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Development of environmental costs in mining company after implementation of innovation - cyclone separator

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Abstract
This article summarizes the scientific discussion on the environmental costs of mining companies. Reducing environmental pollution in mining companies is focused on three strategies. The raw material intensity decrease is the first strategy. The second strategy is orientated to changes in the production of environmental products. The third strategy is directed at the consumption of products and liquidation after their lifetime. The priority goal of this paper was to demonstrate the development of environmental costs after the implementation of cyclone separators focusing on the expenses in the field of water management. Methods of research were focused on using index analysis and structure analysis. Base index and chain index were used in the analysis of the index. The object of the article was the mining company focused on mining limestone in Slovakia. The priority problem is the dust of the mining process. The research brings new solving a cyclone separator in the mining process for reducing dust. The goal "Operational Program Environment" is to invest in the water sector, creating mining companies' problems. Mining companies use water resources for their mining activities. The results of the study show decreasing in environmental costs. Water and sewerage fees eliminate by 11.1 %, air pollution charges by 11.5 %, disposal fees by about 5.2 %, and towing the sump by 1.5 %. The purpose of the mining company is to address environmental costs as a priority issue related to environmental protection. Competitive advantage for the mining industry introduces efficient and acceptable solutions - innovations.

Keywords
costs, efficiency, index, innovation, mining

Introduction

The basic strategy of mining companies is to reduce the burden on the environment and the protection of environmental components in terms of sustainable development (Cehlár et al., 2021). Mining companies significantly affect the quality of the environment. Mine dust is one of the main disasters that threaten the safety of mine extraction, deteriorate the working environment, and induce various occupational diseases. The over-exploitation of mineral resources goes to increasingly serious dust pollution (Ji et al., 2022). The strategic goal of the business is to achieve environmental sustainability (Suchánek et al., 2013). Risk management is a part of environmental management that aims to prevent catastrophes in the ecological area. It is a way to ensure the protection of life and nature in ecological, social, and economic aspects (De Benedicto et al., 2021). Environmental sustainability is built on the approach of Green Growth (Sayetbekovna K.U., 2022).

Green growth is about merging environmental and social protection with economic growth. The OECD countries follow the progress toward greening through a set of indicators. Green growth approach indicators monitor CO2 productivity, material productivity, energy productivity, water consumption, and percentage of municipal waste treatment by recycling, composting, and others (Gavurová et al., 2021). Solving the problem with mining dust is the object of this study. For the environment, mine dust pollution is considered a significant threat. The mining dust influences vegetation, landscapes, weather conditions, and air quality. This problem leads to serious environmental damage around the world (Yu et al., 2023). Mine dust is one of the main disasters that threaten the safety of mine production, deteriorating the working environment and inducing various occupational diseases. One of the alternatives to solving this problem is foam technology for mining dust. Foam technology for dust control has been widely used in coal mines (Ji et al., 2022).

The main purpose of mining companies is to focus on three basic strategies in the process of environmental protection and creation. The first strategy is aimed at reducing the raw material intensity of business activities. This strategy focuses on adhering to the legislative law and instruments in raw materials and their use in mining processes (Umarjonovna et al., 2023). The second step of this strategy is the efficient use of environmentally oriented resources - environmental regulation and green technology innovation (Du et al., 2021). Water is a basic natural resource in mining companies and is used for other recycling activities in mining processes as a very important instrument for the circular economy (Cehlár et al., 2021). The water environment is influenced by more factors that influence the mining process (Biały et al., 2015). In the selected mining company, water resources are the base for the mining process and for eliminating the negative effects on the environment of dust pieces.

This paper's main goal is to show the development of environmental costs after implementing an innovative - cyclone separator focusing on the environmental costs in water management. The priority goal is to reduce mining dust through innovative technology and decrease environmental costs by focusing on water consumption. The second strategy focuses on the environmental efficiency of products in order to reduce the consumption of raw materials and energy, with water being considered a source of energy in mining processes (Suchánek et al., 2015). The quality of products is influenced by inputs such as raw materials and energy in mining companies. The inputs and outputs must be controlled by implementing a quality management system through various important indicators for business performance (Potkany et al., 2020). Satisfaction of customers depends on improving the quality of products, which means the mining company gives customers active quality - the best quality of extraction raw material (Markulik et al., 2021). Active quality of products in mining companies means innovations and sustainable raw materials (Kot et al., 2019).

The third strategy is focused on the environmentally friendly disposal of products after their lifetime and the efficient use of all forms of waste that arise in the production process of the mining organization, such as wastewater (Škvareková et al., 2021). The process is connected to effectively transporting water waste, which creates high costs for the mining company. With the depletion of global resources and the deterioration of the ecological environment, the realization of green reverse logistics management becomes necessary for introducing green growth (Cheng et al., 2022).

Green reverse logistics is a new type of reverse logistics that aims to improve resource utilization and protect the ecological environment. While promoting sustainable development, "green reverse logistics" has social and economic significance (Wu et al., 2022). Sustainable transport in the mining environment can be used for conveyor belts to achieve sustainability (Andrejiová et al., 2021). The important role of transport plays in the maintenance process and employee learning in the preventive maintenance in the mining company (Bilan et al., 2020). From the point of view of sustainable use of water resources, it is necessary to prevent unnecessary waste of water in the mining company and to find out risks and reserves that create a safety process (Hao et al., 2022).

Indicators for the business model are the elimination of losses in the water supply network, setting limits on water use based on their self-renewal rate, increasing the use of useful water for drinking water protection watercourses and making effective use of land reclamation (Gomes et al., 2020). The base of post-mining areas is used for reclamation as a base of sustainability of the mining environment (Biały et al., 2014). The intention of environmental policy of the European Union consists of 13 chapters: General policy provisions, The atmosphere, Garbage, Water, Environment in cities, Protection of nature and biodiversity, Industry, Chemical substances, and

biotechnology, Enlargement of the EU, Environmental impact assessment, Environmental law, and economics, Nuclear safety, Protection of the population. The chapter Environmental Economics is also the preference of projects aimed at saving and rational use of water and energy (Don Bosco et al., 2021). This chapter connects with environmental costs and environmental taxes that introduce the base economic view of environmental pollution (Ramzan et al., 2022).

Material and Methods

As part of the scientific research, we proceeded based on the algorithm of steps (Fig.1), which was the basic tool for managing the implemented project in a selected mining company in Slovakia. Various methods were used in solving the project, such as analytical, statistical, and graphical. We deal with the environmental costs of development in the mining company after innovation.

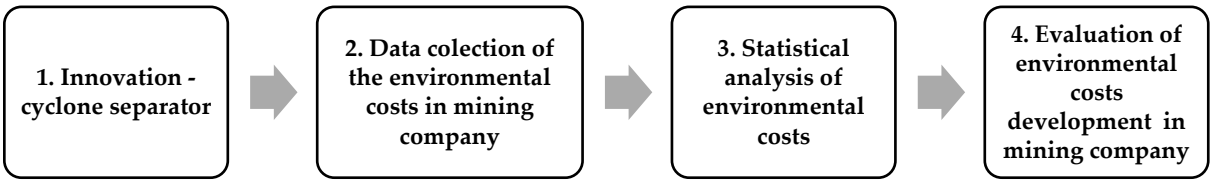

Fig. 1. The algorithm of the research in selected mining company
Source: own source

In the selected mining company, as part of the elimination of environmental costs in the field of water management, a cyclone-separator machine (Fig. 2) was designed and implemented to capture dust particles during the mining process in the year 2017. The main problem of the environment in the mining company was air pollution. In the filter stacks, limestone flour causes dust, and therefore it was necessary to provide a new cyclone-separator that prevents and traps small particles of limestone flour. This innovation can eliminate environmental costs for the mining company. The mining company has to deal with high dust by sprinkling with water resources, and therefore water and sewage costs are the highest items of environmental costs.

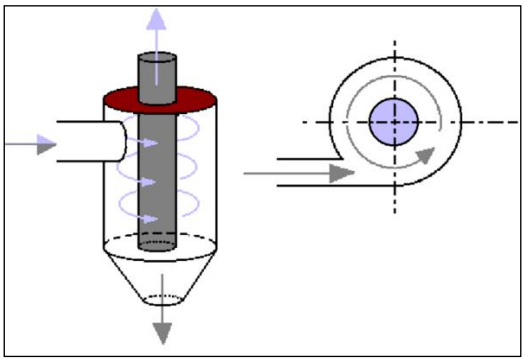

Fig. 2. The cyclone separator machine
Source: own source

The main significance of the new innovation machine for the mining company: The principle of separation in a cyclone is a combination of gravity and centrifugal forces. The gases that enter the cyclone rotate, and a gas vortex is created. The centrifugal forces separate the ash particles from the carrier gas and push them towards the wall of the cyclone, after which they slide to the bottom into the hopper. Cyclone separation is a method of removing particles from air, gas, or steam without the use of filters. The rotational effect and gravity are used to separate the solid-liquid mixture. The high speed of rotation of the air is formed in a cylindrical or conical container called a cyclone. The air flows in a spiral, starting at the cyclone's top (wider end) and ending at the bottom, where the air continues to flow through the cyclone's centre and exits the top. Larger (denser) particles in the rotating stream have more inertia to flow in a tight curve and hit the outer wall, then fall to the bottom of the cyclone, where they can be removed. In a conical system, where the current rotates relative to the narrow end of the cyclone, the rotational radius of the current is reduced, and thus smaller particles are separated.

Data collection was realized in the mining company at the Department of Environment. Environmental costs are monitored in financial accounting in the mining company in the part of accounting on account 501- 588. The mining company used analytical evidence for environmental costs. The statistical analysis of the mining company's environmental costs will include the following indicators:

The base index indicator (Ib) follows the current period with the base period, with the base period being a well-defined year that remains fixed. This indicator is used to monitor changes in business cycles or long periods of time.

$$Ib = N_1/Nb \quad (1)$$

Legend: $N_{1,b}$ environmental costs (€) in real-time, basic time.

The chained index (Ir) indicator calculates the proportion of the two continually followed periods. This indicator is used to monitor changes in real-time to give information about trends of development of environmental costs.

$$Ir = N_1/N_0 \quad (2)$$

Legend: $N_{1,0}$ environmental costs (€) in two selected time periods.

The cost structure (Šn) indicator is an economic indicator that monitors the share of individual cost items to the total costs in percentage.

$$Šn = Nj/N_c * 100 \quad (3)$$

Legend: *Nj* environmental costs (€), *Nc* – the sum of environmental costs (€).

Evaluation of environmental costs according to chain and base index is very important for trends. In general environmental costs have to be minimalized in the selected period. If the index is lower than the number 1, the costs decrease - a positive trend declines. If the index is higher than the number 1, the costs increase - a negative trend, growth". If the value of the index is 1, it means the economic parameters are the same as last year. It is not any change of growth or decline. Cost structure presents the share of the individual environmental cost of the sum of the environmental cost in the mining company. We can refer to the risks and reserves on the base of the structure.

Results and Discussion

The economic impacts of environmental pollution were analyzed in a selected mining company (Fig. 3). This mining company is focused on the extraction and processing of limestone, dolomite, refining, grinding, and sorting of limestone, especially in the field of metallurgy. The mining company's strategy is focused on expanding briquet and granulation due to growing market demand and diversification of business in the field of metallurgical waste materials recycling. The product range of the mining company is limestone gravel, sand, flour, and quarry stone. The offer of steel materials is relatively wide and offers lump lime, lime briquettes, a mixture for injection metallurgy, a mixture for desulphurizing pig iron, synthetic slag, covering slag, coagulator, and others. Due to the offer of the mining company's assortment, it is necessary to take into account the impacts on the environment. The mining company must also use water resources to ensure environmental extraction as part of its production program. The mining process produces dust that needs to be humidified, so the mining company is forced to use water resources.

Fig. 3. Mining company and mining environment
Source: own source

In this paper, we analyze the partial economic impacts of using water resources and wastewater discharges in the mining company and monitor the development of environmental costs after introducing the innovative - cyclone separator. The mining company pays fees for water and sewage, wastewater, and cesspool fees, which represent for the mining company a cost item in the field of water management, which had to be monitored after

the implementation of the cyclone. These costs are part of the mining company's environmental costs, which are reflected in profits and point to effective pollution management. The mining company uses water for sprinkling to prevent large dust generated by the mining process during the production, limestone production, and significantly damages the environment around the quarry. We followed the trend of water and sewerage fees over 6 years (Tab.1). Those costs are connected with the innovation cyclone separator in a mining company in 2017.

Tab. 1. Environmental costs in water management 2016-2021

Year	Water and sewerage fees (€)	Wastewater (€)	Towing the sump (€)
2016	2847	281	387
2017	1783	327	213
2018	1664	295	229
2019	1596	276	246
2020	1556	256	218
2021	1523	238	221

Source: internal documents

All countries actively promote green economic transformation in water management. Formulating reasonable and effective environmental regulation policies is an important way to realize these changes (Cheng et al., 2022). Raising standard sewage charges, water and disposal fees, and raising environmental costs creates possibilities for technological innovation and environmental regulations that can change the economic growth model and realize green industrial development (Cheng et al., 2022). Reducing the environmental burden is a priority for the mining company and a factor that can cause business risks. From the point of view of achieving a competitive advantage and gaining a foothold in the extractive industry market, it is important that the extractive company seeks efficient and acceptable solutions for all parties involved. We statistically evaluated individual fees (Tab.2) in the area of water management by means of an index analysis via a basic index (Formula 1); the base is the year 2017, cyclone separator implementation and (Tab. 3) chain index (Formula 2).

Tab. 2. Index analysis - basic index 2016-2021

Year	Water and sewerage fees ()	Wastewater ()	Towing the sump ()
2016	1.59	0.85	1.81
2017	1	1	1
2018	0.93	0.90	1.07
2019	0.89	0.84	1.15
2020	0.87	0.78	1.02
2021	0.85	0.72	1.03

Source: own source

The results of the index analysis according to the base index - the base is 2017 is the year of implementation of the innovation - the cyclone separator point to the reduction of costs for water and sewage, wastewater. The cost of towing the sump still shows a value above 1, which means higher costs than the value in the base year. The reduction of water, sewage, and wastewater costs is related to the innovation associated with the reduction of dust in the mining area, which in terms of efficiency, can be considered an effective investment and benefit for the mining company. The savings on water and sewage were recorded due to technological modifications to the equipment for the area of air to reduce dust in the extraction and processing of limestone. Wastewater arises from mining activities and, in particular, wastewater from the reduction of air pollution by dust that needs to be sprinkled and the operation of wet mechanical separators, which are very important for the company due to the separation of solid pollutants from produced materials, which are separated through separation of solid particles. Wastewater discharges are set based on the polluter pays principle based on the quantity for the calendar year, month, and, at the same time, the fee also takes into account concentration limits and balance limits. The obligation to pay fees does not apply to the discharge of wastewater from turbine cooling, the sewerage network's relief facilities, or reinjected wastewater from geothermal water sources.

Tab. 3. Index analysis - chain index 2016-2021

Year	Water and sewerage fees ()	Wastewater ()	Towing the sump ()
2016	-	-	-
2017	0.62	1.16	0.55
2018	0.93	0.90	1.07
2019	.95	0.93	1.07
2020	0.97	0.92	0.88
2021	0.97	0.92	1.01

Source: own source

The index analysis results, according to the chain index, point to the reduction of costs for water, sewage, and wastewater from 2017. The cost of towing the sump still shows various values that are increasing (2018, 2019, 2021) and decreasing (2017, 2020). The costs of water and sewerage fees and wastewater step by step are lower in the period 2016-2021, which is connected by innovation - cyclone separator. The cost - the pooling of the sump in the period 2016-2021 has recorded various trends - decline and growth. The mining company also pays fees for pooling the sump according to the filling and the volume of the sump. If the sump fills up faster, it is affected by increased production and mining, and the second factor is the weather. Changes in the number of costs were due to the state of mining in the mining company and the stochastic factor - weather, which the company cannot influence.

Environmental costs are monitored through an established environmental management system. The EMS system brings energy, water, waste minimization, and recycling savings. The EMS system enables clarity of environmental costs, minimization of environmental charges, and fines for environmental pollution. The development of environmental costs in the mining company presents Tab.4.

Tab. 4. Environmental costs in mining company 2016-2021

Year	Water sewerage fees (€)	Waste water (€)	Towing the sump (€)	Fees for extracted minerals (€)	Mining area fees (€)	Waste disposal fees (€)	Air pollution charges (€)
2016	2847	281	387	550	332	668	1323
2017	1783	327	213	276	332	467	1184
2018	1664	295	229	1015	332	1166	876
2019	1596	276	246	1220	332	983	657
2020	1556	256	218	1150	332	765	594
2021	1523	238	221	1070	332	758	687

Source: internal documents

Environmental costs are analyzed by cost structure (Formula 3) in the mining company (Tab.5). The results of the total environmental costs of the mining company are the highest in water and sewerage fees. The level of structure is 29.8%-44.6% during the selected period 2016-2021. The second risk type of environmental cost is fees for extracted minerals from the year 2018 to 2021 in structure 18.10%-23.6%. The third type of environmental cost was air pollution charges and waste disposal fees. In the years 2016-2017 was a structure of air pollution charges on the level of 20.7%-25.8%, and after the year 2017, this structure decreased, and the structure of waste disposal fees was 18.5%-20.9% in the years 2018, 2019.

Tab.5. Structure of environmental costs 2016-2021

Year	Water sewerage fees (%)	Waste water (%)	Towing the sump (%)	Fees for extracted minerals (%)	Mining area fees (%)	Waste disposal fees (%)	Air pollution charges (%)
2016	**44.6**	4.4	6.1	8.6	5.1	10.5	**20.7**
2017	**38.9**	7.10	4.6	6.0	7.2	10.1	**25.8**
2018	**29.8**	5.5	4.10	**18.10**	5.9	**20.9**	15.7
2019	**30.0**	5.20	4.6	**22.9**	6.2	**18.5**	12.4
2020	**31.9**	5.20	4.5	**23.6**	6.8	15.7	12.3
2021	**31.5**	4.9	4.6	**22.2**	6.8	15.7	14.3

Source: own source

Sustainable development requires an absolute reduction of the overall burden on the environment and, at the same time, a minimal environmental impact of the relevant economic activity, which is expressed in terms of environmental costs (Fig.4). Economic instruments in the field of the environment represent environmental costs which, in terms of efficiency, should fulfil the incentive function, which is realized when their application leads to a reduction in costs in the mining companies and safety and protection environment. The development of the mining industry is assessed from the economics through the growth rate of gross domestic product (GDP) and through the national aspect of the national economy's growth rate (Pavolová et al., 2022).

Development of environmental cost in a mining company in 2021 presents: Water and sewerage fees create 31.5%, the second type of environmental cost are fees for extracted minerals 22.2%, and the third type is waste disposal fees 15.7%. Those environmental costs are critical and very important for a mining company in the financial area because they create costs.

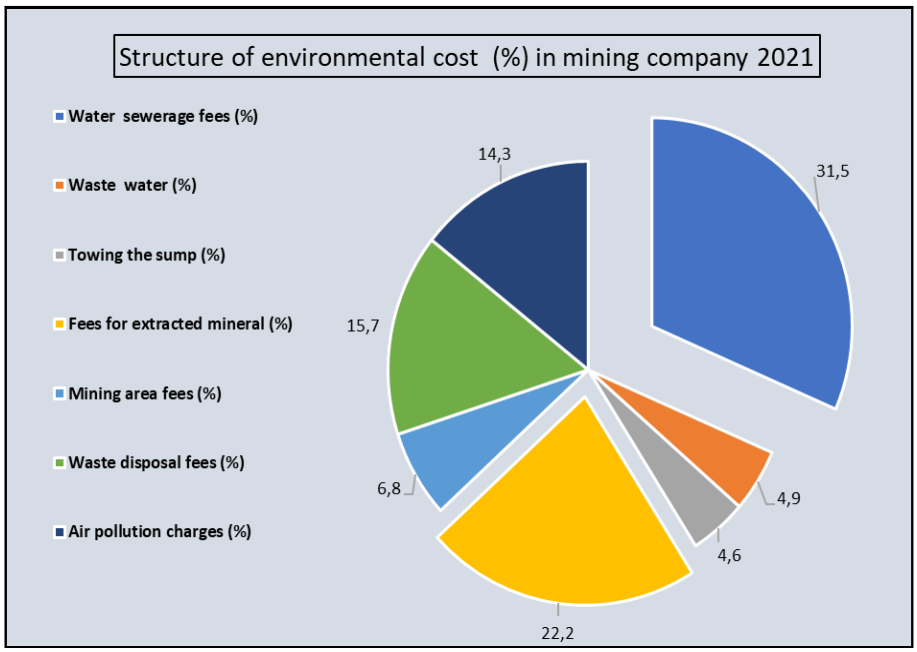

Fig. 4. Structure of environmental cost
Source: own source

Conclusion

Economic growth and development of business activities industry affect environmental pollution. Reducing environmental pollution is part of the Operational Program Environmental Quality in Slovakia. In the field of water management, the Operational Program Environmental Quality focuses on wastewater, drinking water, water monitoring, ensuring the continuity of watercourses, as well as conceptual and information activities. This operational program inspired the mining company to implement the cyclone separator in the mining company in terms of reducing environmental costs. In the mining company, it was a problem with the structure of environmental costs. The main goal of this paper was to show the trend of environmental costs after implementing an innovative - cyclone separator focusing on the environmental costs of water management. The highest environmental costs are water and sewerage fees in 2021, a value of 1523 € which means structure 31.5% of all environmental costs. This is a reason to improve this type of environmental cost.

The Slovak Innovation and Energy Agency, as an intermediary body for the Operational Program Environmental Quality (www.minzp.sk), has issued guidelines for a call aimed at reducing energy intensity and increasing the use of renewable energy sources in companies. Economic instruments are seen as one of the options to support positive changes in environmental protection and natural resource management. The environmental effectiveness of their application lies in the reduction of negative effects on the environment and the reduction of environmental damage and costs.

References

Andrejiová, M., Grinčová, A. and Marasová, D. (2021). Identification with machine learning techniques of a classification model for the degree of damage to rubber-textile conveyor belts with the aim to achieve sustainability. *Engineering Failure Analysis.* 127 (1), 1-12. doi:10.1016/j.engfailanal.2021.105564.

Biały W. (2014). Post-mining areas reclamation – case study. 14th SGEM Geo-Conference on Science and Technologies *In: Geology, Exploration and Mining,* SGEM2014 Conference Proceedings, June 17-26, (3), 443-450, ISSN 1314-2704. doi: 10.5593/SGEM2014/B13/S3.058.

Biały W. and Mroczkowska P. (2015). Influence of coal waste heaps on water environment in upper Silesian borderland areas – case study. 15th SGEM Geo-Conference on Science and Technologies *In: Geology, Exploration and Mining,* SGEM2015 Conference Proceedings, June 18-24, 2 (3), 675-682, ISSN 1314-2704. doi:10.5593/SGEM2015/B13/S3.088.

Bilan, Y., Hussain, H.I., Haseeb, M., and Kot, S. (2020). Sustainability and economic performance: role of organizational learning and innovation. *Sustainability.* 31(1), 93-103. doi:10.5755/j01.ee.31.1.24045.

Cehlár M., Čulková K.; Pavolová H.; Khouri S., 2019, Sustainability of Business with Earth Sources in V4. *In: 4th International Innovative Mining Symposium.* Bristol, Great Britain, Edition Diffusion Presse Sciences 105 (1), 1-7. doi:10.1051/e3sconf/201910504038.

Cehlár, M., and Šimková, Z. (2021). Critical raw materials as a part of sustainable development. *In: Multidisciplinary Sciences. Miskolc: Miskolci Egyetem,* 11 (5), 12-23. doi:10.35925/j.multi.2021.5.2.

Cheng, Z., & Li, X. (2022). Do raising environmental costs promote industrial green growth? A Quasi-natural experiment based on the policy of raising standard sewage charges. *Journal of Cleaner Production*, 343, 131004. doi:10.1016/j.jclepro.2022.131004.

De Benedicto, S.C., Bittencourt, J. J., Silveira, L.L., da Silva, L. H. V. (2021), Environmental law, sustainability and mining companies: risk management and environmental disasters. *Humanidades & Inovacao*, 8 (46), 318-333, ISSN 2358-8322.

Donbosco, I. S., and Chakraborty, U. K. (2021). An IoT-Based Water Management System for Smart Cities. *Water Security and Sustainability*. (1), 247-259. doi:10.1007/978-981-15-9805-0_21.

Du, K., Cheng, Y., & Yao, X. (2021). Environmental regulation, green technology innovation, and industrial structure upgrading: The road to the green transformation of Chinese cities. Energy Economics, 98, 105247. doi:10.1016/j.eneco.2021.105247.

Gavurová, B., Megyesiová, S. and Hudák, M. (2021). Green Growth in the OECD Countries: A Multivariate Analytical Approach. *Energies.* 14(20) 1-20. doi:10.3390/en14206719.

Gomes J.G.C., Okano M.T., Otola M.T., (2020). Creation of indicators for classification of business models and business strategies in production systems. *Polish journal of management studies*. 22 (2), 142-157.doi: 10.17512/pjms.2020.22.2.10.

Hao, M., & Nie, Y. (2022). Hazard identification, risk assessment and management of industrial system: Process safety in mining industry. *Safety science*, 154 (1), 105863. doi: 10.1016/j.ssci.2022.105863.

Ji, M., Sun, Z., Guo, H. (2022). The Application of the Foam Technology to the Dust Control for Reducing the Dust Injury of Coal Mines. *Applied Sciences.* 12(21)10878.doi.org/10.3390/app122110878.

Kot, S, Stefko, R Dobrovic, J., Rajnoha, R., and Vachal, J. (2019). The main performance and effectiveness factors of sustainable financial administration reform using multidimensional statistical tools. *Sustainability.* 11(13), 609-618. doi:10.3390/su11133609.

Markulik, Š., Nagyová A., Turisová R., and Vilinsky T. (2021). Improving quality in the process of hot rolling of steel sheets. *Applied sciences.* 11(12), 146-153. doi:10.3390/app11125451.

Pavolová, H., Čulková, K., Šimková, Z., Seňová, A., & Kudelas, D. (2022). Contribution of Mining Industry in Chosen EU Countries to the Sustainability Issues. *Sustainability*, 14(7), 4177. doi:10.3390/su14074177.

Potkany M., Gejdos M., Lesnikova P., and Schmidtova, J. (2020). Influence of quality management practices on the Business performance of Slovak manufacturing enterprises. *Acta Polytechnica Hungarica*. 17(9), 161-180.

Ramzan, M., Raza, S. A., Usman, M., Sharma, G. D., & Iqbal, H. A.(2022). Environmental cost of non-renewable energy and economic progress: Do ICT and financial development mitigate some burden? *Journal of Cleaner Production*, 333 (1), 130066. doi: 10.1016/j.jclepro.2021.130066.

Sayetbekovna, K.U. (2022). Environmental management, types and objectives. *American Journal of Interdisciplinary Research and Development,* 9 (1), 287-290.

Škvareková, E., Taušová, M., Seňová, A., Wittenberger, G., Nováková, J. (2021). Statistical evaluation of quantities measured in the detection of soil air pollution of the environmental burden. *Applied Sciences,* 11(7), 1-14. doi: 10.3390/app11073294.

Suchánek, P., Králová, M., Marinčin, P., Pokorná, J., Rešlová, M.., Richter, J., Seláček, M. (2013). Influence of quality to performance and competitiveness. 147, Brno. ISBN 978-80-210-6627-4. doi: 10.5817./CZ.MUNI.M210-6627-2013.

Suchánek, P., Richter, J., & Králová, M. (2015). Customer satisfaction, product quality and performance of companies.*Review of economic perspectives,* 14(4), 329-344. doi:10.1515/revecp-2015-0003.

Umarjonovna, D. D., and Akbaralievna, Y. M. (2023). Global Environmental Problems and Their Solution. Web of Semantic: *Universal Journal on Innovative Education*, 2(3), 326-330.

Wu, Z. Q., Zhao., Z. Q. (2022). Sustainable development of green reverse logistics based on blockchain. *Journal of environmental and public health,* 2022 (3797765). doi:10.1155/2022/3797765.

Yu, H. X., Zahidi, I. (2023). Environmental hazards posed by mine dust, and monitoring method of mine dust pollution using remote sensing technologies: An overview. *Science of the total environment.* 864 (161135). doi:10.1016/j.scitotenv.2022.161135.