

# Resource conservation as a condition for preserving non-renewable natural capital

*Vladimir Strovsky, Oksana Logvinenko, Irina Moor, and Natalia Pustokhina*

Ural State Mining University, Research laboratory of reclamation of disturbed lands and man-made objects, 620144 Kuybysheva st., 30, Yekaterinburg, Russia

**Abstract.** The article overviews the problem of slowing down the rates of natural non-renewable sources depletion in the process of resources development. The goal of the presented research is to justify the implementation of the most appropriate method of carrying out a complete resource development process by incorporating the mining and raw material extraction facilities available in the country. The study provides scientific evidence of a large-scale harmful impact caused by the raw materials development to all the elements of the biosphere and their interdependence. The presented research also demonstrates that solving the problem of resource-conservation is a first-hand priority due to the fact that there is in a close interconnection between the levels of environmental pollution and the levels of natural resources extraction. The solution to the problem of natural resources conservation is based on the concept of implementing environmentally clean technology (ECT); this technology gives an opportunity for developing a concept of the best available technology (BAT) and the concept of a closed-loop supply, the latter of which has become widely-used as a form of circular economy. The authors of the article have also suggested a systematic range of techniques aimed at extracting following resources in full capacity: commercial resources, non-commercial resources, overburden rocks and man-made mineral formations. The authors of the article suggest the necessity for enlarging the scope of available mineral resources by ensuring governmental support and developing small deposits, first and foremost focusing on the territories with a developed infrastructure and which had previously been developed. The ideas presented in the article express and support the necessity for prospective implementation of the mining factories waste products as a reserve for mineral and raw materials resources; as well as the necessity for increasing their production rates from the circular economy perspective. Some measures which would help to accelerate this process are: improving the legislative system, developing mechanisms for economic incentive and providing various forms of state-business co-operation.

## 1 Introduction

Human life is a constant series of interaction with the natural environment, however, “interaction” in the modern world has transformed itself into “impact”, i.e., human beings, whose activity can roughly be evaluated through the prism of economic damage [1-3],

constantly destroy nature in the process of interaction with it, causes it harm, among these, there are three generally accepted forms of human impact:

- natural resources extraction from its natural environment;
- pollution, which causes modifications in the (chemical, mechanical, physical, etc.) properties of the natural environment;
- disruptions of the landscape and lithosphere masses [4].

It should be mentioned that the last two types of impact are a combination caused by the first type of impact, i.e., natural resources extraction is followed by pollution and disruption of the solid resources (landscapes) and deposits, as well as the formation of artificial landscape. In the subsequent processes, factories and plants incorporate polluting methods as the first-priority methods of producing end products [5-2]. Mining companies provide the manufacture facilities with raw materials and have impact on the natural environment at the initial stage of production; meanwhile, the raw materials-based local economy promotes the harmful impact. Researchers note that there is a large-scale impact caused by the mining companies on the biosphere, which takes in nearly all the elements of mining production [6]. It is considered that moderate impact is caused on the air basins, flora and fauna. The remaining elements of the biosphere: surface and subterranean waters, soil layer, landscape and natural deposits are being strongly impacted. The approximate estimation of the natural resources extraction methods shows that the open-cut mining method cause the greatest damage, while the geotechnological methods cause the least damage [6-9]; these facts are supported by various researchers globally. In the process of open-cut mining, the main elements of the biosphere, which are vulnerable to anthropogenic impact, are the atmosphere and the solid resources (soil); in the process of underground mining, the subterranean waters and the lithosphere (the depths of the solid ground) are impacted the most [10,11].

Naturally, contamination inevitably takes place during the process of developing natural resources – gas-like, liquid, solid waste along with excessive heat enters the natural environment, in addition, over 90% of the ready-cut mass is extracted from the carriers by implementing the drilling-and-blasting method [12]; open-pit coal mines are areas of with an exceptionally contaminated natural environment. Given that nearly all the carrier rock formations contain silicone, the atmosphere is at a greater threat of being contaminated. The main processes, which contribute to air pollution are: large-scale blasting operations held at the carrier site, road transport, material handling operations, drilling operations, which pollute the high-walls and bench areas of the carriers with dust. The top layer of the natural landscape and water resources become contaminated. The mining companies in Russia dump more than 1.3bln m<sup>3</sup> of wastewater, which often contain concentrations of commercial components comparable to or even exceeding the concentration of those commercial components in the ores [13]. An example of this are tin mining deposits in the Far-Eastern region of Russia, the sewage waters of the Tyrnauz processing plant as well as the Urup coal-preparation plant. According to the official data, the impact caused by coal production in terms of sewage waters waste is estimated at a rate of 7% out of the overall total in Russia. During the extraction of 1 mln tons of coal, 3.22 mln m<sup>3</sup> of sewage waters are being dumped into the environment [14]. Man-made sewage waters destroy the water ecosystems, decrease the natural water quality; an especially important threat is posed by the problem of contamination caused by oil spills and river contamination resulting from an unorganized sewage waters dumping from the top layer of the oil and oil products water-collecting basin; this sewage waters accesses the natural waters due to emergency oil spills and in the process of oil hole-drilling, oil transportation, etc [16]. Coal mining is accompanied with significant air contamination processes: research shows that, when 2 bln tons of coal is extracted, approximately 27 bln m<sup>3</sup> of methane and 16.8 bln m<sup>3</sup> of carbon dioxide are being emitted into the air. The extraction of one bln tons of coal is generally

followed by 2.93 thousands of tons of contaminants released into the atmosphere. Closing down mines are also causing ecological problems. Natural observation analysis reveals that a dust layer of 6.5 cm is being blown off a 50 m coal-dumping site; the intensity of a dust-forming layer at a 300 m distance from the coal dumping site is estimated at a rate of 14.3 g/m<sup>3</sup>. Contamination caused by waste products not only pollutes the atmosphere, but also the soil. An example of this is the Kursk Magnetic Anomaly (KMA) where there were formed zones of abnormal soil contamination; there are nine ingredients of the 1st and 2nd hazard category registered in the waste products found at the site [15]. The critically contaminated zone is located at a radius of 15-20 km from the mining sector. The concentration of elements of the 1st hazard category is registered at a rate of 70% in the soil located in the extra-hazardous impact zone (10 km from the carrier). Tailing dumps are another factor provoking critical situations at the mining site [17]. The contamination of the neighboring territories, for example, near the tailing dump Grachev Log of the KMA, was 10 times larger than the total area coverage of the tailing dump itself.

Nevertheless, as had already been mentioned above, the problem of environmental contamination is not a first-hand priority problem due to the fact that waste dumps and emissions, likewise the formation of solid waste, are accompanied by the process of developing mines. The research materials suggest that in most cases no more than 2% of the extracted mass is processed into valuable resources; the remaining portion of the extracted mass is normally returned to its natural environment [18]. The amount of waste products increases, thus, increasing the wasteland areas. The collected waste products (the uptake of which still remains insufficient) are becoming one of the key factors for anthropogenic modifications in the natural environment. Experience shows that the maximum size of the disrupted land area reaches 640 ha/per 1 bln ton of iron ore extraction, 580 ha of non-ore materials, 600 ha of manganese, 74 ha of sulfur and phosphate, 43 ha of coal, 120 ha of limestone. Every 100 km of road area requires a footprint of 200 ha of soil and pipelines covering an area of up to 450 ha. Meanwhile, 60-75% of this area is covered by waste dumps and tailing dumps [19, 20]. According to several sources providing estimated data, there 100 bln tons of mining production waste collected in Russia, the annual volume of these waste products makes up 3.7-3.8 bln tons, out of which nearly 40% are recycled. In the Prokopyevsk-Kiselevsky district of Kuzbass, the annual amount of dump products reaches up to 5-mln m<sup>3</sup> during the coal mining process. The enrichment process also involves waste products, extracting 1 ton of metal material leads to a subsequent emergence of tailing dumps ranging from 30 to 100 tons in total. According to the official data on the mining and non-ferrous metallurgy, the amount of tailing dumps is estimated at a level of nearly 140 mln.m<sup>3</sup> per year [21]. Being the reason for the increasing rates of land disruption, waste products also become the source of environmental pollution [22-24]. Thus, in the case of KMA, the general amount of waste products from the tailing dump exceed 8319 tons/year; the tailing dump of the Solnechny MPP located in Khabarovsk Krai, has been flooded numerous times by incoming water floods when the filter bed of the dam was broken by the waste product flows containing a large amount of heavy metals, which entered the river basin as a result. Mature tailings as well as piled up and unused wastes (spoil heaps and tailing dumps) of one-factory towns, where the mining and metallurgical factories manage the town pose an exceptional threat. The towns expand their land area, this results in the waste products piling up near the boundaries of the town or even within the town boundaries. A developed system of correlative connection between the environmental pollution and illnesses among the urban citizen allows stating the fact that there is a high risk of obtaining a disease or even reaching death on the territories with a high capacity of waste products. This was followed by a logical reaction, i.e., measures were taken to eliminate the consequences of environmental contamination: increased rates of financing environmental protection events, carrying out mining and technological re-

cultivation works, partial waste burial and using it for planting new crops, installing environmental protection equipment, issuing financial sanctions for hazardous emissions and dumping, etc. However, the first-hand priority is given to the measures aimed at sustaining the resources, which are fundamental in decreasing the levels of pollution. It is impossible to achieve a complete termination of waste dumping in the mining industry, but increasing the exploitation of the mining sites to its full capacity would decrease the amount of waste products by slowing down the process of developing new mining sites, which would lead to a new and an even more critical cycle of environmental pollution, including waste products storage. The mission of resource preservation is to maximize the waste products recycling processes and to create closed-loop production cycles.

## **2 Materials and methods**

The methodological basis of the presented research comprises of following general scientific methods: the method of generalizing the quantitative analysis and synthesis, the comparative method and the grouping method. The informational basis of the research consists of materials of the Ministry of Natural Resources and Environmental Protection of the Russian Federation and regions of the Russian Federation, statistical data, reference data, and the research results of consequences written by scholars on the presented topic worldwide.

## **3 Results and discussion**

The problem of natural resources conservation is becoming exceedingly a topic of first-hand priority. This problem did not seize to exist and never did so, however, in the 1980's and the beginning of the 21st century, it was overcasted by a more significant problem of contamination.

Presently, the conservation of natural resources (capital) is a generally accepted problem of primary concern; the government is planning to achieve this by conserving the natural resources. As of today, a long-forgotten concept of clean or environmentally clean technology (ECT), which is aimed at minimizing the waste and delivery rates of the main raw material resources by altering the technologies, production materials, products and the methods of economic management.

The concept of the best available technology (BAT) and closed-loop delivery (circular economy) is to some extent a result of improving ECT. Meanwhile, the BAT concept is, first of all, aimed at decreasing the effects of anthropogenic impact caused contamination. The ECT strategy regards waste products as lost raw material resources, which should be put into production. In the conditions when the option of using these resources is unavailable, other measures should be taken to prevent the formation of these unused resources; presently, this is the main strategic trend of circular economy [26, 27]. The resource conservation process mainly focuses on the waste products, while, in fact, resource conservation requires an initial process of mining resources development to be put into action, i.e., the natural resources extraction. Adopting the resources conservation policy aimed at the preservation of the natural resources (capital), which comprises of non-renewable resources, as well as at slowing down the paces of its depletion presumes launching the process of maximizing the consumption of the resources available in the mining deposits: state-registered resources and, whenever possible, the non-registered resources along with the waste products (man-made and mineral waste products). Using the state-registered resources to their full capacity should lead to the minimizing of production losses and attenuation, which is only possible to achieve by implementing the social and

economic approach in developing conditions, improving the waste products and attenuation justifying procedures as well as ensuring that these procedures are put into action; other measures include: holding full capacity mining exploration works, forecasting and eliminating possible cases of non-reasonable natural reserves debooking, putting the entire complex of natural resources into production, all of which requires a comprehensive solution to the problem of licensing due to the fact that, in the mean time, each type of natural resources requires a separate licensing agreement, a multi-criteria selection of the development methods; one of these specific methods is minimizing the production loss, introducing a system of material incentives for the reduction of losses during the process of developing low-duty natural deposits, incorporating the resource preservation policy at the mining site along with a system of evaluative figures, which allow monitoring the procedure of the policy implementation as well as ensuring any necessary modifications in compliance with the professional feedback.

An exceptionally important condition for the resources to be used to their full capacity is the possibility of transferring the physical mineral and raw material base of the non-state funded reserves. This process is largely impeded by the administrative limitations, connected with the necessity of transferring the non-state funded reserves into state-funded ones and confirming these reserves; the problem of low-duty, low-condition and low-gain and natural deposits is a very critical one in terms of developing the mineral and raw materials base. Developing them requires a legislative support and implementing the development and further production of hard-to-recover and low-gain reserves as well as dumping sites, and mining production waste, including small gold placer mines; all this needs to be done within a short time-period. A significant support in solving this problem could be provided by the government, including their assistance in implementing the mechanism of public-private collaboration (PPC) in the process of using the deposits, which are successfully initiated in various countries on a global scale. Promoting high levels of investment possibilities in developing such deposits requires finding new forms of PPC, which would guarantee a long-term stable taxation, insurance and risk allocation system as well as a guaranteed approval for accessing the mining facilities, etc.

It is undoubtedly important to solve the problem of waste products within the concept of natural resources preservation, when it is regarded as a potential mineral and raw materials source [28].

The man-made deposits, which are formed by waste dumping, often contain considerable amounts of valuable components, the extraction of which promotes the preservation of the natural raw materials in their deposits [29]. For instance, the waste products of mining factories of the Trans-Baikal territory contain approximately 149 tons of gold, 925 tons of silver, as well as considerable amounts of tin, wolfram, molybdenum, lead, zinc, copper, cadmium, tantalum, niobium, beryllium, bismuth, arsenic, sulfur and other components. Estimations indicate that incorporating these resources into the mining and production process is a profitable measure. At the same time, there will be a decrease in the negative impact on the natural environment. Looking at the problem from this perspective, the information provided by L.Z. Bykhovsky, and L.V. Sporykina on the implementation of man-made waste products in the process of enriching the mineral and raw materials base seems to be quite a persuasive solution. The non-ferrous refinement tailings contain the following amounts of non-extracted components in the initially extracted (base) ore (%) [30]: Sn – 35-58, W – 30-50, Zn – 26-47, Co – 24-36, Pb – 23-39, Mo – 19-23, Cu – 15-25, Ni – 10-25.

Man-made deposits processing is becoming a considerably important topic due to the cleaning-up of natural deposits located in the central regions with a well-developed infrastructure; this factor disallows investing into the development of new deposits located predominantly in the low-developed and difficult to reach regions; moreover, the deposits

in these regions have low quality characteristics. A comparative analysis of the natural components contained in the waste products and the base ore showed the following results: the dumping sites of the Deputatsky MPP (the Sakha Republic (Yakutia)) contains 1.29% of man-made tin placers; 1.15% of tin in ledge ores; the dumping sites of the Primorsky MPP (Primorsky region) as well as the dumping sites and middlings of the Iultinsky MPP (Chukotka) contain 0.1-0.3% of wolfram trioxide which exceeds or coincides with the amount of this resource in the base ore deposits, etc. The technical and economic calculations of man-made deposits development show that the economically profitable development can often be achieved only with governmental support, especially, when the companies wish to incorporate the best available technologies (BAT); these procedures include taxation preferences (the abolishment of the land tax, decreasing the income tax rates, exclusion from the list of properties indicated in the taxation bases, etc.) [31]. The legislative base also requires some improvement [32. 33]. The problem of using the man-made deposits is a practical example of applying the concept of circular economy and one of its approaches:

- a complete renovation of the products and/or a restoration of the components of the worn out products, mainly:

- waste and worn out products utilization/recycling – any restoration operations, with the help of which the waste and worn out products are recycled into materials, resources, and substances for the initial or other miscellaneous purposes [26, p. 250].

Thus, in this case, the use of these waste products to their full capacity is regarded from the perspective of slowing down the rates of depletion of the non-renewable natural resources, which serves as a critically important evaluation criterion of sustainable development, including the specialized types of natural resources management.

## 4 Conclusions

1. The research confirmed that there is a large-scale anthropogenic impact on the processes of natural resources development and on all the elements of the biosphere.

2. The problem of contamination is also addressed in the article, along with other problems, such as landscape and lithosphere layers disruption, the latter two aspects being forms of impact which are accompanied by extractions of non-renewable resources from their natural environment and this predefines the priority of preserving the natural resources.

3. It is reasonable to use the concept of PPCs in executing the resource management policy, which is aimed at minimizing the waste products and main raw materials consumption by altering the production technologies, materials, products, and economical management methods; it also serves as the basis for the BAT concept in closed-loop delivery processes.

4. A list of measures, which would contribute to slowing down the depletion of non-renewable mineral resources, is aimed at providing a full extraction of the natural resources, including the non-state funded ones as well as the expansion of their mineral and raw materials based by developing small deposits with hard-to-extract and low-gain resources with some governmental support.

5. The implementation of waste products as a source of preserving the non-renewable natural resources – an approach applied within the concept of circular economy, which needs to be improved on the legislative level as well as initiating a range of measures of providing economic support and promoting the PPC process.

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