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AN ASSESSMENT OF ENVIRONMENTAL IMPACT OF TALC PROCESSING: FLOTATION AND MINE WATER QUALITY

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Abstract— Talc processing, particularly flotation and tailings management, presents significant environmental challenges due to waste generation, contamination risks, and potential ecological degradation. This study examines the environmental impacts of talc processing, specifically focusing on flotation and mine water quality. The research assesses the quality of mine waters, evaluates pollutant levels, and investigates the effectiveness of current mitigation strategies. Through a detailed analysis of mine water composition over multiple years, the study identifies fluctuations in key environmental indicators, including dissolved oxygen, sulfane, chemical oxygen demand, and heavy metal concentrations. While most parameters remained within regulatory limits, occasional exceedances were noted, particularly in nitrite nitrogen and non-polar extractable substances. Additionally, the total volume activity of α exceeded limits persistently, reflecting the influence of the geological environment. These findings underscore the need for continuous monitoring, enhanced waste management practices, and regulatory compliance to minimise environmental risks. The study also highlights the role of mine water recycling in reducing resource consumption and mitigating environmental impact. Given the projected 50- to 70-year lifespan of talc extraction in the studied region, sustainable management strategies are imperative. Recommendations include improved tailings containment, stricter pollution control measures, and the development of advanced treatment technologies to ensure long-term environmental sustainability. This research contributes to the broader discourse on responsible mineral resource exploitation and offers insights for policymakers, industry stakeholders, and environmental agencies working to balance industrial needs with ecological preservation.

Keywords— environmental impact, mine water quality, sustainable mining, waste management, mineral processing.**)**

I. INTRODUCTION

Mineral raw materials, including talc deposits, represent the basic platform determining the further development of anthropogenic society in interaction with the economic development of each country. The intensity of exploitation of mineral deposits must currently consider their rarity, non-renewability, technology level, and accessibility of alternative or renewable resources [1, 2]. It is necessary to regulate the possibilities of exploitation of mineral resources deposits by the limits of the territory and the environment, since not only the exploitation of minerals, but also their primary, secondary, or tertiary treatment and processing have significant impacts on the environment, which are directly determined by the mining method (underground, or surface mining) [1,3,4]. In the mining industry, which is a hazardous industry related to the specifics of its production, in particular, the risk management and analysis process should be considered [5,6,7].

Talc processing is a crucial step following mining, involving flotation, separation, and tailings disposal. While effective in refining talc, these processes present significant environmental risks that must be managed through strategic risk assessment and regulatory compliance. A more effective use of the potential of non-mineral raw materials is possible, among other things, by reducing the environmental and energy burden during the extraction and processing of raw materials [8]. Nawrocki and Jonek-Kowalska recommend some methodological activities for improving risk management in Central and Eastern European mining enterprises, including implementing enterprise management systems or introducing risk evaluation and monitoring methods [9]. The most significant environmental impacts include irreversible changes in the relief, a reduction in the aesthetic value of the landscape, changes in the hydrogeological regime of groundwater, changes in the chemical composition of soils and waters, soil degradation, the creation of landfills, dumps, tailings, dust fallout on large areas in the vicinity of deposits and processing facilities, previously established mining areas that encroach on the territories of protected parts of nature and municipal infrastructure [10]. Among the most serious consequences of mineral raw materials extraction is the creation of large, excavated spaces underground and on the surface, which is associated with surface instability due to undercutting. Other adverse effects on the environment are caused by the drainage effect of mining works and excavations - drainage of rock complexes and a drop in the groundwater level, a reduction in the yield of used groundwater resources, and the emergence of concentrated mine water discharges to the surface with often unsatisfactory quality, threatening the purity of surface flows. Accumulating a large number of residual materials after mining and treating mineral raw materials containing contaminants on heaps and tailings creates a risk of contamination spreading into the air, soil, surface, and underground water [11].

Despite extensive research on individual aspects of mining environmental impacts, a significant knowledge gap remains regarding the comprehensive assessment of environmental risks specifically associated with talc processing operations, particularly the integration of flotation process optimisation with tailings management strategies in the context of long-term sustainability [12-14]. This study addresses this gap by providing a detailed analysis of mine water quality trends over multiple years and proposing evidence-based mitigation measures aligned with international best practices. This research aims to fill critical knowledge gaps in understanding how talc processing activities contribute to environmental pollution and landscape degradation, with a specific focus on developing and validating risk assessment methodologies that can be applied to similar mineral processing operations globally. The study contributes to the broader scientific discourse on responsible mineral resource exploitation and provides practical insights for policymakers, industry stakeholders, and environmental regulatory agencies working to balance industrial development needs with ecological preservation requirements.

The primary objective of this research is to provide a comprehensive environmental impact assessment of talc processing operations, with particular emphasis on flotation processes and mine water quality management, to develop scientifically-based strategies for sustainable mineral extraction that align with international environmental standards and circular economy principles.

II. MATERIALS AND METHODS

Talc flotation is a wet processing procedure for mineral separation based on hydrophobicity and hydrophilicity properties, utilising different surface wettability characteristics [15]. This procedure is based on the separation of materials with different surface properties, using the basic physical property, hydrophobicity, respectively hydrophilicity, i.e. their different wettability by the liquid. After aeration of the mash, air bubbles adhere to the hydrophobic particles of the useful mineral, whereby particle-bubble aggregates are formed. There is a physical process in which solid particles of the useful component (talc) in the water are carried to the surface by fine air bubbles. According to the basic theoretical assumption, a particle whose density is lower than the density of the flotation solution floats. At the level of the flotation cells, a compact layer of concentrated useful component is formed, which is then collected from the surface by wiping. This concentrate is then concentrated and filtered on vacuum filters or presses to obtain a dewatered flotation concentrate with residual moisture of about 15 %.

The flotation building is designed as an insulated clad hall with a steel structure. After secondary comminution on the rebound crusher, the piece material is connected to the material flow of the 0 - 6 mm fraction and is transported by means of an elevator to the buffer tank of the input raw material. Through the feeding devices, the input raw material enters the node of wet grinding, followed by wet sorting. The sub-sieve material from this node enters the flotation as a direct feed, the middle/intermediate material is passed to the gravity splitting spirals and the oversize material is lifted for grinding into a bar mill.

The gravity separation node (gravity spirals) ensures the separation of light and heavy products (grains) based on the difference in bulk density. Grain sorting occurs during the execution of a floating vertical spiral path and the action of centrifugal force. In this way, the accompanying minerals in the form of a heavy product (tailing material) are precipitated from the process, which are concentrated at the central axis of the spirals due to their weight and greater frictional force, as well as abrasiveness. These grains represent tailing material, are excluded from the process, and are placed outside the hall by a conveyor belt, ultimately becoming an admixture in the base material. The light product (talc) is returned for grinding into a bar mill.

The ground fine fraction with water (flotation mash) enters the battery of flotation cells and passes through pumping through pipelines and also by gravity, predefined connections of basic, control, flotation and individual purification stages of flotation. With the addition of the flotation reagent and the flotation cells aeration, a layer of concentrated useful component is formed on their surface, which is subsequently cyclically cleaned in individual purification stages and wiped into collecting troughs. The concentrated third purification product is fed through a chute to the flotation concentrate thickener. In the thickener, the solids, useful components, are sedimented by gravity. After concentration to the desired density, the concentrate is pumped and filtered on dewatering devices. The dewatered flotation concentrate with residual moisture of approximately 15 % is transported to the intermediate landfill/box of dewatered concentrate, which is located inside the flotation hall. From there, it is then continuously transported by a wheel loader and stored in a roofed warehouse of wet flotation concentrate. The water from the filtration is raised to the process water tank.

Mine water (Figure 1) is currently used for the flotation treatment of talc raw material carried out in a closed cycle; the used water is returned to the production process after sedimentation. Losses of technological water, caused by product drying (evaporation) and residual moisture in the flotation sludge, are compensated by mine water. Mine waters are also used to produce concrete in the internal concrete plant; the inert material created during mining and manual sorting of talc waste is used as a filler in the base mix, as well as inert material from the flotation process and cement as a binder. The concrete mixtures produced in this way are taken into rail concrete wagons, which transport them to the place of establishment of the reclaimed spaces underground [16].

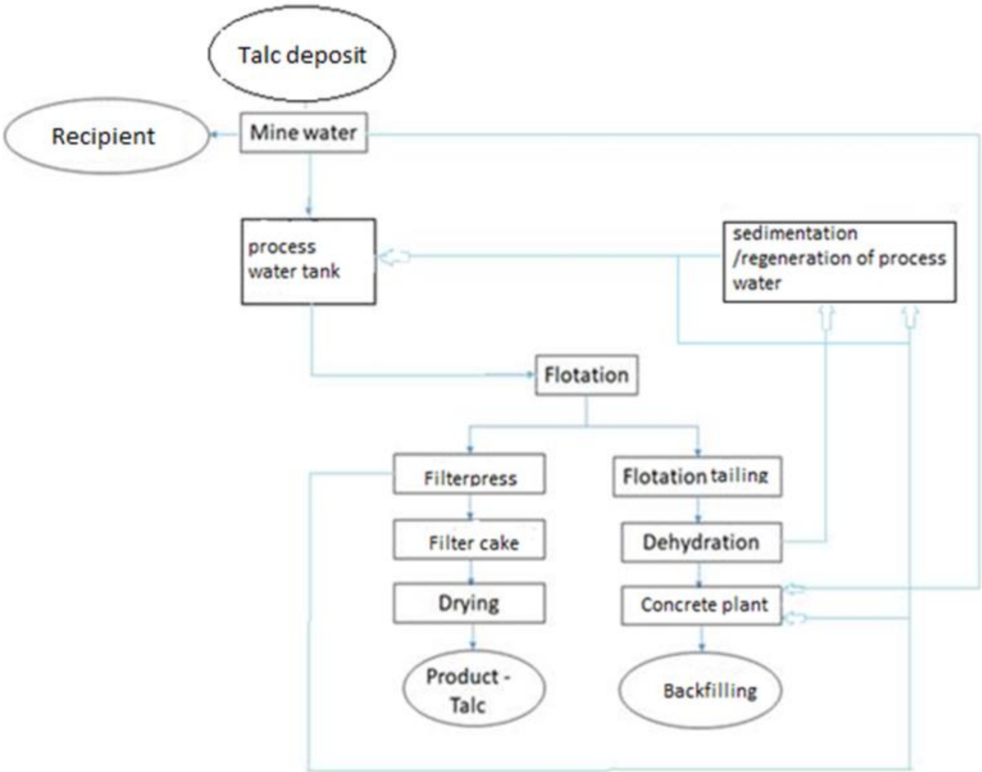


Figure 1. Use of mine water in the exploitation of talc.

The chemical analysis of the composition of mine water, which was determined by the surrounding bedrock environment, was measured by an accredited laboratory following the applicable Slovak legislation.

An integral part of talc exploitation is its flotation treatment, which takes place in an insulated, sheathed hall with a steel structure, where the input raw material is fed to wet grinding, followed by wet sorting. The under-sieve material enters the flotation as a direct feed, the medium/int-sieve material is forwarded to the gravity separation spirals, and the above-sieve material is sent to the rod mill for grinding. The gravity sorting (gravity spirals) ensures the separation of light and heavy products (grains) based on the difference in bulk weight. The sorting of grains occurs during the floated vertical spiral route and the action of centrifugal force. In this way, accompanying minerals in the form of a heavy product (inert material) are excluded from the process, which, due to their weight and greater frictional force and abrasiveness, are concentrated near the central axis of the spirals. These grains represent barren material; they are excluded from the process and placed outside the hall by a conveyor belt and end up as an admixture in the base material. The light product (talc) is returned to the rod mill for grinding. The ground fine portion with water (flotation mash) enters the battery of flotation cells and passes by pumping through pipelines and by gravity through the pre-defined connection of the basic, control flotation, and individual purification stages of flotation. With the addition of a flotation reagent and aeration of the flotation cells, a layer of concentrated final component is formed on their surface, which is subsequently cyclically purified in the individual purification stages and wiped into the collecting canal. The concentrated product from the third purification stage is led to the flotation concentrate thickening cell by a canal. In the thickening cell, sedimentation of the solid portion – the useful component – occurs by gravity. After the thickening process, the concentrate is pumped and filtered on drainage devices. Dewatered flotation concentrate with a residual moisture of approx. 15% is transported to the intermediate dump/box of dewatered concentrate located inside the flotation hall. From there, it is continuously transported by a wheel loader and stored in a roofed warehouse of wet flotation concentrate. The water from the filtration is pumped into the technological water tank.

III. RESULTS

The quantity and quality of mine waters arising from the exploitation of talc are determined by the intensity and method of extraction of the talc raw material, its mineralogical composition, and the rock environment around the tunnel. Based on chemical analyses, the exploited talc, which determines the quality of mine waters, contains 60.2 % of SiO_2, 32.04 % of MgO, 0.91 % of Fe_2O_3, 0.79 % of FeO, 0.23 % of CaO, 0.1 % of Al_2O_3, and 0.001 % of TiO_2. [17].

As already mentioned, the composition of mine water is directly determined by the rock environment, the method of extraction of talc raw material, but also by other risk factors, which include potential extraordinary events negatively affecting environmental quality, including the health of living organisms. Extraordinary events can be caused by the accidental release of pollutants from the territory of the mining and treatment operation, which can generally cause, among other things, an extraordinary deterioration of water quality, or an extraordinary threat to water quality, which is following Act no. 364/2004 Coll. to be characterized as a sudden, unforeseen and serious deterioration or serious threat to the quality of water caused by the discharge of wastewater or special waters without a permit or caused by an uncontrollable release of pollutants, which are mainly manifested by the colour or smell of the water, a greasy coating, the formation of foam on the surface, the occurrence of dead fish or the occurrence of pollutants in the environment related to surface water or groundwater [18]. Mine water management in the conditions of talc exploitation is governed by the decision of the Rožňava District Office [19] following the Water Act [18] and in connection with the Mining Act [20]. The development of mine water quality was monitored and compared with the decisions of the Rožňava District Office for mine waters from the affected area, while the quality indicators listed in Table 1 were determined for mine waters from the exploited talc deposit.

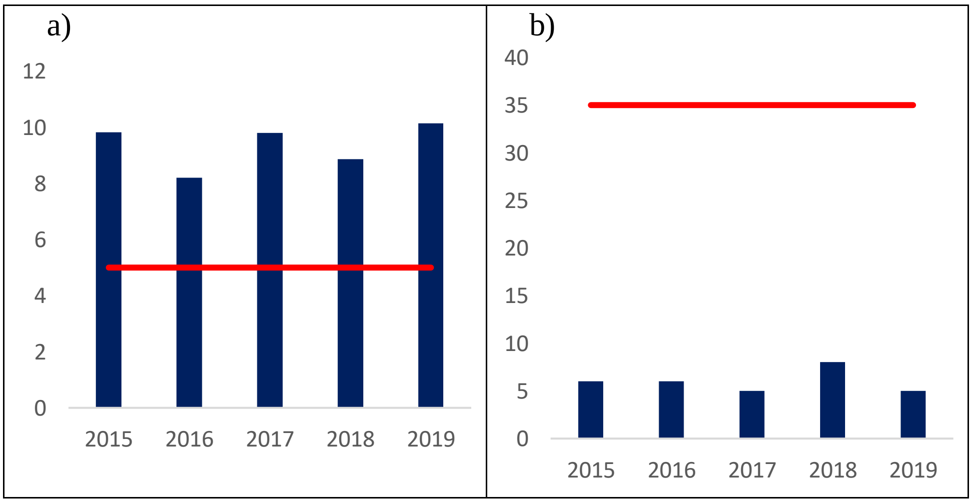
TABLE 1
Indicators of mine water of talc exploitation.

Indicator	**Regulation by the Government of the Slovak Republic No. 269/2010 Coll.**	**The decision of the Rožňava District Office**	**Unit**
Dissolved oxygen, O_2 (LV)	-	> 5.0	$mg.l^{-1}$

Chemical oxygen demand, COD_{Cr} (LV)	-	35	$mg.l^{-1}$
Sulphane, S^{2-} (LV)	-	0.02	$mg.l^{-1}$
Water reaction, pH (RV)**	6.0 – 9.0	6.8 – 9	$mg.l^{-1}$
Solutes (LV)	-	1000	$mg.l^{-1}$
Total iron, Fe_{total} (LV)	4	2	$mg.l^{-1}$
Manganese total, Mn (RV)	-	0.3	$mg.l^{-1}$
Ammoniac nitrogen, $N\text{-}NH_4$ (LV)	-	1	$mg.l^{-1}$
Nitrite nitrogen, $N\text{-}NO_2$ (LV)	-	0.02	$mg.l^{-1}$
Nitrate nitrogen, $N\text{-}NO_3$ (LV)	-	5	$mg.l^{-1}$
Arsenic, As (LV)	0.5	30	$mg.l^{-1}$
Copper, Cu (LV)	1	20	$mg.l^{-1}$
Calcium, Ca (LV)	-	200	$mg.l^{-1}$
Magnesium, Mg (LV)	-	100	$mg.l^{-1}$
Non-polar extractable substances, NES (LV)	3	0.1	$mg.l^{-1}$
Insoluble matter, IM (RV)	40	25	$mg.l^{-1}$
Total volume activity, α	-	0.5	$Bq.l^{-1}$
Total volume activity, β	-	1	$Bq.l^{-1}$
Radon volume activity, Ra	-	-	$Bq.l^{-1}$
Yield	-	-	$l.s^{-1}$

Key: LV – limit value; RV – recommended value; prepared according to [19]

The trend of dissolved oxygen O_2 showed a fluctuating tendency in the analysed period, with the highest value in mine water in 2019 and, conversely, the lowest in 2016, while during the entire analysed period, the limit value (LV) in terms of the Decision (Figure 2a) was observed.



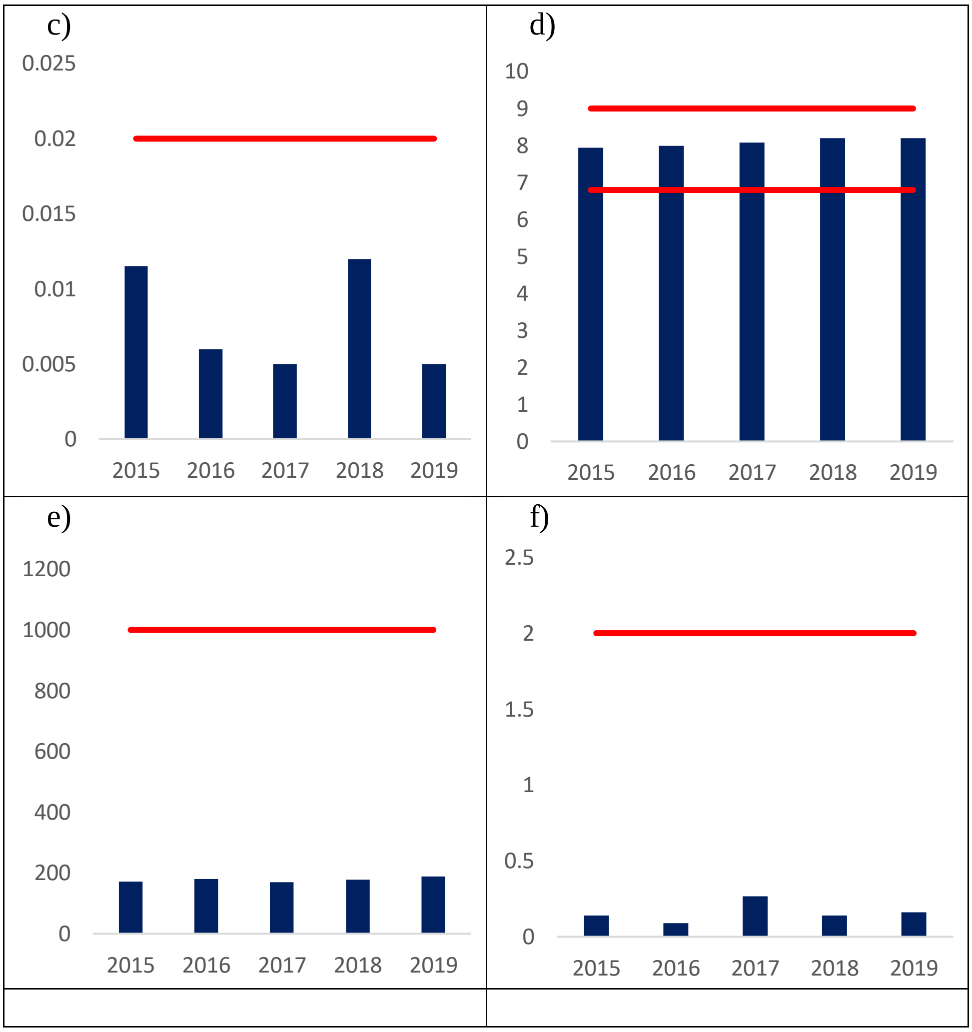


Figure 2. Trend of a) dissolved oxygen, b) S^{2-}, c) COD, d) pH, e) soluble substances, f) Fe_{total}, in the mine water of talc exploitation. Key: blue box – the value of the parameter; red line – the limit value given by the decision of the Rožňava District Office, in case of pH, the limit is given by the range between the two red lines.

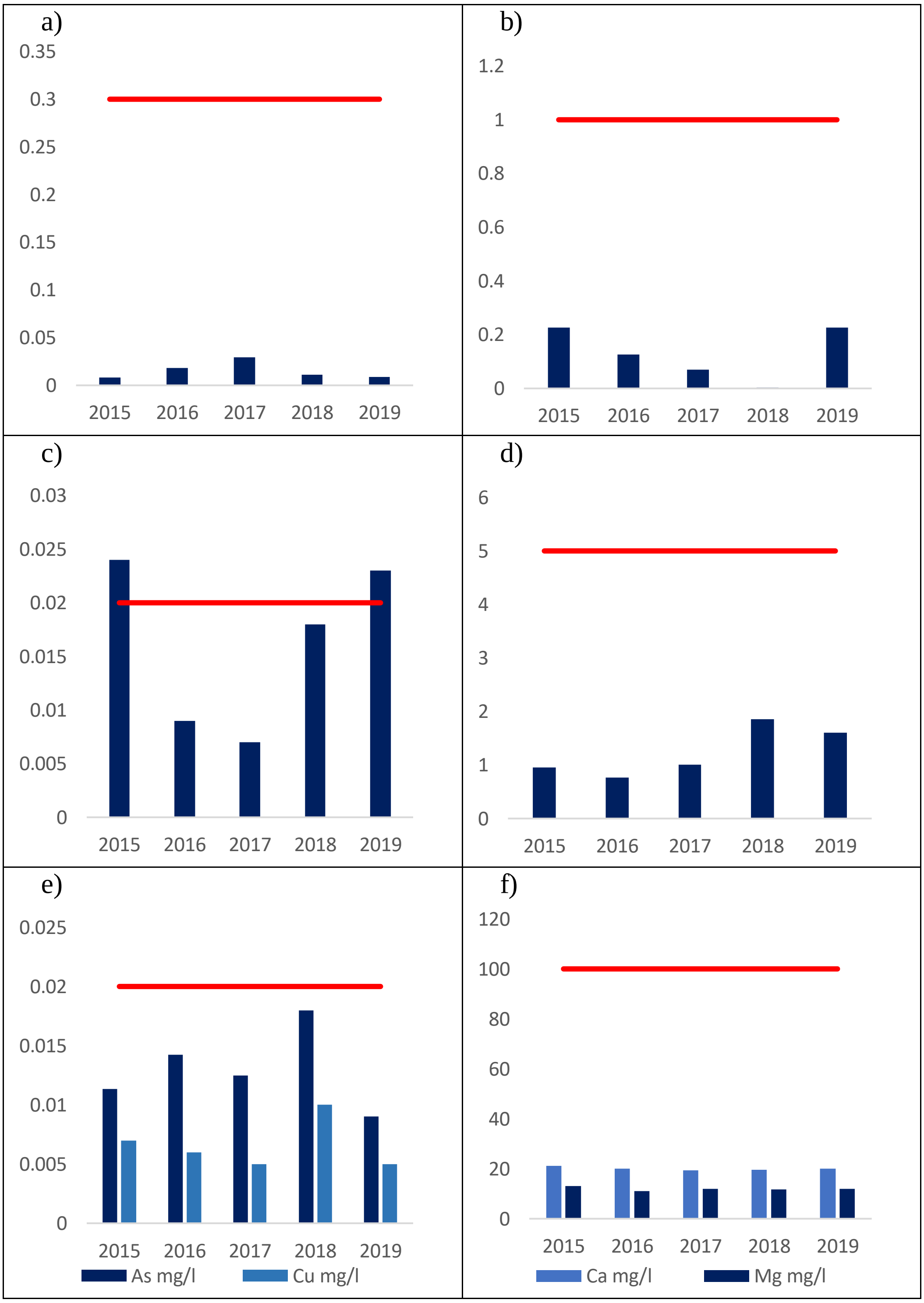
During the analysed period, the sulfane S^{2-} showed a fluctuating trend with values significantly below the limit, with the highest value in mine water in 2018 and, on the contrary, the lowest in 2017, while during the entire analysed period, the compliance of LV in terms of the Decision was observed (Figure 2b).

The chemical oxygen demand (COD) in the analysed period also showed a fluctuating trend with values significantly below the limit, with the highest value in mine water in 2018 and, on the contrary, the lowest values of less than 0.005 mg/l in 2017 and 2019, while during the entire analysed period, the compliance of LV was observed following the Decision (Figure 2c).

During the analysed period, the pH showed a relatively stable trend in the alkaline region of the water reaction, which is determined by the composition of the exploited talc raw material, while during the entire analysed period, the reaction of the mine water was within the range of OH according to the Decision (Figure 2d).

In the analysed period, the soluble substances showed a slightly fluctuating trend with values significantly below the limit, with the highest value in mine water in 2019 and, conversely, the lowest value in 2017, while during the entire analysed period, the LV was observed in the sense of the Decision (Figure 2e).

Also, the Fe_{total} showed in the analysed period a fluctuating trend with values significantly below the limit, with the highest value in mine water in 2017 and, conversely, the lowest value in 2016, while during the entire analysed period, the LV was observed not only in terms of the regulation of the Government of the Slovak Republic no. 296/201 Coll., but also in terms of the Decision (Figure 2f).



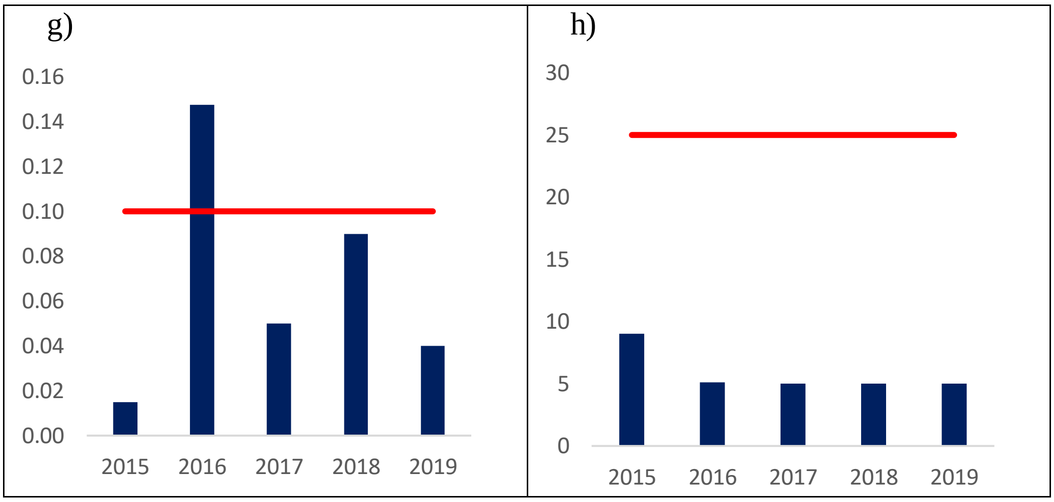


Figure 3. Trend of a) manganese, b) ammoniac nitrogen, c) nitrite nitrogen, d) nitrate nitrogen, e) As and Cu, f) Ca and Mg, g) NES, f) insoluble matter in mine water of talc exploitation. Key: blue box – the value of the parameter; red line – the limit value given by the decision of the Rožňava District Office.

Also, the Mn showed a fluctuating trend with values significantly below the limit in the analysed period, with the highest value in mine water in 2017 and, on the contrary, the lowest value in 2015, while during the entire analysed period the OH in the sense of the Decision was observed (Figure 3a).

Also, the $N\text{-}NH_4$ showed a fluctuating trend in the analysed period with significantly below-limit values characterised by development disparities, with the highest value in mine water in 2015 and, conversely, the lowest value in 2018, while the LV in the sense of the Decision was observed during the entire analysed period (Figure 3b).

The $N\text{-}NO_2$ showed a fluctuating trend in the analysed period, with the highest value in mine water in 2015 and, conversely, the lowest value in 2017, while during the analysed period the LV was slightly exceeded in terms of the Decision in 2015, specifically by 0.004 mg/l and in 2019, specifically by 0.003 mg/l (Figure 3c).

The $N\text{-}NO_3$ in the analysed period showed a fluctuating trend with values significantly below the limit, with the highest value in mine water in 2018 and, conversely, the lowest value in 2016, while during the entire analysed period, unlike $N\text{-}NO_2$, the LV was observed in the sense of the Decision (Figure 3d).

The As and Cu showed a fluctuating tendency in the analysed period, with the most As in mine water in 2018 and the least in 2019, and the most Cu in 2018 and the least in 2017 and 2019, when Cu showed less than 0.005 mg/l, while during throughout the analysed period was in both analysed heavy metals., complied with LV in terms of the Decision (Figure 3e).

The Ca and Mg showed a fluctuating tendency in the analysed period with values significantly below the limit, while the most Ca was in the mine water in 2015 and the least in 2017, and the most Mg in 2015 and the least in 2016 (Figure 3f).

The insoluble extractable substances showed a fluctuating tendency in the analysed period, while the highest insoluble extractable substances were in mine water in 2016, when at the same time there was also a slight exceedance of the LV according to the Decision by approx. 0.05 mg/l, and the lowest in 2015 (Figure 3g).

In the analysed period, the insoluble substances showed a slightly fluctuating trend of development with values significantly below the limit not only in terms of the regulation of the Government of the Slovak Republic no. 269/2010 Coll. but also in terms of the Decision, while the most insoluble substances were in the mine water in 2015 and, conversely, the least in the years 2017-2019, specifically less than 5.0 mg/ (Figure 3h).

The total volume activities α, β and Ra showed a fluctuating trend in the analysed period with significantly above-limit values of the total volume activity α in the sense of the Decision, while the highest values were in mine water in 2015 and, conversely, the lowest in 2019. Below-limit values were shown by the total volume activity β, the highest values of which were in mine water in 2019 and, conversely, the lowest in 2016. The highest values of total volume activity Ra were in mine water in 2018 and the lowest in 2015, while no limit was set for this indicator by the Decision (Figure 4).

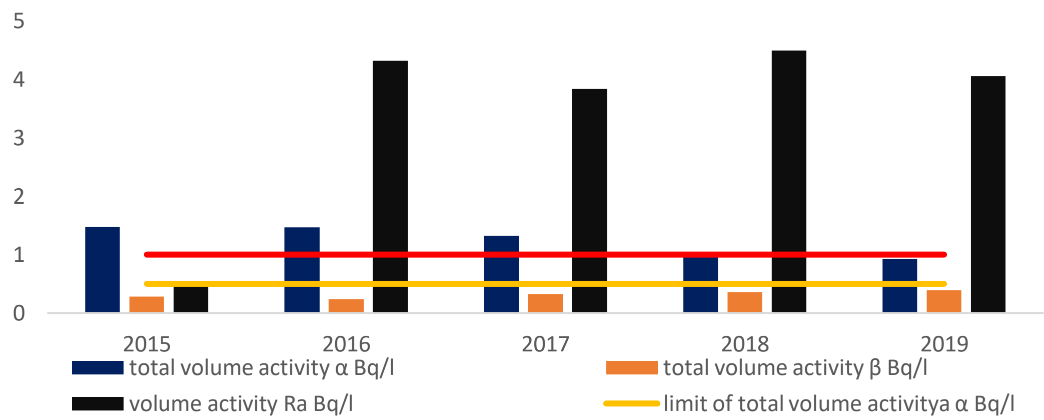


Figure 4. The development of total volume activities α, β, and Ra in the mine water of talc exploitation.

The limits in the outlet object to the recipient were not exceeded, except for the total volume activity α. Exceeding this indicator is almost constant and reflects the influence of the rock environment – gemerid granites. Considering the facts mentioned so far, it can be partially concluded that mine waters during talc exploitation do not harm the quality of the recipient, however, in the case of accidental releases of pollutants from mining and processing facilities of talc exploitation, which include areas for storage, handling of transport by wheeled and rail means of transport [19], there may be an extraordinary deterioration in the quality of mine waters, or an extraordinary threat to the quality of the water in the container.

IV. Discussion

The environmental impacts of talc processing identified in the study align with broader concerns about sustainable mineral extraction in the context of global environmental challenges [21-24]. The mining industry, responsible for approximately 100 billion tonnes of waste annually, faces increasing pressure to adopt sustainable practices that minimise environmental degradation while meeting growing global demand for mineral resources [25,26]. The findings of the study regarding mine water quality fluctuations and occasional parameter exceedances reflect systemic challenges observed across the mineral processing sector, where the balance between operational efficiency and environmental protection remains complex [27,28].

The persistent exceedance of total volume activity of α (ranging from 0.8-2.1 Bq/l) in the studied area reflects the geological influence of granitic formations, a phenomenon commonly observed in similar geological settings worldwide [29,30]. This finding is consistent with studies from other talc mining operations in metamorphic terrains, where naturally occurring radioactive materials (NORM) present ongoing challenges for water quality management [31,32]. The radioactive contamination issue extends beyond local environmental concerns, as it represents a broader challenge for the mining industry in managing naturally occurring radioactive elements during mineral processing [9].

The findings demonstrate both compliance achievements and areas requiring improvement when compared to international water quality standards. The observed nitrite nitrogen exceedances (0.004 mg/l in 2015 and 0.003 mg/l in 2019) and non-polar extractable substances (0.05 mg/l in 2016) represent relatively minor deviations that are commonly encountered in mineral processing operations [33,34]. However, these exceedances highlight the importance of implementing comprehensive monitoring programs that can detect and address water quality variations before they escalate into significant environmental concerns [35].

Modern sustainable mining practices increasingly emphasise the implementation of circular economy principles, where waste materials become resources for other processes [36,37]. The mine water recycling system employed in the studied talc operation demonstrates progress toward these principles, though opportunities exist for further optimisation through advanced treatment technologies such as membrane-based filtration and biological treatment systems [38,39]. Studies from similar operations have shown that integrated water treatment approaches can achieve up to 95% water recovery rates while maintaining strict environmental compliance [10].

The integration of advanced monitoring technologies represents a critical advancement in environmental management for mineral processing operations [11,16]. Real-time monitoring systems, incorporating satellite imagery, artificial intelligence, and automated alert systems, provide mining operators with unprecedented capability to detect and respond to environmental deviations [40,41]. The multi-year monitoring approach of the study provides valuable baseline data for implementing such advanced systems in the future.

The flotation process employed in talc processing presents both opportunities and challenges for environmental management [15,42]. While flotation enables efficient mineral separation with relatively low environmental impact compared to other processing methods, the use of flotation chemicals introduces potential risks for water contamination [43,44]. Recent developments in environmentally benign flotation reagents and collector-less flotation techniques offer promising alternatives for reducing chemical impacts on mine water quality [45].

The environmental risks associated with talc processing extend beyond immediate water quality concerns to encompass long-term ecosystem impacts, community health implications, and regulatory compliance challenges [17,18]. The findings of the study support the need for comprehensive risk assessment frameworks that consider cumulative environmental impacts over the entire mine lifecycle, from exploration through closure and post-closure monitoring [19,20].

Current regulatory frameworks in many jurisdictions are evolving to incorporate more stringent environmental protection requirements, including mandatory implementation of best available technologies and adaptive management approaches [21,46]. The EU Mining Waste Directive and similar regulations worldwide emphasise the importance of preventing pollution at source and implementing integrated environmental management systems [47].

The specific geological setting of the studied talc deposit significantly influences mine water quality, particularly regarding the persistent α activity exceedances [48]. The Gemerid granites underlying the deposit contain naturally elevated levels of uranium and thorium, which contribute to the observed radioactive signature in mine waters [49,50]. This geological influence necessitates specialized treatment approaches that may not be required in other talc mining operations with different geological settings.

The hydrogeological characteristics of the mine site, including groundwater flow patterns and rock-water interaction processes, directly influence contaminant transport and natural attenuation processes [51,52]. Understanding these site-specific factors is crucial for developing effective environmental management strategies and predicting long-term environmental impacts.

The flotation process parameters, including reagent dosages, pH conditions, and residence times, significantly influence the quality of process waters and tailings [53,54]. Our study's focus on mine water quality provides insights into the effectiveness of current process optimisation strategies, though further research into the relationship between process parameters and environmental outcomes would strengthen future environmental management approaches.

The tailings management approach employed at the studied site, utilising concrete production from inert materials, demonstrates innovative waste valorisation strategies [55,56]. This approach not only reduces waste disposal requirements but also provides economic value from materials that would otherwise require costly disposal [57]. However, the long-term environmental implications of this approach require continued monitoring and assessment.

Several research gaps emerge from the performed study that warrant further investigation. First, the long-term environmental fate of flotation chemicals and their degradation products in mine water systems requires detailed investigation, particularly under varying pH and redox conditions [58,59]. Second, the effectiveness of different treatment technologies for addressing the specific contaminant profile observed in talc processing operations needs systematic evaluation [60,61].

The development of predictive models for mine water quality evolution over the 50-70 year projected mine life would support proactive environmental management planning [62,63]. Such models should incorporate site-specific geological, hydrological, and operational factors to provide reliable forecasting capabilities for environmental managers and regulatory authorities.

The findings from the study contribute to the development of industry best practices for talc processing operations worldwide. The successful implementation of mine water recycling and waste valorisation strategies provides a model for other operations seeking to improve their environmental performance while maintaining operational efficiency.

Technology transfer opportunities exist for sharing successful environmental management approaches across the talc mining industry and related mineral processing sectors. The establishment of industry-wide environmental performance benchmarks and the sharing of best practices through professional associations and technical conferences would accelerate the adoption of sustainable practices across the sector.

The long-term success of mineral extraction operations increasingly depends on maintaining social license to operate through transparent environmental management and community engagement [64,65]. The findings of the study support the importance of proactive environmental monitoring and public reporting of environmental performance data to maintain community trust and regulatory approval.

The integration of local community concerns and traditional ecological knowledge into environmental management planning represents an important opportunity for improving both environmental outcomes and social acceptance of mining operations [66,67]. Future research should explore mechanisms for incorporating stakeholder input into adaptive environmental management frameworks for mineral processing operations.

V. CONCLUSION

Talc processing, particularly flotation and tailings management, introduces environmental risks requiring stringent monitoring and control. The study emphasises the need for improved waste management practices, enhanced infrastructure resilience, and regulatory compliance to minimise adverse environmental effects. The talc deposit near Gemerská Poloma in the Rožňava district contains talc reserves for extraction during the next 20 to 30 years. In addition, underground exploration is still ongoing in the location, based on which the mining period should be extended to 50 to 70 years. The extraction of talc is accompanied by several potential risks that can threaten the quality of the environment, including environmental health. During the extraction of talc, mine waters are produced, the quantity and quality of which depend mainly on the intensity and method of extraction. Mine waters are used for the flotation treatment of talc raw material and to produce concrete in the concrete plant.

The trend of mine water quality was monitored, and the values were compared with the relevant permits. It is possible to state:

- the contents of dissolved oxygen, sulfane content, COD, soluble and insoluble substances, Fe_{total}, Mn, $N\text{-}NH_4$, $N\text{-}NO_3$, As, Cu, Ca, and Mg were fluctuating, the limits were not exceeded,
- pH was stabilized, the limits were not exceeded,
- $N\text{-}NO_2$ content was fluctuating, the limits were slightly exceeded for two years,
- non-polar extractable substances were fluctuating, the limits were slightly exceeded for one year,
- the total volume activities of α, β, and Ra were fluctuating; the limits of the total volume activity of α were significantly exceeded, and the limits of the total volume activity of β and Ra were not exceeded.

Based on the study results and the facts mentioned above, it can be concluded that mine waters during the exploitation of talc do not negatively affect the recipient's quality.

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