The formation procedure of scenarios on mining waste processing: environmental and social aspects

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Abstract. The formation procedure on scenarios of processing waste generated by mining enterprises was developed. It consists of seven stages and takes into account the design capacity of the enterprise, the chemical composition of a technogenic deposit, remoteness from residential areas and consumer requirements for product quality. The proposed procedure combines technologies for waste processing and land reclamation in accordance with the regulatory requirements of the legislation, consumers and society interests. The developed procedure ensures the reduction of environmental damage as a result of the technogenic impact of production and the improvement of the life quality of the population in mining areas.

1. Introduction

Currently, the volume of waste increases [1] due to the growth of mining and mineral processing [2] which has a negative impact on the environment and the life quality of the population in mining areas [3]. Most modern procedures of waste management at mining enterprises aim at improvement of environmental and social situation of the districts through penalties, sanctions and do not take into account the integration of recycling, reclamation and creation of socio-cultural infrastructure.

2. Mathematical statement of the problem

The above mentioned conditions the development of a procedure for the scenarios formation of waste recycling, disturbed land reclamation and creation of objects of socio-cultural infrastructure. For that it is necessary to formulate the task of scenarios formation [4]:

Task 1. There is a list of options for recycling waste and reclamation of disturbed lands j, $j \in [1; J]$. Each j-th variant is characterized by a certain set of technologies Th(j) and indicators $F(j) = \{F_l(j), l \in [1;L]\}$, with L = 5: economic effect – F_1; the area of restored land – F_2; the amount of pollution as a result of negative production activities – F_3; population with standard indicators – F_4; prevented pollution per capita – F_5.

It is required to form a set of scenarios A_n, $n \in [1;N]$ on waste recycling with creation of objects of social and cultural infrastructure on the reclaimed lands from j-th variants, $j \in [1; J]$, which allow the negative effects of production to be eliminated in accordance with regulatory indicators $\{F^*_l\}$:

$$\sum_{t=1}^{T}\sum_{n=1}^{N}\sum_{i=1}^{I} Kp_{tni} \rightarrow \min \text{ if } A_n = \bigcup_{j=1}^{J} Th(j),$$

on condition that:

$$F^*_1(A)<F_1(A);\ F^*_2(A)<F_2(A);\ F^*_3(A)>F_3(A);\ F^*_4(A)<F_4(A);\ F^*_5(A)<F_5(A).$$

3. Results and discussion

To solve this problem, a procedure was developed for the formation of scenarios on processing waste, reclamation of disturbed lands and creation of objects of social and cultural infrastructure integrating existing technologies (figure 1) [4].

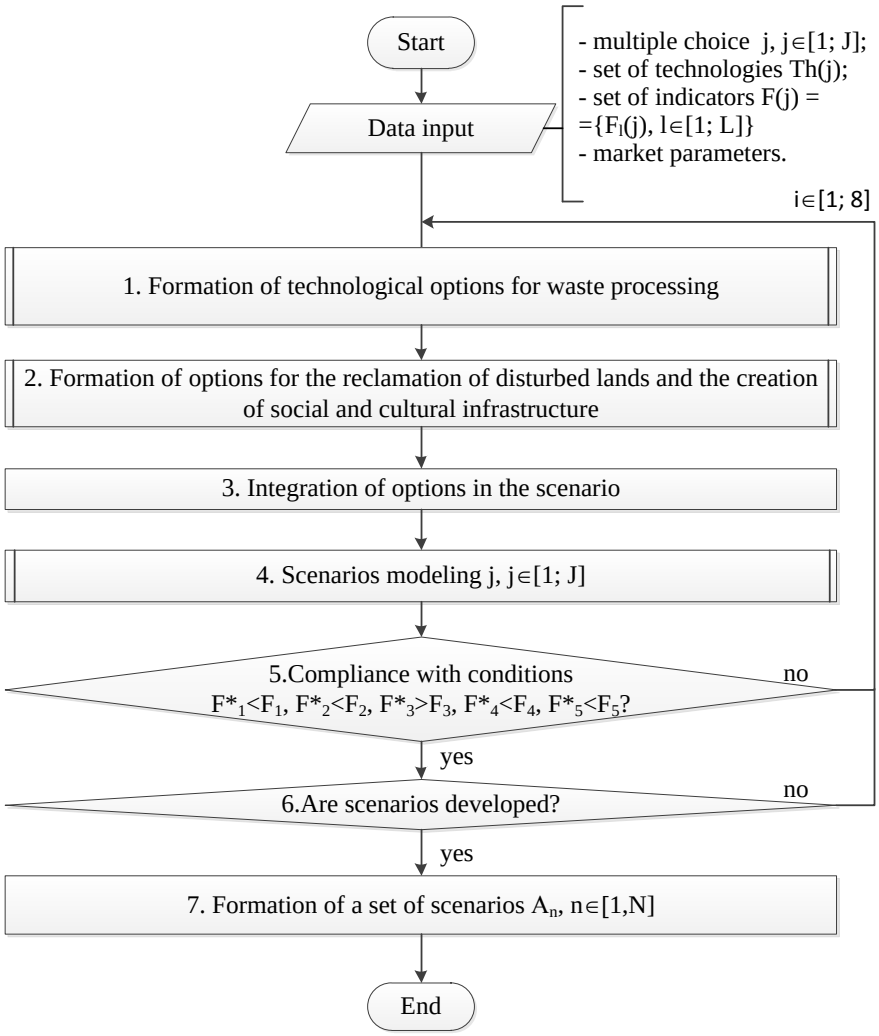

Figure 1. The formation procedure of scenarios on waste processing, reclamation of disturbed land and the creation of objects of socio-cultural infrastructure [5].

Based on the results of the activities of mining enterprises, environmental indicators, the following data are used in the procedure:

- options for waste treatment and reclamation of disturbed lands j, j∈ [1; J];
- a set of technologies Th (j);
- state of the market (demand for products from waste and objects of social and cultural infrastructure).

The accepted number of iterations of the procedure is i∈[1;8]. After i = 8, the procedure stops. If a solution is not found, the source data (set of technologies and their parameters) and constraints are changed. The cycle is restarted to find a solution.

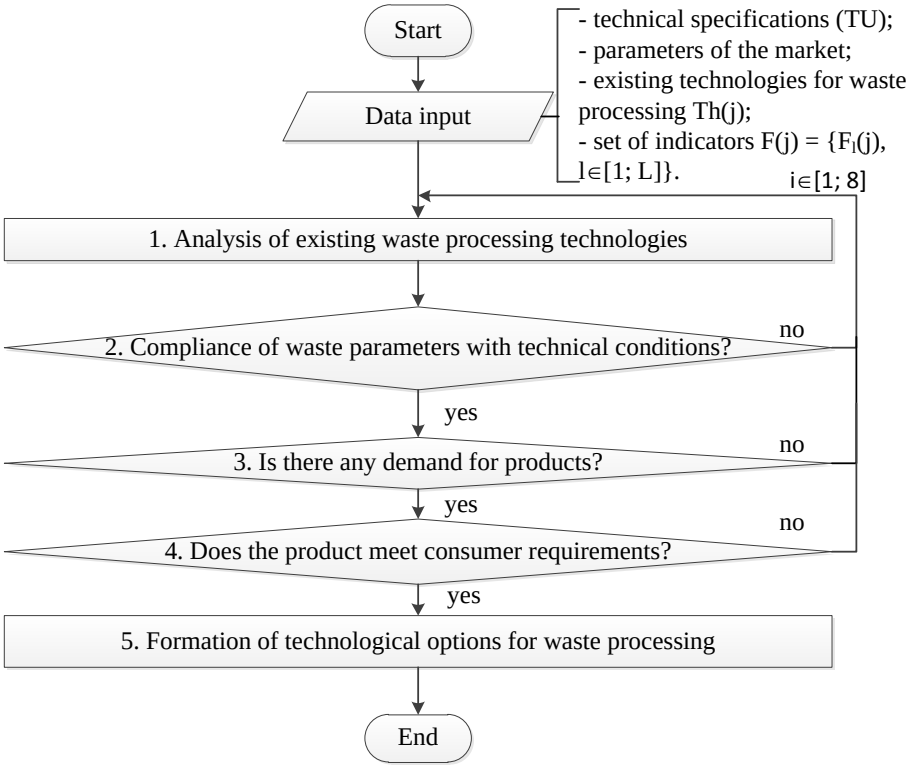

Figure 2. Formation of technological options for waste processing.

First stage. Implemented on the basis of a predefined procedure (figure 2). In the predefined procedure the following data are used: technical conditions, technological features of the mining enterprise; market parameters (demand for primary and secondary products, competitive environment, etc.); a set of technologies for recycling Th(j); a set of indicators of waste-free and low-waste technologies $F(j) = \{F_l(j), l \in [1;L]\}$.

For the formation of alternative options (stage 1 of the procedure, figure 1) of waste treatment technologies, an analysis of a set of Th (j) [6] is carried out:

- scope, potential buyers of primary and secondary products;
- requirements for the parameters of recyclable waste;
- capital costs for introduction of waste-free and low-waste technologies;
- annual capacity of the waste treatment facility;
- the cost of production and parameters of the products (ash, grade, concentration, humidity, etc.).

The formation of alternative options is carried out from the set of technologies for waste recycling Th(j), (substage 6, figure 2), satisfying the following conditions:

- compliance of waste parameters with the requirements of technologies (technical conditions) for disposal (substage 2);
- availability of demand for products by consumers (market, 3 substage);
- compliance with the requirements of buyers (quantitative and qualitative characteristics, the cost of production, 4 substage).

Consequently, the design of options for processing technologies from the Th(j) set is carried out at the first stage of the procedure (figure 1), taking into account the compliance of the design features of the mining enterprise with the technologies of waste processing and the demand for primary and secondary products.

Second stage. It is implemented through a predefined procedure shown in figure 3.

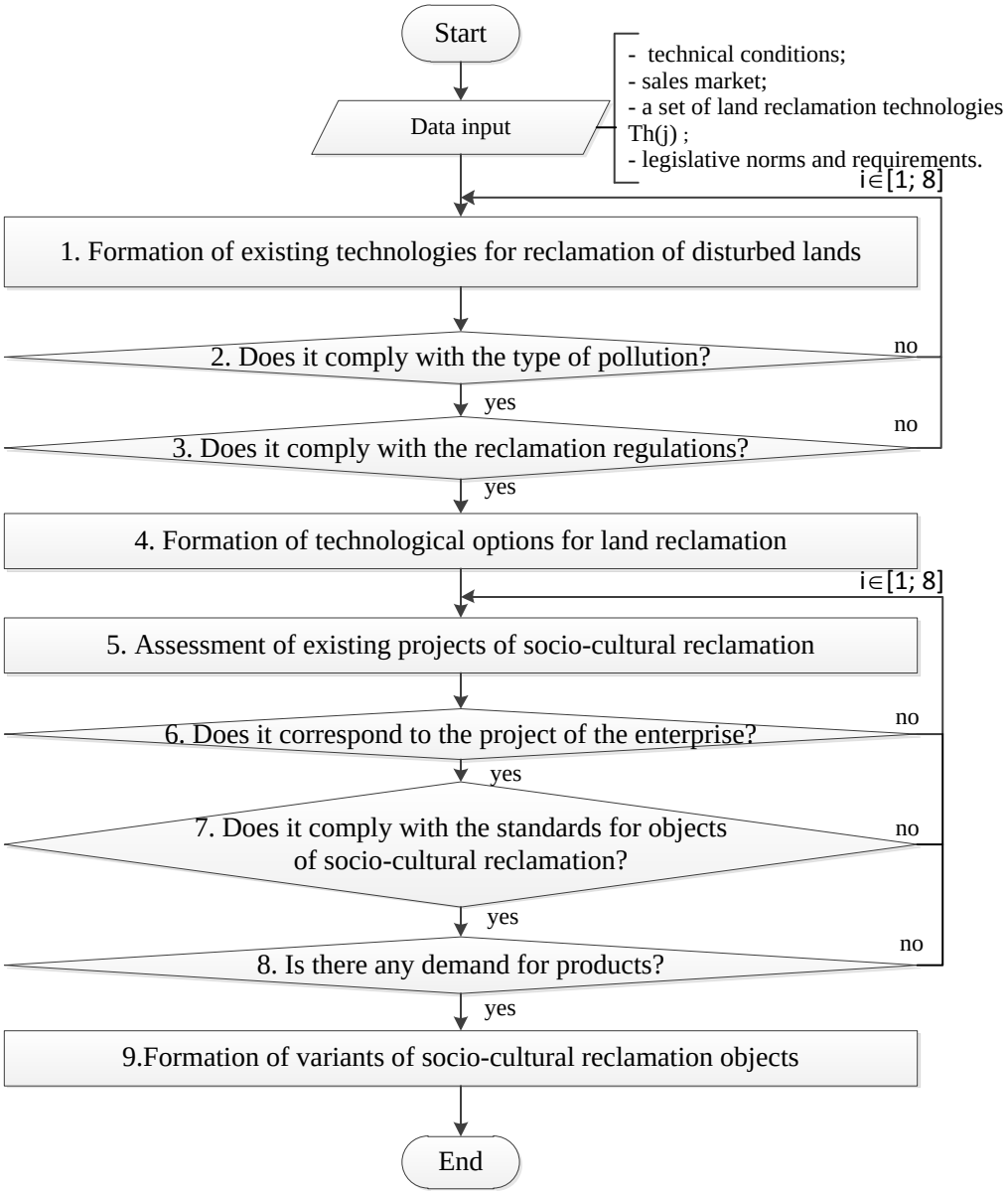

Figure 3. Formation of alternative options for reclamation of disturbed lands and creating objects of social and cultural infrastructure.

The formation of existing technologies for the reclamation of disturbed lands and the creation of objects of social and cultural infrastructure is carried out on the basis of the analysis of the set of technologies Th(j) (1 substage).

Next, the formation of alternative technologies for the reclamation of territories from a set of Th(j) (4 substage) is carried out in accordance with the following standards:

- the level of pollution and the degree of disturbance of the land (substage 2);
- requirements imposed on the parameters of the reclaimed lands (concentration of harmful substances in the soil, in water, in the atmosphere, radiation background and others, substage 3).

After the formation of options for land reclamation technologies, projects of socio-cultural infrastructure facilities (parameters, capital investments, construction time, etc., substage 5) are evaluated. The subsequent formation of options is carried out taking into account:

- project of the enterprise: mine, open-pit mine, factory (substage 6);
- regulatory requirements and regulations for recreation areas: planting of trees and shrubs, concentration of harmful substances, etc. (7 substage);
- demand for social and cultural infrastructure in accordance with the project and distance from populated areas (8 substage).

Consequently, legislative requirements and standards, the concentration of harmful substances and disturbed lands of mining enterprises are taken into account when forming alternative technologies for reclamation of disturbed lands. When forming alternative options for creating social and cultural infrastructure facilities, geographical and climatic features of the area, their relevance and distance from residential areas are taken into account. For example, pits of dumps and septic tanks can be used as artificial reservoirs. With good climatic conditions and soil fertility, it is possible to grow crops on land allotments.

Third stage. Alternative options for recycling technologies, reclamation of disturbed lands and creation of social and cultural infrastructure facilities (the second and third stages of the procedure) are integrated in scenario j, $j \in [1;J]$. For example, during processing and/or extracting waste coal sludge from dumps, the cleared lands are contaminated with fine coal particles. Consequently, the appropriate technology of reclamation is used, aimed at cleaning the soil from coal sludge.

The condition of the reclaimed land corresponds to a specific project of the socio-cultural infrastructure: with fertile soil it is possible to grow crops, with infertile soil and a small distance from residential areas – to create various complexes for recreation of the population.

In the event of a change in the environmental conditions, a decrease in the economic efficiency of waste treatment processes, deterioration of the environmental and social situation in a mining region, at any stage of the enterprise operation, new alternatives are selected with their subsequent integration.

With a difficult economic situation and a low investment level, the treatment process may not be carried out; various nursery plants are planted on the reclaimed lands for subsequent landscaping of the territory. It is possible to use the accumulated waste in the reclamation and creation of objects of social and cultural infrastructure, to dispose or sell (if there is a demand for them).

Fourth stage. Modeling of j-th scenarios of waste processing, reclamation of disturbed lands and creation of objects of socio-cultural infrastructure, providing improvement of the social and environmental situation in areas with a high concentration of mining enterprises, is implemented in Scilab, visual modeling Xcos [7].

Fifth stage. Based on the results of simulation, the indicators of the scenarios for waste processing are checked for compliance with the conditions of the task set with subsequent creation of objects of the socio-cultural infrastructure on the reclaimed lands (1).

Sixth stage. The check for the presence of scripts that satisfy the condition is performed: $n > 0$.

Seventh stage. Based on the selection from the j-th scenarios (stages 1-5), a set of A_n, $n \in [1;N]$ is formed for waste recycling with the creation of socio-cultural infrastructure in the reclaimed territories for the subsequent selection of optimal scenarios.

4. Conclusion

Thus, the procedure for the formation of scenarios is based on the integration of low-waste and non-waste recycling technologies, the reclamation of disturbed lands and the creation of objects of social and cultural infrastructure. The developed procedure ensures the reduction of environmental damage as a result of industrial impact of production and improvement of the quality of life of the population of mining areas by taking into account legal requirements and standards, specifics of project documentation of enterprises, investment potential, waste parameters, socio-cultural infrastructure objects and their remoteness from populated areas. The proposed approach is recommended for managing social projects at the stages of life cycle [8], ensuring an increase in the social effect due to

the gradual coordination of regulatory and incentive influences on stakeholders when programming projects in fuel and resource areas.

References

[1] *Federal State Statistics Service. Official statistics. Environment.* http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/environment/
[2] Tarazanov I G 2018 *Coal* **12** 60–69
[3] *Regions of Russia. Socio-Economic Indicators 2017: Statistical Digest* (Moscow: Rosstat) p 1402
[4] Shorokhova A V and Novichikhin A V 2016 *EMSU* **4.1 (22)** 194–200
[5] Shorokhova A V, Novichikhin A V and Yuryeva E N 2018 *IOP Conference Series: Earth and Environmental Science* **206** 012051
[6] Shorokhov A V 2015 *Proc. of the Int. Sci. Conf. on Institutes and Mechanisms of Innovative Development: World Exp. and Russian Practice* (Kursk) pp 469–472
[7] Shorokhova A V and Novichikhin A V 2016 *EMSU* **4 (22)** 93–100
[8] Shorokhova A V, Novichikhin A V and Yuryeva E N 2018 *Steel in Translation* **10 (48)** 637–641