

20th Balkan Mineral Processing Congress

PROCEEDINGS BOOK

Editors

Esra Baştürkcü

Yusuf Enes Pural

Zeynep Üçerler Çamur

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This congress is dedicated to the memory of Prof. Dr. Güven ÖNAL.



*Prof. Dr. Güven ÖNAL
(1940-2024)*

*President of Balkan Mineral Processing Scientific Committee
(1995-2024)*

*President of Balkan Mineral Processing Science Academy
(2001-2024)*

Dear Readers,

Putting together the proceedings of a congress is, in many ways, a quieter kind of work. One that happens behind the scenes while everything else is taking shape. As the editorial board of BMPC 2026, we have had the privilege of being close to this process from early on, and this volume is the result of that collective effort.

Of the 139 papers included, 13 are plenary presentations, 86 are oral, and 40 are poster contributions. The most active sessions in terms of submissions were Hydrometallurgy, Pyrometallurgy and Bio-Processing with 22 papers, Flotation and Surface Chemistry Processes with 20, and Material Analysis and Mineral Characterization with 18, together accounting for more than 43% of all contributions. These figures reflect where much of the current research energy in the field is concentrated, though the breadth of topics across all 16 sessions points to a community that remains wide in its interests.

Geographically, Türkiye led with 65 contributions, followed by Albania with 11 and Kosovo with 6. Beyond the immediate region, researchers from Finland, Germany, Norway, Brazil, Algeria, and Australia were also among the contributors, reflecting a community that has quietly but steadily grown in reach over the years.

We would like to thank all authors for their submissions and their patience through the review and editing process. Our gratitude also goes to the reviewers, whose careful evaluations were essential in maintaining the scientific quality of this collection.

We hope this volume serves as a useful reference, and perhaps as a starting point for new collaborations.

Dr. Esra BAŞTÜRKÇÜ Dr. Yusuf Enes PURAL Dr. Zeynep ÜÇERLER ÇAMUR
Editorial Board, BMPC 2026 Proceedings

Since 1973: Advancing Mineral Processing Together

For several decades, a significant number of researchers and specialists in the Balkan region have devoted their efforts to advancing the science and practice of mineral processing. Their work has focused on establishing and improving industrial concentration processes, expanding production capacities, optimizing operational performance, enhancing energy efficiency in processes and equipment, and developing innovative machinery and technologies. Through these sustained efforts, mining and mineral processing activities in the Balkans have achieved steady progress and continue to play an important role in the region today.

This long-standing scientific endeavor has led to the emergence of many distinguished researchers in mineral processing across the Balkan region. In 1973, the first Balkan Mineral Processing Committee (BMPC) was established by its founding members: Prof. Dr. Kiriak Petrov Kovachev (Bulgaria), Prof. Dr. Parachiv Ilie (Romania), Prof. Dr. Dusan Salatic (Serbia), and Prof. Dr. Zeki Doğan (Türkiye).

The Balkan Mineral Processing Congress (BMPC) has been held for more than fifty years. The first Balkan Mineral Processing Conference took place in Varna, Bulgaria, from November 12 to 15, 1973. During the final session of that event, the Balkan Mineral Processing Scientific Committee (BMPSC) for Conferences was formally established. Today BMPSC has 27 active members from Albania (3), Bosnia-Herzegovina (2), Bulgaria (2), Greece (3), Republic of Kosovo (3), Moldova (1), Montenegro (3), North Macedonia (3), Romania (3), Slovenia (1), Türkiye (3), and 12 honorary members from Albania (2), Bulgaria (2), North Macedonia (1), Romania (3), Serbia (1), Türkiye (3).

In early meetings of BMPSC, the Committee decided that a Balkan Mineral Processing Conference would be organized every two years (later changed to three years), each time hosted by a different Balkan country. A major milestone in the development of BMPC occurred during the 9th Balkan Mineral Processing Conference, held in Istanbul (Türkiye) from September 11 to 13, 2001, under the chairmanship of Prof. Dr. Güven Önal. At that time, the event evolved from a “Conference” into a “Congress,” reflecting its growing scientific impact, the increasing number of participants, and the high quality of the papers presented. To date, nineteen (19) conferences/congresses have been successfully organized in various Balkan countries, including Albania (2), Bosnia-Herzegovina (1), Bulgaria (3), Greece (1), Republic of Kosovo (1), Romania (3), North Macedonia (1), Serbia (3), and Türkiye (3).

Following the establishment of the Balkan Mineral Processing Scientific Committee, the Balkan Mineral Processing Science Academy (BMPSA) was founded in 2001. Its founding members included Prof. Dr. Güven Önal (Türkiye), Prof. Dr. Zeki Doğan (Türkiye), Prof. Dr. Gülhan Özbayoğlu (Türkiye), Prof. Dr. Suna Atak (Türkiye), Prof. Dr. Dusan Salatic (Serbia), Prof. Dr. Nadezda Calic (Serbia), and Prof. Dr. Parachiv Ilie (Romania). Today, BMPSA has 43 members, including founding members, full members, and corresponding members; unfortunately, some of these distinguished members have passed away. Prof. Dr. Güven Önal served as the President of both the Balkan Mineral Processing Scientific Committee from 1995 and the Balkan Mineral Processing Science Academy from 2001 until his passing on March 31, 2024. Following his leadership, Prof. Dr. Fatma Arslan has continued this responsibility as President.

Participation in the activities of the Balkan Mineral Processing Scientific Committee has created a strong connection between regional scientific development and global

technological trends. It has also provided valuable opportunities for direct interaction among researchers, designers, equipment manufacturers, and investors from the Balkan region and beyond. Over time, the BMPC has evolved into a well-established international event held every three years, attracting participants not only from the Balkan countries but also from many other parts of the world.

The XXth Balkan Mineral Processing Congress (BMPC 2026) was held in Istanbul, Türkiye, on April 9-11, 2026, for the fourth time in the country. The congress is organized by the Mineral Processing Engineering Department of the Mining Faculty at Istanbul Technical University, in cooperation with the Turkish Mining Development Foundation (YMGV). This congress is the first one after Prof. Güven Önal's loss and is dedicated to the memory of Prof. Dr. Güven Önal.

I would like to express my sincere gratitude to the Head of the Mineral Processing Engineering Department, Prof. Dr. Murat Olgaç Kangal, and to the President of the Turkish Mining Development Foundation, Mr. Ali Türkoğlu, for their leadership in organizing this congress. I also extend my thanks to the secretaries of the organizing committee, Prof. Dr. Feridun Boylu and Prof. Dr. Gülay Bulut (BMPSC Secretary), and to Assoc. Prof. Dr. Genc Demi (BMPSC Vice President), to all members of the Balkan Mineral Processing Scientific Committee, to the members of the organizing committee, and to all participants whose contributions have made this congress both valuable and memorable. Without their dedication and support, this congress would not have been possible.

Finally, I would also like to extend our sincere appreciation to the sponsoring organizations and institutions whose generous support has significantly contributed to the successful organization of BMPC 2026.

Prof. Dr. Fatma ARSLAN

President

Balkan Mineral Processing Scientific Committee

Balkan Mineral Processing Science Academy

Dear Participants,

The Mining Development Foundation of Turkey has, since its establishment, continued its efforts to support the development of mining and mineral processing in Türkiye, to promote the effective utilization of domestic resources, and to contribute to the dissemination of scientific knowledge through congresses, conferences, and publications.

The XXth Balkan Mineral Processing Congress (BMPC 2026), held in Istanbul on April 9–11, 2026, represents a well-established regional platform that enables the exchange of scientific and technical knowledge in the field of mineral processing. Organized in cooperation with the Department of Mineral Processing Engineering of the Faculty of Mines at Istanbul Technical University, the congress continues a long-standing tradition of collaboration and knowledge sharing across the Balkan region and beyond.

Over time, BMPC has evolved into an international platform where researchers, engineers, and industry representatives come together to discuss technological developments, operational challenges, and new approaches. The congress supports not only scientific exchange but also the strengthening of professional networks and the development of regional collaborations.

At a time when our Foundation marks its 40th anniversary, the organization of the Balkan Mineral Processing Congress for the 20th time demonstrates both the continuity of institutional knowledge and its transformation into a scientific platform with international recognition.

This year's congress holds additional significance as it is the first BMPC organized following the passing of the late Prof. Dr. Güven Önal, who made important contributions to the Turkish mining sector and the Balkan mineral processing community. Prof. Dr. Güven Önal, who served for many years as the President of the Mining Development Foundation of Turkey and played a key role in shaping its current institutional structure, also held long-term leadership positions within the Balkan Mineral Processing Scientific Committee (BMPSC) and the Balkan Mineral Processing Science Academy (BMPSA). Through these roles, he guided the institutional and scientific development of BMPC and made pioneering contributions to its establishment as an international platform. We remember him with respect, gratitude, and deep appreciation.

As the Mining Development Foundation of Turkey, we would like to express our sincere thanks to the Ministry of Energy and Natural Resources of the Republic of Türkiye, Istanbul Technical University, the Faculty of Mines, and the Department of Mineral Processing Engineering, as well as to all institutions and organizations that contributed to the organization of the congress. We also extend our gratitude to our sponsors, invited speakers, session chairs, authors, reviewers, members of the organizing and scientific committees, and all participants.

We are pleased to present this proceedings book to the national and international mining and mineral processing community and hope that it will serve as a valuable resource for future studies.

M. Ali TÜRKOĞLU
Chairman of the Board
Mining Development Foundation of Turkey

Dear Colleagues,

It is a great honor and privilege to present the proceedings of the 20th Balkan Mineral Processing Congress (BMPC 2026).

Since its inception in 1973 in Varna, Bulgaria, the Balkan Mineral Processing Congress has evolved into a well-established and respected scientific platform, bringing together researchers, academics, and industry professionals from across the region and beyond. Over the decades, BMPC has played a significant role in promoting knowledge exchange, fostering collaboration, and advancing the field of mineral processing.

The 20th edition of the Congress proudly continues this strong tradition by addressing contemporary challenges and emerging opportunities in mineral processing and extractive metallurgy. Particular emphasis has been placed on innovative and sustainable approaches in mineral beneficiation, recycling of secondary resources, critical raw materials, and environmentally responsible processing technologies.

This volume comprises a total of 139 scientific papers, contributed by researchers from 30 different countries, reflecting the truly international character of the congress. The contributions are organized across 16 thematic sections, covering a broad spectrum of topics and demonstrating the diversity and interdisciplinary nature of current research in mineral processing.

The papers included in this proceedings volume represent a high level of scientific quality and provide valuable insights into current research trends, technological advancements, and industrial applications. We believe that this collection will serve as an important reference for both academic researchers and industry practitioners.

I would like to express my sincere gratitude to all authors for their valuable contributions, to the members of the Scientific and Organizing Committees for their dedicated efforts, and to all reviewers for their careful evaluations, which have ensured the high quality of this publication.

I also extend my appreciation to all participants, sponsors, and supporting institutions whose contributions have made BMPC 2026 a successful and impactful event.

I hope that this volume will inspire further research, strengthen international collaboration, and contribute to innovation in the field of mineral processing.

Yours sincerely,

Prof. Dr. Murat Olgaç KANGAL

Chairman, BMPC 2026

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SELECTION OF AN APPROPRIATE TECHNOLOGY FOR FLOTATION TAILINGS DISPOSAL USING THE SAW METHOD

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ABSTRACT

A global trend is the development of sustainable mining practices to minimize environmental impact. Following these trends, the lead and zinc mine with underground exploitation from North Macedonia applies three variants for the disposal of flotation tailings, including disposal in a tailings dam, dry stacking, and the backfill method. The flotation tailings used for the backfill method account for about 42% of the total amount, about 30% is used for dry stacking, while the remaining part (about 28%) is deposited in a tailings dam. Based on the presented disposal technology for all three variants, a multi-criteria analysis was performed to determine which of these technologies is most appropriate for achieving the goals of sustainable mining and environmental protection. The Simple Additive Weights method was applied, and decision-making criteria were established based on scientific and expert knowledge in this field. The results show that the most appropriate method that will contribute to the development of sustainable mining and environmental protection is the backfill method.

Key words: *Simple additive weights, backfill, dry disposal, tailing dam*

1. INTRODUCTION

The global mining industry is increasingly oriented towards the development and implementation of sustainable practices aimed at minimizing adverse environmental impacts. This transformation reflects the growing recognition of the need to balance mineral resource exploitation with environmental protection, economic efficiency, and social responsibility. As global demand for mineral resources continues to rise, the pressure on mining companies to adopt environmentally responsible and socially acceptable practices has intensified (PWC 2023; UNCCD 2021). In particular, sustainability in mining has evolved from a voluntary commitment to an operational necessity, driven by stricter environmental regulations, international sustainability frameworks, and community expectations (IISD, 2024).

Conventional mining operations, particularly those involving the disposal of flotation tailings, have historically been associated with significant ecological challenges, including soil degradation (Koucham et al., 2025; Barbosa et al., 2025), water contamination (Mahmood & Elektorowicz, 2015), and long-term landscape alteration (UNEP, 2020). The fine-grained nature and chemical composition of tailings often lead to the release of heavy metals and sulfide minerals, which can oxidize and produce acid mine drainage, thereby contaminating surrounding soils and water bodies (Lindsay et al., 2015, Manaviparast et al., 2024). Furthermore, the physical instability of tailings dams poses additional risks of catastrophic failure, resulting in severe and long-lasting environmental damage. These issues underscore the urgent need for improved tailings management technologies that ensure both environmental safety and operational efficiency.

Consequently, the adoption of sustainable tailings management strategies has become an essential component of modern mining operations. Sustainable approaches focus on reducing the generation of tailings at the source, promoting their reuse and recycling, and implementing disposal methods that minimize ecological footprints. Technologies such as dry stacking (Lupo

& Hall), paste backfilling (Tikou and Benzaazoua, 2007), and integrated waste management systems (Koucham et al., 2025) have gained increasing attention for their potential to enhance mine safety, reduce water consumption, and facilitate post-mining land rehabilitation. Moreover, the integration of multi-criteria decision-making methods enables the evaluation of tailings management options based on environmental, technical, and socio-economic indicators, providing a structured framework for selecting the most sustainable solutions (Štilić, and Puška, 2023).

In alignment with these international trends, a lead and zinc mine with underground exploitation in North Macedonia has introduced several alternative approaches for the disposal of flotation tailings. The mine employs three distinct disposal variants: deposition in a tailings dam, dry stacking, and the backfill method. Each of these technologies presents specific technical, environmental, and economic characteristics that influence their suitability within a framework of sustainable mining. To identify the most appropriate disposal method, a comprehensive multi-criteria analysis was conducted using the Simple Additive Weights (SAW) method. The decision-making criteria were established based on relevant scientific findings and expert evaluations. The purpose of this study is to assess and compare the three disposal technologies to determine the most sustainable and environmentally responsible solution for the management of flotation tailings in the context of underground mining operations in North Macedonia.

2. MATERIAL AND METHODS

In order to develop a sustainable mining practice to minimize environmental impact, an underground mine in North Macedonia has introduced several alternative approaches for the disposal of flotation tailings, such as:

- disposal in a tailings dam;
- backfill method;
- dry stacking.

To determine which of these technologies is most appropriate for achieving the goals of sustainable mining and environmental protection, a multi-criteria analysis, such as the Simple Additive Weights method, was performed.

2.1. Flotation Tailings Disposal Methods

Disposal in a tailings dam

Approximately 28% of the flotation tailings generated in the flotation process are gravitationally conveyed to the tailings dam via a pulp pipeline and partially dewatered using hydrocyclones, so that the liquid phase is deposited in the settling pond, and the material from the solid phase is used to build the downstream dam. A settling pond is formed in the rear part of the tailings dam accumulation area, farthest from the dam crest. In order to reduce water consumption in the flotation process, the mine has introduced a system for recirculating part of the clarified water from the settling pond and returning it to the flotation process through installed pumps and a return line for the gravitationally settled wastewater of the settling pond.



a) b)
Figure 1. Flotation tailing dam, a) Dam, b) Settling Pond

Backfill method

The filling of the excavated areas is carried out with backfill material - paste, which consists of: flotation tailings, cement, fly ash and water. The paste is prepared in the Paste plant.

In order to cover all zones of the mine where the Backfill method is applied, about 7.5 km of pipeline have been installed and 1 km of boreholes have been drilled.

Preparatory work for the application of the Backfill method is fastening the backfill pipes, making a barricade, installing pipes for draining the backfill, etc.

After completing these activities, the installation of the paste begins. The length of the block to be filled is 150 m. Three pipelines are installed in the crown of the drift, the first of which is 150 m long, the second 100 m and the third 50 m.

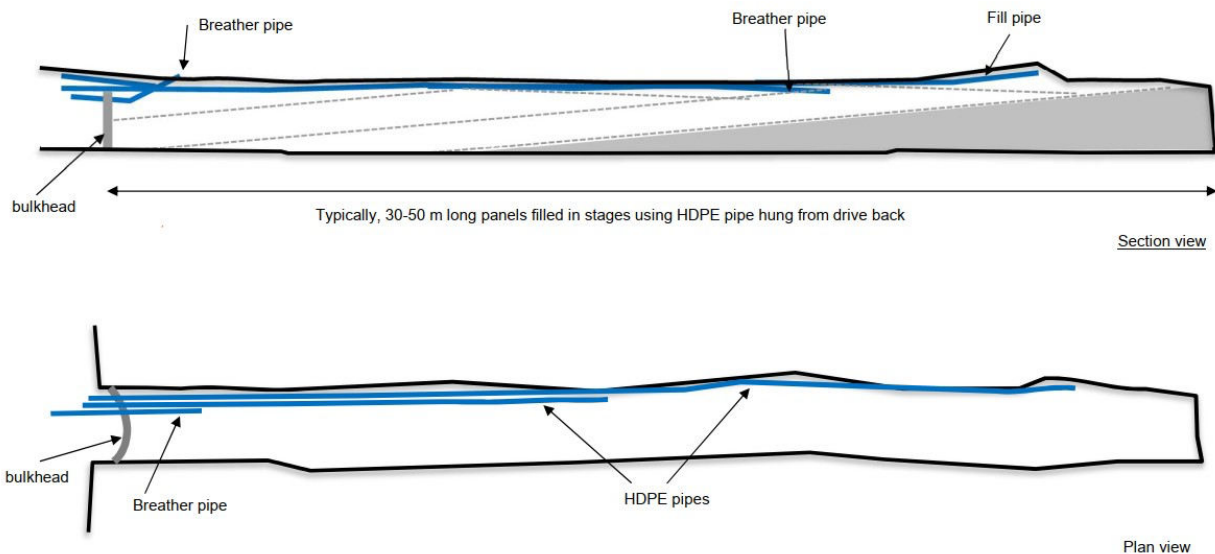


Figure 2. Illustration of the principle of backfill method

The delivery of backfill from the Paste Plant to the excavations is regulated by an automatic regulation system – SCADA system.

Dry stacking

To apply the dry stacking method, it is necessary to have two main parts: Dry Stacking Plant and Dry Stacking Installation (previously suitably prepared space).

As input material to the Dry Stacking Plant, partially dewatered hydro tailings from a thickener with 65% solids are used.

Further dewatering is carried out in a filter press, after which a filter cake with 11.5% moisture is obtained. This material is transported via two conveyor belts to a temporary storage warehouse. It is then transported to the dry disposal installation by conveyor belts or trucks. Approximately 30% of the flotation tailings are stored using this method.

2.2. The Simple Additive Weighting (SAW) Method

The Simple Additive Weighting (SAW) Method is often known as the weighted addition method. The basic concept of the SAW method is to find a weighted sum of the performance ratings for each alternative on all criteria. The SAW method requires a decision matrix normalization process (X) to a scale that can be compared with all existing alternative ratings (Iqbal Panjaitan, (2019) (Mude, 2016).

This SAW method requires the decision-maker to determine the weight for each criterion. The total score for the alternatives is obtained by adding up all the multiplication results between the rating (which can be compared across criteria) and the weight of each criterion. The rating of each criterion must be dimension-free in the sense that it has passed the previous matrix normalization process (Helilintar, 2016).

The rating of each attribute must be dimension-free in the sense that it has passed the previous matrix normalization process.

The quantification of qualitative criteria in the simple additive weights (SAW) method is made according to Table 1 (Despodov, 2002).

Table 1. Quantification of qualitative criteria in the Simple Additive Weight (SAW) method

Type of criteria	Goal	bad	good	average	very good	excellent
C_{max}	Max	1	3	5	7	9
C_{min}	Min	9	7	5	3	1

The formula for carrying out the normalization (Eq. 1) is as follows (Christioko et al., 2017);

$$R_{ij} = \begin{cases} \frac{X_{ij}}{\max X_{ij}}, & \text{for } C_i \rightarrow \max \\ \frac{\min X_{ij}}{X_{ij}}, & \text{for } C_i \rightarrow \min \end{cases} \quad (\text{Eq. 1})$$

Where:

R_{ij} is a normalized performance rating; X_{ij} is the attribute value of each criterion;
 $\max X_{ij}$ is the greatest value of each criterion; $\min X_{ij}$ is the smallest value of each criterion;
 R_{ij} is the normalized performance rating of the alternatives A_i on criteria C_j ;
 $i = 1, 2, \dots, m$ and $j = 1, 2, \dots, n$.

The preference value for each alternative (V_i) is given as:

$$V_i = \sum_{j=1}^n W_j \cdot R_{ij} \quad (2)$$

Where V_i is the ranking for each alternative, W_j is the weighted value of each criterion. A larger V_i value indicates that the alternative A_i is preferred.

3. RESULTS AND DISCUSSION

Based on a comprehensive analysis of the three tailings disposal alternatives, it was determined that the most relevant criteria for their evaluation include: geological, hydrogeological, and geotechnical conditions; environmental protection; hazard risk;

sustainability; capital investment costs; operating costs; return on investment; safety and social aspects; and regulatory requirements.

Table 2 provides a descriptive presentation of the selected criteria for all considered alternatives, whereas Table 3 defines the objectives for each criterion and presents the evaluation of the alternatives using the Simple Additive Weighting (SAW) method.

Table 2. Description of the criteria for each alternative

Alternatives \ Criteries	Tailing dam	Backfill method	Dry stacking
Geological, Hydrogeological and Geotechnical conditions	Construction of a tailings dam requires impermeable and sterile rocks	The orebody must be suitable for the application of a backfill method	The construction of a dry tailings storage facility requires sufficient available area with impermeable and sterile rocks
Environmental protection	Low level of protection of water, air, and soil	No adverse impact on the environment	Medium level of protection of water, air, and soil
Hazard risk	Risk of dam failure and contamination of water, air, and soil	No significant hazard risk	Risk of air (dust) pollution
Sustainability	Limited disposal capacity	Depends on the operating conditions for applying this method	Limited disposal capacity
Investigation costs	Costs related to the construction and closure of the tailings dam	Costs for construction of the paste backfill plant	Costs for construction of the dry tailings processing plant and for construction and closure of the dry stacking facility
Operation costs	Low operating costs (gravity-driven transport of tailings slurry)	Relatively high operating costs due to electricity consumption, construction of bulkheads, and cement usage	Moderately high operating costs for electricity consumption and dry tailings transport
Return on investment	No direct return on investment	By applying this method, the amount of mined ore reserves increases from 80% to 100%	No direct return on investment
Safety and Social conditions	Risk of dam failure and potential dissatisfaction of the local population	Mandatory implementation of occupational health and safety measures	Mandatory compliance with the designed geometry of the disposal facility
Regulatives	Higher requirements for monitoring and permits	Low requirements for monitoring and permits	Lower requirements for monitoring and permits

Table 3. Evaluation of the criteria for each alternative

Criteries	Tag	Goal	Alternatives		
			Tailing dam	Backfill method	Dry stacking
Geological, Hydrogeological and Geotechnical conditions	C ₁	Max	3	9	5
Environmental protection	C ₂	Max	1	9	3
Hazard risk	C ₃	Min	7	1	3
Sustainability	C ₄	Max	3	7	3

Investigation costs	C ₅	Min	9	5	7
Operation costs	C ₆	Min	3	7	5
Return on investment	C ₇	Max	1	9	1
Safety and Social conditions	C ₈	Max	3	9	7
Regulatives	C ₉	Max	3	9	7

Table 4. Selection of the most acceptable alternative for tailings disposal

Criteria C _j	Goal	Criterion Weight W _j	Alternatives - A _i					
			Tailing dam – A ₁		Backfill method – A ₂		Dry stacking – A ₃	
			Normalized performance rating - R _{ij}	Ranking V ₁	Normalized performance rating - R _{ij}	Ranking V ₂	Normalized performance rating - R _{ij}	Ranking V ₃
C ₁	Max	0.15	0.3333	0.0500	1.0000	0.1500	0.5556	0.0833
C ₂	Max	0.2	0.1111	0.0222	1.0000	0.2000	0.3333	0.0667
C ₃	Min	0.15	0.1429	0.0214	1.0000	0.1500	0.3333	0.0500
C ₄	Max	0.05	0.4286	0.0214	1.0000	0.0500	0.4286	0.0214
C ₅	Min	0.05	0.5556	0.0278	1.0000	0.0500	0.7143	0.0357
C ₆	Min	0.1	1.0000	0.1000	0.4286	0.0429	0.6000	0.0600
C ₇	Max	0.1	0.1111	0.0111	1.0000	0.1000	0.1111	0.0111
C ₈	Max	0.1	0.3333	0.0333	1.0000	0.1000	0.7778	0.0778
C ₉	Max	0.1	0.3333	0.0333	1.0000	0.1000	0.7778	0.0778
Total Ranking			0.3206		0.9429		0.4838	

The selection of the most acceptable alternative for tailings disposal was performed using the Simple Additive Weighting (SAW) method and is presented in Table 4.

Considering global trends toward increasingly stringent environmental protection, the highest weights were assigned to the criteria of geological, hydrogeological, and geotechnical conditions; environmental protection; and hazard risk. In the cost analysis, greater weight was assigned to operating costs, as capital investment costs represent one-time expenditures. The scores for each criterion and alternative were assigned in accordance with the descriptions provided in Table 2.

Among the evaluated alternatives, the backfill method achieved the highest overall ranking, primarily due to its minimal environmental impact, elimination of surface tailings disposal, and increased ore recovery rate. In contrast, the tailings dam alternative ranked lowest, mainly as a result of its higher environmental risks, potential for structural failure, and greater regulatory and social concerns. Dry stacking represents an intermediate solution, offering improved environmental performance compared to conventional tailings dams, but with limitations related to operational complexity and storage capacity.

4. CONCLUSION

This study presents a comparative evaluation of three tailings disposal alternatives—tailings dam, backfill method, and dry stacking—using a multi-criteria decision-making approach based on the Simple Additive Weighting (SAW) method. The assessment was conducted by applying

a set of technical, environmental, economic, safety, and regulatory criteria, selected on the basis of a comprehensive analysis of the relevant geological and operational conditions. The results indicate that environmental protection and hazard-related criteria play a decisive role in the selection process, reflecting current global trends toward more sustainable and environmentally responsible mining practices. By assigning higher weights to geological, hydrogeological, and geotechnical conditions, environmental protection, and hazard risk, the analysis emphasizes the importance of long-term stability and risk reduction in tailings management.

Based on the obtained results, it can be concluded that the backfill method represents the most suitable and sustainable tailings disposal option under the analyzed conditions. The applied methodology has proven to be an effective decision-support tool and can be successfully used for evaluating tailings management alternatives in similar mining projects.

REFERENCES

- Barbosa, M., Figueiredo, J. C. G., Negreiros, D., Maia, R., Oki, Y., Rodrigues de Souza, L., dos Santos, M.P., Ferreira-Reis, R., Ferreira Rocha, Q. E., Ferreira Nunes, Y. R., das Dores Magalhaes Veloso, M., Fernandes, G. W., (2025) "Impact of mining tailings on soil decomposition and carbon stabilisation in a riparian atlantic forest", *Discover Environment*, 3 152.
- Despodov, Z., (2002) "Determination of optimal parameters of belt conveyors for their application in mining for metallic minerals with underground exploitation in the Republic of Macedonia", Doctoral Dissertation (unpublished), Faculty of Mining and Geology, University "Cyril and Methodius" Skopje.
- Helilintar, R., (2016), Application of saw and fuzzy methods in scholarship acceptance decision support system in decision support system scholarship, *Citec J*.
- International Institute for Sustainable Development, (2024), Navigating global sustainability standards in the mining sector. <https://www.iisd.org/system/files/2024-11/global-sustainability-standards-mining.pdf>
- I. P., Muhammad, (2019), Simple Additive Weighting (SAW) method in Determining Beneficiaries of Foundation Benefits: *Jurnal Teknologi Komputer*, 19-25.
- Koucham, M., Khalil, A., Mouhagir, L., Zouhri, L., El Adnani, M., (2025) "Comprehensive assessment of environmental behavior of mine tailings for sustainable waste management and mitigation of pollution risks", *Water* 17 (1) 43.
- Lindsay, M. B. J., Moncur, M. C., Bain, J. G., Jambor, J. L., Ptacek, C. J., Blowes, D. W., (2015) "Geochemical and mineralogical aspects of sulfide mine tailings", *Applied Geochemistry*, 57 157-177.
- Lupo, J., Hall, J., Dry Stack Tailings – Design Considerations, AMEC Earth & Environmental, Englewood, CO, USA. Available at: https://www.iqpc.com/media/6139/588.pdf?utm_source=chatgpt.com
- Manaviparast, H. R., Miranda, T., Pereira, E., Cristelo, N., (2024) "A comprehensive review on mine tailings as a raw material in the alkali activation process", *Applied Sciences*, 14 (12) 5127.
- Mahmood, A. A., Elektorowicz, M., (2015) "A review of sustainable management of mine tailings", *Applied Mechanics and Materials*, 773 1256-1260.
- Mude, M. A., (2016) "Comparison of SAW and TOPSIS methods in the case of MSMEs", *ILKOM Jurnal Ilmiah*.
- PWC (2023), Mine 2023: The era of reinvention. PwC. Available at: https://www.pwc.com/id/en/pwc-publications/industries-publications/energy--utilities---mining-publications/mine-2023.html?utm_source=chatgpt.com

Štilić, A., Puška, A., (2023) "Integrating multi-criteria decision-making methods with sustainable engineering: A comprehensive review of current practices". *Engineering*, 4 1536-1549.

Tikou, B., Benzaazoua, M., (2007) "Design and application of underground mine paste backfill technology", *Geotechnical and Geological Engineering*, 26 147-174.

United Nations Convention to Combat Desertification (UNCCD), (2021), Mineral resource governance. Available at: https://catalogue.unccd.int/1431_extractive_industries.pdf?utm_source=chatgpt.com

United Nations Environment Programme (UNEP), (2020, August), Global Industry Standard on Tailings Management. https://wedocs.unep.org/bitstream/handle/20.500.11822/36139/GISTM_En.pdf