International Business Management 9 (5): 935-939, 2015
ISSN: 1993-5250

Evaluating the Effectiveness of Utilization of Mining Waste

Vladimir I. Golik, Alexander N. Doolin, Maria A. Komissarova and Roman A. Doolin
South-Russian State University of Technology, Rastor Oblast, Russian Federation

Abstract: The estimation was given for methods for determination of environmental costs and criterion to evaluate, the mineral potential of the region in the form of discounted earnings with the compensation costs for the preservation of the environment recommended. It is proposed to evaluate the effectiveness of the use of secondary mineral potential, taking into account environmental and economic situation, the cost of goods of recyclable resources and increasing effectiveness of subsoil use. Using an example of a mining company, it is shown how the use of non-traditional technological schemes provides both economic and environmental benefits.

Key words: Mineral raw materials, mineral resources, technology, mechanochemistry, compensation

INTRODUCTION

The main danger to environment comes from chemicals of natural desalination of mining waste storage facilities. It is determined by the nature and time of contact of solid and liquid media, the ratio of sulfides and carbonates, amount of carbon dioxide and pyrrhotite, etc. (Golik *et al*., 2008).

Reclamation of tailing dumps without tails disposal does not diminish but increases the risk at the expense of manifestations of new, unexplored and unpredictable factors operating indefinitely. Damage from the impact of the tailing dumps may exceed the value of the extracted minerals, especially since, the average period of existence of mines is a few 10 of years and the tailing dumps-centuries.

The main mechanism of pollution the release of the chemical element from a mineral matrix as a result of natural physical, chemical and bacterial processes. It is opposed to a controlled process of metals technological extraction from tailings with providing security to secondary tails for use without sanitary restrictions. (Kaplunov *et al*., 2003).

Valuation techniques as a criterion for appropriate technology use: the cost of production, profit, capital costs, profitability, differential mining rent and other parameters.

Lack of techniques lies in the fact that they do not take into account environmental aspects of environmental destruction with waste which reduces confidence in the economic calculation.

Evaluation of environmental costs requires changes in the methodical approach to the selection of criterion and indicators of the mineral and resource potential of the region (Polukhin *et al*., 2014).

MATERIALS AND METHODS

The efficiency of mining waste utilization is considered on the example of usage of waste of enriching and metallurgical processes of ores during underground mining in conditions of Sadonsky lead-zinc plant.

The existing methodologies for determining environmental costs are analyzed and it is recommended to evaluate, the effectiveness of the use of secondary mineral and raw material potential, taking into account the ecological and economic situation using another complex criterion.

The example of a mining company getting both economic and environmental benefits through, the use of non-traditional technological schemes is considered. The economic effects of production of substandard raw materials after the change of its properties in activators are studied.

Economic modeling of indicators of technologies with receipt of quantitative parameters of processing is carried out.

The statement that the combination of traditional innovative technology can provide both economic and environmental benefits is proven.

Main part: Economic and environmental assessment of the effectiveness of tailings processing in the region that has secondary mineral and raw material potential is proposed to be determined as the sum of effects:

$$Э = \sum_{i=1}^{n} Э_i$$

Where:

$Э_i$ = The total environmental, social and economic effect

n = The number of estimated effects

Corresponding Author: Vladimir I. Golik, South-Russian State University of Technology, Rastor Oblast, Russian Federation

The criterion of effectiveness of waste utilization is represented by the sum of profit or notional income at waste disposal. Its introduction puts companies on an equal footing, since disposal costs depend on their technological capabilities, the more correct technology is the lower are the costs for rehabilitation of environment (Shestakov, 2000).

Effective utilization of tailings consists of reducing the amount of environmental damage caused by the storage of tailings, the value obtained in the processing of products, raw materials for the construction industry and corresponding consumable goods (Burdzieva, 2010).

In assessing, the impact of the storage of materials usually only tangible aspects are considered: land employment for the tailings, dumps, etc. Even in incomplete form, the damage reaches 50-75% of the production costs.

If we assess, the damage to environment, not only now but also after an indefinitely long time afterwards, its scale will be bigger (Golik *et al.*, 2014):

$$\sum_{i=1}^{t} Y_Э = \sum_{i=1}^{t}\left(Y_p \times n + Y_Э \times m + Y_Л \times p\right)$$

Where:

$Y_р$, $Y_Э$, $Y_л$ = Damage during exploration, exploitation and elimination of mines and factories

n, m, p = Existence of enterprises stages duration specific weights

At the exploration stage, it is not possible to organize active waste utilization, so the damage caused by the storage of waste and tailings:

$$Y_p = \sum_{t=1}^{t}\sum_{n=1}^{n}\sum_{k=1}^{k} M_e \times Ц_M + \sum_{t=1}^{t}\sum_{r=1}^{r}\sum_{f=1}^{f} QЦ_q \rightarrow \max$$

Where:

t = Time of tailings storage

n = Number of leachable components

k = The number of self-organization effects

M_e = Quantity of metals entering environment from tailings

$Ц_M$ = The price of useful components

r = The number of direct factors of environment abuse

f = No. of secondary factors of environmental violations

Q = The number of beneficial effects lost during violation of useful effects ecology

$Ц_q$ = The cost of lost effects and quality

When processing waste disposal hazard for environment does not decrease. It increases due to manifestations of new, unexplored and unpredictable factors. It increases by the fact that access to the hazardous waste is terminated (Golik, 2013a). Environmental damage from reclaimed without utilization tailings dumps:

$$Y_{px} = \sum_{t=1}^{t}\left(\sum_{n=1}^{n}\sum_{k=1}^{k} M_e Ц_M + \sum_{r=1}^{r}\sum_{f=1}^{f} QЦ_q + \sum_{q=1}^{q} Q_г Ц_г\right) \rightarrow \max$$

Where:

q = The number of factors of the global impact of tailings and waste

$Q_г$ = The number of effects of global destruction of the environment

$Ц_г$ = Price of environment destruction factors compensation

Technological solutions of environmental character are typed by us on the basis of their level of implementation (Table 1). Directions to reduce the negative impact of tailings dumps over the environment (Golik, 2013b):

- Reducing the number of mining units at concentration of operations
- Reducing the time between exploration and exploitation
- Filling in voids with hardening mixtures and tails of leaching
- The use of non-waste methods of ore processing

Ecological and economic models of effective utilization of tailings on the criterion of maximum profit taking into account ecology of the region has the form (Golik *et al.*, 2013a, b):

$$Ц = \sum_{p=1}^{P}\sum_{o=1}^{O}\sum_{п=1}^{П}\sum_{t=1}^{T}\sum_{f=1}^{F}\sum_{n=1}^{N}\left\{\left(M_{ey}Ц_{My} + Q_y Ц_{qy}\right)\right\} - \sum_{З=1}^{З}\left[K\left(1+E_{Hy}\right) + E_q + E_x\right] - \left[\left(M_e Ц_M + QЦ_q\right) + Q_г Ц_г\right] K_c K_y K_T K_б K_г K_{Bp} K_ч \rightarrow \max$$

Where:

P = Utilization products

O = Types of waste, involved in processing

П = Processes of waste processing

T = Time of waste processing

F = Phases of mine and factory existence

N = Stage of waste disposal

З = The cost of waste disposal

K = Capital investments in organizing disposal site

K_c = Coefficient of dumps self-organization

Table 1: The enviornmental character are typed by us on the basis of implementation

Hierarchic level	Management type	Realization level
Global	Raw material types decrease	International agreements
	Concerns cooperation	Concerns cooperation
Regional	Enterprises cooperation	Enterprises enlargement
	Cooperation of complexes	Regional complexes creation
	Participants' cooperation	Planning and coordination
Local	Dilution minimization	Setting up with empty hardening mixtures. Geotechnological ways of extraction
	Improving of benefication technologies	Hydrometallurgy, mechanochemical technology
	Extraction of metals from waste	Traditional technologies, innovational technologies
	Complex processing	Non-waste production

The risk of incomplete verification of projects is characterized by a degree of risk:

$$r = \frac{K_б}{K_Н + K_б}$$

Where:

$K_б$ = Expandable part of the investment in recycling costs
$K_Н$ = Used part of investments

The economic effect of manufacturing products from enrichment tailings:

$$Э = \sum_{t_0+1}^{t} \left(\frac{P \times Ц - З_а}{1.08^{t-t_0}} \right) \times A$$

Where:

P = Production from waste, weight units
Ц = Production unit price, monetary unit
$З_а$ = Given costs of activation, monetary unit/weight unit
t_0 and t = Time of the beginning and end of the work
A = The volume of tailings disposal

The model of tailings disposal costs optimization:

$$C = (C_1, C_2, \ldots C_n) \rightarrow \min$$

Where:

C = The cost of the final disposition of the product
$C_1, C_2, \ldots C_n$ = Cost manufacturing processes

Ecological and economic efficiency is characterized by indicators:

$$K_{эээ} = \int_1^n f(dx_1, dx_2, \ldots dx_n) = Q_и : Q_у$$

Where:

$Q_и$ = The amount of material extracted on surface, m^3
$Q_у$ = the amount of utilized materials m^3
$x_1, x_2, \ldots x_n$ = The process parameters

Enhancement of land creates economic benefits. Productivity and value of the crops cultivated in the region and their gross value per year is determined by calculation (Table 2) (Ermishina, 2011). Remediation of land, including decrease in mineralization, makes profit (Table 3).

When returning contaminated land to usage with the cost of land 895000 thousand rubles profit will reach 11,650 thousand \$ ha^{-1}. The damage to biosphere caused by impact of tailings desalination products (Golik, 2009):

$$У_{ТМ,ТМ} = \sum_1^m (A_п \ldots _п - A_Ъ \ldots _Ъ) + \Sigma$$

Where:

m = No. of species of flora and fauna
$A_п$ and $A_Б$ = The number of flora and fauna before and after the implementation of new technology
$Ц_п$ and $Ц_д$ = Price of flora and fauna before and after the implementation of new technology
Σ = The cost of damage reduction

Ecological and economic efficiency of utilization of mine refuse is confirmed by the calculation for the conditions of the North Ossetia.

Annual income from the processing of mine refuse and metallurgy, taking into account environmental damage:

$$П_х = \frac{\sum_1^{n_0} (C_{ТО} - з_{0.0} - з_{0.М}) \times Q_0}{t_0} + C_ш^0 + \frac{\sum_1^{n_М} (C_{ТМ} - з_{ММ} - з_{ММ}) \times Q_М}{t_М} + C_ш^М,$$

Where:

$П_х$ = Annual income from the processing of tailings (rub t^{-1})
$C_{ТО}$ = The value of sales of products of tailings processing (rub t^{-1})
$з_{0.0}$ = The cost of mill tailings treatment (rub t^{-1})
$з_{0М}$ = The cost of metallurgical redistribution of mill tailings (rub t^{-1})
n_0 = The number of extracted components from mill tailings

Table 2: Productivity and value of some crops cultivated in the Republic of North Ossetia-Alania

Crops	Productivity (dt ha^{-1})			Price per item (\$ dt^{-1})	Production amount (\$ ha^{-1})		
	Max.	Average	Min.		Max.	Average	Min.
Wheat	35	24.0	15	14.30	500.5	343.2	214.5
Corn	75	55.0	37	12.50	937.5	687.5	462.5
Oats	33	20.0	15	10.70	353.6	214.0	160.5
Barley	34	19.5	14	10.70	363.8	208.7	149.8
Rye	25	18.5	11	14.30	357.5	259.0	157.3
Buckwheat	7	4.0	3	28.60	200.0	114.4	85.8
Sunflower	18	15.0	12	16.10	289.3	241.5	193.2
Beetroot	550	350.0	250	7.15	3932.5	2502.5	1785.5
Potato	200	160.0	140	14.30	2860.0	2288.0	2002.0
Cucumber	90	75.0	60	10.70	963.0	802.5	642.0
Tomato	175	160.0	140	17.90	3132.5	2864.0	2506.0

Table 3: Gain on reduction of land contamination

Sample	Production amount (\$ ha^{-1})	Recultivation (\$ ha^{-1})	Field expenditures (\$ ha^{-1})	Areas (ha)	Profit, thousand (\$ year^{-1})
Wheat	343.2	50	150	4488	642.682
Corn	687.5	65	235	4488	1739.100
Oats	214.0	50	130	4488	152.592
Barley	208.7	50	130	4488	128.806
Rye	259.0	50	150	4488	264.792
Sunflower	241.5	50	170	4488	96.492
Beetroot	2502.5	50	170	4488	10243.860
Potato	2288.0	60	170	4488	9236.304
Cucumber	802.5	60	210	4488	2389.860
Tomato	2864.0	60	210	4488	11641.872

Table 4: Indicators of mill tailings and metallurgy processing

Articles	1 month	Treatment		Metallurgy	
		1т	Total	1т	Total
Processing, tons	3000	-	5000000	-	3000000
Products: metals	400	0.13	650000	0.20	600000
Stones	300	0.10	500000	-	-
Sands	1500	0.50	2500000	0.50	1500000
Silt	800	0.27	1350000	0.30	900000
Production (thousands rubles)	2600	1.07	5350000	2.00	6000000
ROF expenditures (thousands rubles)	700	0.3	1500000	0.5	1500000
MZ expenditures (thousands rubles)	1100	0.5	2500000	1.0	3000000
Profit (thousands rubles)	800	0.27	1350000	0.5	1500000
1 complex (thousand tons year^{-1})	-	-	200	-	200
Complexes (items)	-	-	2	-	1
Processing term (years)	-	-	12.5	-	15
Profit (thousands rubles year^{-1})	-	-	108000	-	100000
Penalties (thousands rubles year^{-1})	-	-	15000	-	15000
Profit taking into account ecologh (thousands rubles year^{-1})			123000		115000

Technology realization total profit 238000 thousands rubles year^{-1}

Q_0 = Mass of mill tailings (t)

t_0 = Time of processing of mill tailings

$C_{ш}^{0}$ = Penalties for possession of mill tailings (rub year^{-1})

C_{TM} = Sales of metallurgica lmill tailings products (rub t^{-1})

$з_{OM}$ = Costs for metallurgical tailings treatment (rub t^{-1})

$з_{M}$ = Expenses for metallurgical redistribution of metallurgy tailings (rub t^{-1})

n_M = The number of components extracted from metallurgy tailings

Q_M = Weight of metallurgy tailings (t)

t_M = Time of metallurgy tailings processing

$C_{ш}^{M}$ = Fines for metallurgy tailings storage (rub year^{-1})

The results of modeling the efficiency of utilization of tailings for conditions of the Republic of North Ossetia-Alania are summarized in Table 4 (Golik *et al*., 2013a, b).

The use of non-traditional technological schemes that protect the environment from the adverse effects of natural tailings desalination disintegration at involving them in the production with combined mechanochemical activation and chemical desalination in the disintegrator, can provide substantial economic effect.

RESULTS AND DISCUSSION

Summary: It is proved that the efficiency of metallurgical and treatment redistributions waste utilization during underground polymetallic ores extraction should be assessed taking into account the ecological and economic situation using complex criterion of efficiency which is the discounted profit.

The possibility of obtaining by a mining company at the same time, both economic and environmental impact during production of products of nonconforming raw materials after the change of its properties in the activator.

CONCLUSION

Correct assessment of environmental costs requires changes in the method of selection of criterion and indicators of the mineral and raw material potential conditions of the region.

Economic and environmental assessment of the efficiency of the processing of tailings in the region that has secondary raw material potential is proposed to determine, taking into account environmental and economic situation, the cost of goods of recyclable resources and completeness of mineral resources use.

As a criterion for the efficiency of mining technologies it is logical to use discounted profit taking into consideration compensation costs for the conservation of environment ecosystems.

The use of non-traditional technological schemes provides both economic and environmental effect which is especially, relevant during development of upland minefields.

REFERENCES

Burdzieva, O.G., 2010. The criterion of effectiveness of utilization of tailings. Regional Interdisciplinary Conference of Young Scientists “Science-society” VSC RAS, Vladikavkaz S., pp: 56-61.

Ermishina, E.B., 2011. Ways of diversification in the economic system of North Ossetia-Alania. E.B. Ermishina (Eds.), Herald of Adygeya State University, Ser. The Economy, 1: 95-100.

Golik, V.I., A.A. Ermolenko and V.F. Lazovsky, 2008. Organizational-economic problems of use of natural resources in the Southern Federal District. UMO. Universities. Krasnodar. YUIM, pp: 323.

Golik, V.I., Y.I. Rasorenov and A.B. Efremenkov, 2014. Recycling of ore mill tailings. Applied Mechanics and Materials (two thousand and fourteen). Trans. Tech. Publications, Switzerland, 682: 363-368. DOI: 10.4028.

Golik, V.I., V.I. Komashshenko and Y.I, Rasorenov, 2013a. Activation of Technogenic Resources 1 Disintegrators. Springer International Publishing Switzerland, pp: 116-120. DOI: 10.1007/978-3-319-02678-7_107.

Golik, V.I., V.I. Komashshenko and K. Drebenstedt, 2013b. Mechanochemical Activation of the Ore ind Coal Tailings in the Desintegrators. Springer International Publishing Switzerland, pp: 163-167. DOI: 10.1007/978-3-319-02678-7-101.

Golik, V.I., 2013a. Conceptual approaches to the creation of small and non-waste mining production on the basis of a combination of physical-technical, physical and chemical geotechnology. J. Mining, 5: 46-52.

Golik, V.I., 2013b. Mechanochemical technology of metals extraction from ore coal washery. Proceedings of XV Balkan mineral processing congress Sozopol Bulgari., pp: 263-271.

Golik, V.I., 2009. Rohstofbasis des Nordlichen Kaukasus. Rohstofbasis Russland. Technische Universitet Bergakademie Freiberg, pp: 76-80.

Kaplunov, D.R., M.V. Rilnikova, E.A. Blum and A.V. Krasavin, 2003. Scientific aspects of geotechnological strategy selection for the development of ore deposits in a combined way. GIAB. Moscow: Moscow State Mining University, 1: 36-40.

Polukhin, O.N., V.I. Komashcenko, V.I. Golik and C. Drebenstedt, 2014. Substantiating the possibility and expediency of the ore beneficiation tailing usage in solidifing mixtures production. Technische University Bergakademie Freiberg, Germany Publisher: Medienzentrum der TU Bergakademie Freiberg Printed in Germany, pp: 402-413. ISSN: 2190-555X.

Shestakov, V.A., 2000. Optimization of the production capacity of the mine and storage processing order. V.A. Shestakov, S.O. Versilov and A.V. Doolin (Eds.), Mining Information-analytical Bulletin, 9: 68-72.