugh, 2011). The hydrodynamic model of the wider area of the "Tamnava-West Field" surface pit was designed and constructed as a multi-layered model with a total of eight layers, observed in a vertical profile. The basic dimensions of the matrix covering a wider study area are 4000 m x 7500 m, that is 30 km^2 . Discretization of the electric field in the plan was performed with the basic cell size of 50m x 50m, which was condensed with a net of squares measuring 12.5 x 12.5 in parts of greater interest. The calibration of the "Tamnava-West Field" surface pit model was carried out under non-stationary flow conditions, during a month's time, and on a lower level of iteration, the basic time period was divided into ten parts of unequal duration.

According to one of the alternative solutions, the impact of moving the "Tamnava-West Field" surface pit drainage system away from the "Kalenic" regional landfill on the groundwater regimes in the landfill area was simulated and quantified. Effective infiltration set at 14% of mean perennial rainfall for the period from 1960-2010. The influence of the surface flows and underground inflows for each aquifer was given in the values obtained during the calibration of the model for the conditions in 2013. The arrangement of the piezometric levels for the period of thirty years is shown in Figure 1. From the shown picture of the piezometric

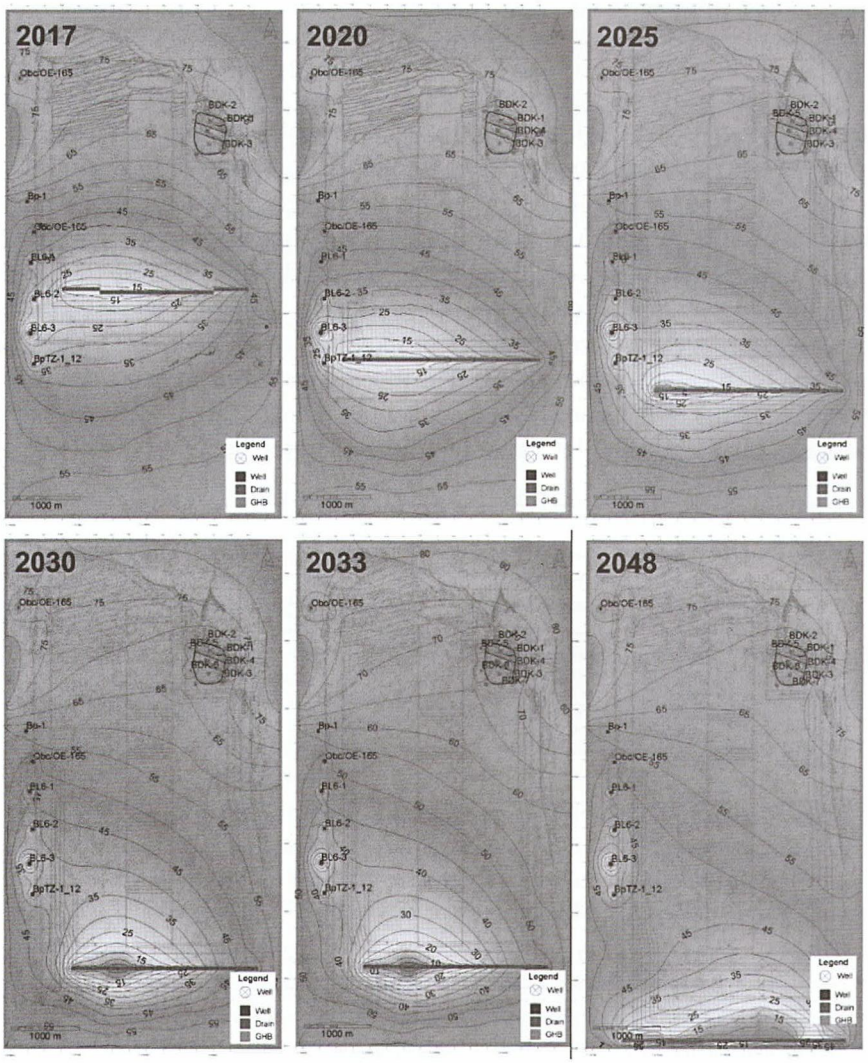

Figure 1. Predictive hydrodynamic calculations - the piezometric head for the future period (2017-2048)

level arrangement in the floor aquifer over the entire area of the "Tamnava-West Field" surface pit, it can be concluded that over time, with the movement of the pit towards the South, there will be a gradual increase of groundwater levels in the North of the area, as well as at the location of the "Kalenic" regional landfill. This confirms the prediction that this will occur as a consequence of moving the pit further away from the location of the landfill. Concerning the groundwater levels at the location of the "Kalenic" regional landfill, it can be concluded that over time there occurs a rise of groundwater at the location of the landfill itself as a consequence of moving the "Tamnava-West Field" surface pit with the accompanying groundwater protection system.

The hydrodynamic analysis of the state and changes of groundwater levels at the location of the regional landfill was carried out in detail by introducing fictive points for reading the values of groundwater levels at the location of the landfill during the predictive calculations. The fictive points are related only to groundwater levels at the floor aquifer. For each time section analysed, the values of the groundwater levels at these points were read and the results are shown in Figure 2. It can be seen in the diagram that all control points (except for point T4) show an increase of groundwater levels as a consequence of moving the drainage system of the pit away from the location of the landfill. The most jeopardized parts are the Western and Northern parts of the landfill. At other control points, there is a slower, but permanent rise of groundwater levels for the entire analysed period of time.

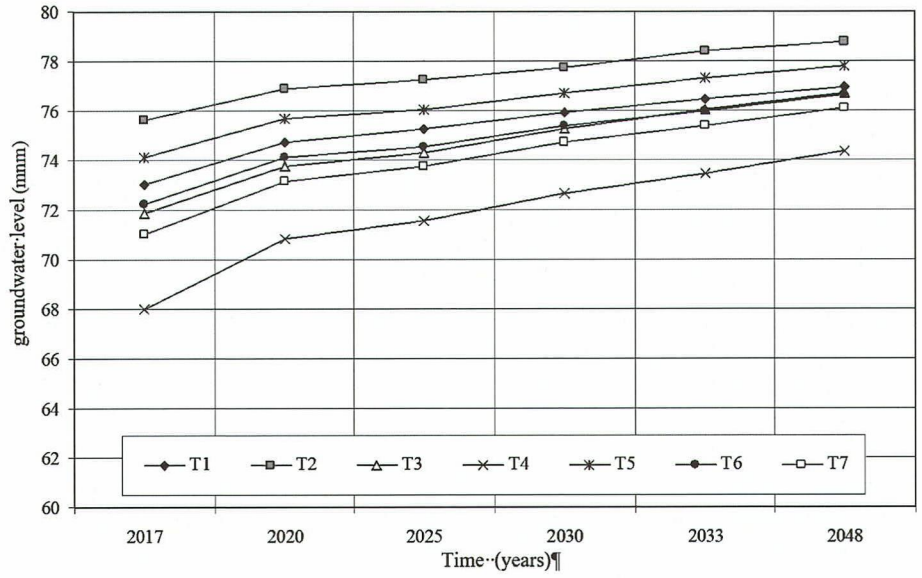

Figure 2. Values of the peziometric level in the floor aquifer at control points on the "Tamnava-West Field" hydrodynamic model

CONCLUSION

The conducted hydrodynamic analysis shown in this study made it possible to come to certain conclusions about the characteristics of the groundwater flow at the wider area of the location of the "Kalenic" regional landfill. By exploiting the hydrodynamic model and creating the predictive alternative calculations for the characteristic time sections (the end of 2017, the end of 2020, the end of 2025, the end of 2030, the end of 2033 and the end of 2048), it can be concluded that over time, with the movement of the pit towards the South, there is a gradual increase of groundwater levels at the location the "Kalenic" regional landfill. On the other hand, in the future it will be necessary to carry out the groundwater monitoring with certain dynamics. Moreover, during the functioning of the landfill, in addition to monitoring the groundwater, it is also recommended to do the control verification (and change) of the set long-term predictions. When it comes to the groundwater quality under the operating conditions, the monitoring of the groundwater below the bottom of the landfill and the surrounding area on which it has an immediate impact must be such as to provide information about the quality of groundwater which can be polluted as the consequence of the functioning of the landfill.

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