Transition to advance technologies of subsoil use

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Abstract
Complex use of mineral resources allows, in addition to scientific and technological achievements, implementing the economic and environmental interests such as producing the maximum possible volumes of competitive products with higher utility value at the lowest cost of material, labor, financial and intangible resources and reducing negative impacts on the environment. At the moment, the problem of man-made waste water treatment is very relevant and it is global in nature. This is primarily connected with a sharp jump in the development of chemical industries in recent decades, as well as with significantly increased volume of use of household chemicals. Approximately one third of all waste water is discharged into surface water bodies untreated or insufficiently treated. The article raises the question of the formulation of the concept of technological development in the sphere of subsoil use. An analysis of existing technologies and technological methods is given, and the author’s proposals for the development of modern subsoil (mining, oil and gas industry), as the industry characterized by a number of challenges and problems (in this case we do not consider the political challenges and problems, which somehow have a negative impact on the development of the subsoil) are described.
Key words: SUBSOIL, MINING AND PETROLEUM INDUSTRIES, CHALLENGE, TECHNOSPHERE, TECHNOLOGY, MECHANISM, LITHOSPHERE, HYDROSPHERE, RECYCLING, INNOVATION, TECHNOGENESIS, NANOTECHNOLOGY

Introduction

The sphere of technologies in the XXI century, according to the analysis and scientifically sound forecasts [3, 4], is fundamentally different from the technology of XIX and XX century. This phenomenon has some important reasons.

Firstly, recently there is a previously unobserved on speed transformation of the biosphere into the technosphere. So, a global change of climate (characterized by rapid melting of glaciers) and nature on the planet is observed, the emergence of the Internet and then “smart” materials and things alters dramatically formed technogenic environment. In addition, the modern human society finally becomes digital, and its ontology acquires the hybrid character, which does not allow the real and the virtual to be separated [5]. Thus, the vast majority of social practices are directly related to digitization (in the subsoil use it is “smart mine”, “intellectual oil production”, etc.) and work with rather big data.

This raises the following question: On which way strategy should future technologies be developed (Figure 1)?

Variant of catching-up development is well-known by the example of Japan, South Korea, Singapore, Malaysia and, of course, China. At the core of this variant is the maximum use of available technologies in the world market, which are purchased or involved in the country with foreign capital. However, it should be noted that imported technologies are generally not the most advanced in the world.

It is fundamental that for modern national industry the model of advanced development is more relevant, which implementation in the early stages, of course, should be supported by the state including financial issuers.

The current knowledge about the technologies of the future in the field of subsoil use can reveal their following features.

Mineral raw materials of various types and sources of energy (where coal is about 41%) at all times have been and remain quite important material basis of human society.

Thus, at the present stage the annual mineral extraction (excluding construction materials) has already exceeded 16 billion tons. This is due to the fact that the mineral raw material determines the pace of development of the means of production (modern technic) and comfort (conditions) of the people’s lives.

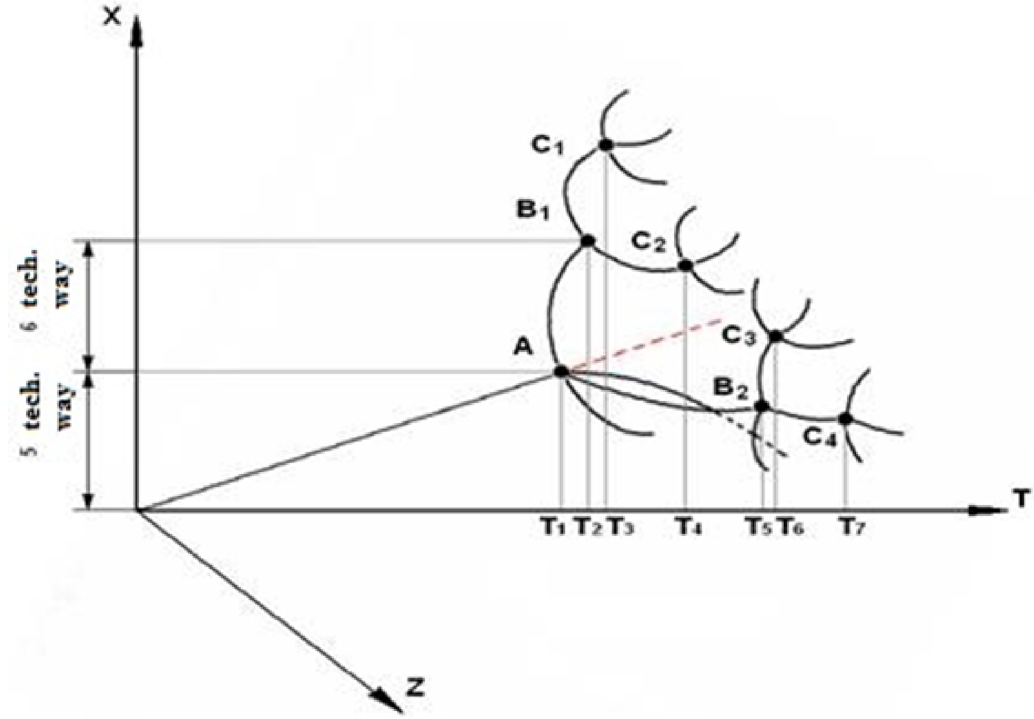

Figure 1. A bifurcate nature of the ways of development of subsoil use technology as a complex system: X, Z – system parameters, t - time, A, B and C - bifurcation points

Thus, this circumstance is often due to an increase in the depth of development or mineral raw materials deterioration (for example, many recently discovered deposits of gold-bearing ores are characterized by the presence of fine particles mineralization or technologically harmful impurities such as arsenic, etc., oil field with a high water content and so on). A significant extent of delivery "shoulder" of the obtained products (especially oil and gas, in particular, the system of main pipelines "Yamburg - Western boundary of the CIS" has a total length of 28.7 thousand km and the length of "Eastern Siberia - Pacific Ocean" pipeline is 4770 km) and increasing the volumes of its extraction by formation of tonnage mineral wastes leads to an increase in environmental costs. At the same time recovery ratio of minerals from the subsoil is often extremely low in the oil industry its value is 0.4. In addition, the current use of mineral resources is characterized by the appearance of numerous accidents and emergencies (caused by relatively low technology security).

Considered challenges are primarily related to the subsoils, which (as multifactor system with multiple links and vectors) are characterized by significant uncertainty affecting the actual production of extraction and primary processing of raw materials. As the result, a steady rise in the cost of systems development or rather, the value of extracted minerals is observed.

This situation was predetermined by the fact that easily accessible and free-milling mineral raw material over time has been gradually worked out, and now for the development of new types of minerals new forward-looking technologies based on new principles and functioning mechanisms are required. It is necessary not only to get rid of existing technology "relics" in the subsoil use, and to transfer to the radically new technologies of mineral deposits development that are quite appropriate to modern realities.

A similar situation exists in the coal industry, where due to the traditional use on the mines of multioperational and cyclical technologies (coal lifting), productivity of worker is 115.4 tons/month. Although, at the coal strip mines it exceeds 196.6 tons/month.

Discussion of the problem

1. *Technologies of purposeful reproduction of mineral resources (ores, oil, gas, coal and fresh water) in lithosphere, hydrosphere and industrial entities.*

The relevance of studying this aspect of subsurface is due to the fact that mankind economic activity is accompanied by steadily increasing volumes of various types of industrial waste and urban public utilities (on a global scale, they accumulate in the amount of more than 20^{10} tons per year), which significantly pollute the environment.

On the other hand, it should be noted that geogenic depletion of mineral resources is observed. Thus, the modern world community provision of oil reserves is about 50 years.

In addition, there is a distinct trend of energy consumption: according to the British scenario in 2020, 17% increase in global energy consumption will occur, and by 2040, global energy consumption will grow by 48% (estimated by the US Department of Energy).

Therefore, the search and development of new strategies for providing humanity with sources of energy including the ecological component as the main vector of sustainable development are relevant and appropriate. In particular, it is necessary to develop efficient methods of recycling the carbon-containing wastewater, while providing the technogenic resumption of mineral raw materials (synthetic oil and oil-like compounds) in the lithosphere.

The same applies to the fuel gas, ores of different metals (by redistributing the useful components along mountain range), artificial synthesis in the fresh water lithosphere (for example, under the present world population of more than 7 billion people and an annual growth rate of 83 million people, an annual increase in fresh water needs will amount to 64 million m^3), and in some aspects – coal and waste of coal mining.

Earlier, the concept of resource reproduction of mineral raw materials from waste of mining and processing industries, as well as the poor and lean, or cut-off grade ores both on the daylight surface and in depths of the lithosphere was developed by Professor A.E. Vorob'ev [1]. During the research, it has been found that a targeted improvement in the properties of minerals in the rock mass is a geochemical process involving the separation of one or more components from the rocks using the active agents or water, migration of metal-bearing solutions and precipitation of useful components in a localized volume under the influence of geochemical barriers. At the same time, the aim of improvement the minerals properties is the concentration of their limited part to the industry values, which gives the possibility of obtaining the technogenic ores and their subsequent involvement in metallurgical treatment.

Development of the mechanism and technology of mineral resources reproduction is closely associated with the solution of such relevant problem according to scientists' field as comprehensive development and preservation of the Earth's interior, innovative processes of developing mineral deposits and deep processing of mineral raw materials.

Technologies of purposeful reproduction of mineral resources are focused on the use of a significant amount of unclaimed by industry mineral wastes both on the daylight surface and in the lithosphere. Managed character of resource reproducing technologies will provide their industrial and environmental safety.

2. Development of the mechanism and principles of the biosphere improving technologies of subsoil use.

The humanity has entered in XXI century with a number of unsolved, but very urgent tasks. One of them is the study and forecasting of the modern evolution of the Earth's biosphere, which comprehensive study would allow us to develop a strategy for the future sustainable development of mankind. Analysis of the environmental situation on our planet at the moment shows that the main cause of the looming crisis is a technocratic concept prevailing in the relationship between our society and the biosphere. It is based on the consideration of the biosphere mainly as a source of physical resources (air, water, soil, mineral raw materials, energy, etc.) that are used to meet human needs, as well as a "sewer pipe" to remove arising various wastes. Although in recent years mankind has been trying to shift the focus in their relationship both with the biosphere and with their habitat, and to choose the right direction of this displacement.

In the meantime, the existing concept of the biosphere protection does not solve 2 major problems that dooms mankind to hopelessness: it does not prevent the growing environmental pollution and does not relieve the world from the threat of degradation and depletion of natural resources. Following the existing concepts of interaction between man and biosphere can only delay or slow down, but do not prevent the crisis (until death) of human civilization from impending ecological and resource disaster.

Thus, despite the tendency to limit the harmful effects on the biosphere (which reveals itself in increasing the degree of purification of discharges and emissions, reduction of unsanctioned sources of pollution, etc.), cardinal improvement of the existing negative environmental situation is not expected. This is due to the entropy processes of natural dispersion of the substance concentrated by man often obtained in forms and amounts that do not exist in nature (for example, in spite of the clearly expressed oxidizing environment on earth many metals are converted to the reduced state and are used in refined form, etc.). And if humanity finally completely solve the problem of pollution of the biosphere ***at the stage of production*** of life activities necessary for it, such acute problem will be still inevitable when their ***consumption***. Therefore, a fundamentally new strategy of co-evolution of humanity and the biosphere is required.

During its development, we should proceed from the capabilities of the main redistribution mechanism of the elements on the earth's surface, i.e. natural biogeochemical cycling of atoms and its ratio to man-made load. Over 3.5 billion years of the evolution of our planet, the equilibrium of system linking together the Earth's crust, hydrosphere, atmosphere and biosphere has been supported mainly by the exchange of substances and energy: solar radiation, the action of gravity (gravitation), geological forces, chemical and biogenic energy.

Prior to the intervention in the biosphere of industrial or agricultural technologies, such atoms cycle was carried out harmoniously subjecting to common energy laws being governed by the combined action of biological and geochemical factors.

At present, the world economy only each year emits in the atmosphere more than 250 million tons of fine aerosols, about 200 million tons of carbon oxide, 150 million tons of sulfur dioxide, 120 million tons of ash, more than 50 million tons of hydrocarbons, a significant amount of fluorine compounds, mercury and other toxic substances.

Moreover, the processes occurring under the technogenic influence are different from natural in qualitative and quantitative ways. Qualitative differences lay in the synthesis of compounds (brick, porcelain, plastics, gasoline, new elements and other isotopes) alien to the biosphere or in concentrations (creation of products from metallic iron, aluminum, manganese, nickel, etc.). According to the nature and direction, anthropogenic impacts may not correspond to the na- tural conditions of the territory (for example, the occurrence of local technogenic earthquakes caused by oil extraction, construction of artificial reservoirs, introduction of large-scale mass explosions in non-seismic zone, etc.). Quantitative differences are in more significant volumes, speed and uptake intensity of the various elements (for most of technogenic sources), as compared to natural objects (e.g., volcano).

In this regard, the natural cycle in the biosphere is often simply lacks time for the technogenic emissions. Therefore, we need to streamline the ratio of materials incoming the biosphere with the possibility of biogeochemical cycle. A quantitative and qualitative account of elements and compounds coming in the biogeochemical cycling of atoms and creation of their optimal ratio serve to this purpose. Knowing the values of the natural cycles and volume of income (from human activities) of various elements, we can predict the amount and form of the substances necessary for the full implementation of modern cycle. In other words, the imbalance of elements in the biosphere cycle arising in anthropogenic era should be changed. And if we cannot completely prevent the available scattering of the material, but at the present state of development humanity has already been capable to purposeful inclusion in the cycle of additional volumes of the necessary elements.

Therefore, it is advisable to review the challenges and opportunities of the mining complex traditionally considered only as a source of mineral raw materials for the subsequent production of human life-support products.

3. Nanotechnologies of subsoil use.

Currently in the world, there is a technological revolution connected with the development and entry to the market of nanotechnologies, i.e. transition to different nanoparticles, which sizes do not exceed 100 nm. According to the forecasts of scientists of National Initiative in the area of the US nanotechnology, the development of nanotechnology in 10-15 years will create a new economic sector with a turnover of 15 billion USD and about 2 million of workplaces.

Maximum progress in the creation of nanotechnology is observed in the US. Japan appears to be their main rival. In Europe, Germany plays the most important role. In the world there are the classic areas of nanotechnology network:

- Nanoelectronics;
- Nanoengineering;
- Functional Nanomaterials and High-Purity Substances;
- Functional Nanomaterials for Energy;
- Functional Nanomaterials for space equipment;
- Nanobiotechnology;
- Structural Nanomaterials;
- Composite Nanomaterials;
- Nanotechnology for security systems.

Over the past 70-80 years, several hundreds of various nanoscale objects have been synthesized such as particles, structures and materials (allofeny, giant clusters, coacervates, centaurs, tactoids, fazoidy, fullerenes, fulleroids, nanotubes, etc.).

These compounds often have (identified or not) analogues in mineral raw materials (minerals and rocks). In particular, the nanocrystals can be in the form of spheres, polyhedrons, flakes, rods, rings, combinations of these simple shapes and fractal aggregates.

Studying of nanomineral forms allowed us to make several preliminary conclusions.

Firstly, still evaluating the content of minerals and, therefore, mineral resources was accompanied by a serious underestimation of the presence of these nanomineral forms, i.e. it was characterized by significant losses (sometimes exceeding 35%). And besides, the existence of mineral nanoforms allowed revealing previously unknown types of mineral deposits such as gold-bearing ferruginous quartzites, gold-bearing coal or graphite (containing gold nanoforms with a concentration from 17 to 150 g/t).

Secondly, nanomineral forms of minerals suggest the development of entirely different production technologies (in particular the safe development of aquatic gas hydrate deposits can be carried out only with the use of nanotechnology) and processing (beneficiation), which are significantly hampered, for example, by a high buoyancy of nanogold particles (due to their physical and mechanical properties and characteristics of the surface relief).

Thirdly, knowing the nanomineral forms (and also gas inclusions) allows us to explain the mechanism of many dangerous phenomena such as sudden coal and dust bursting from fundamentally new positions.

Furthermore, the coalbed gas-dynamic activity is significantly increased in accordance with the tendency of mining works deepening in lithosphere. Among the known gas-dynamic phenomena the most dangerous are sudden coal and gas bursting occurring suddenly and rapidly with the release of the rock mass and an increased liberation of natural gas (methane) to the mining works atmosphere with significant damage to the production causing the damage of lining, equipment and often death of people.

Of the total number of mines in the world (2634), the number of mines developing outburst coal beds is 276 (just over 10%). Gas-bearing of coal beds at depths of modern mining works reaches 45 m^3/t. Practical experience in the development of high gas content coal beds in coal mining countries reveals that the use of conventional technologies of coal excavation without special measures to prevent dangerous gas shows is not possible.

The sudden outburst of coal and gas in a coal mine is implemented in the following order: the avalanche formation of cracks in the bed causing a momentary methane expansion with the drop of pressure to atmospheric when increasing the specific volume of methane; a significant increase in gas temperature, a mixture of methane and air followed by auto-ignition and explosion when simultaneous dissociation of methane to carbon and atomic hydrogen under high temperatures, with possibility of a more powerful secondary explosion as a result of oxidation of the dissociation products with oxygen and nitrogen of air.

It is necessary to make decomposition of stages of sudden release process followed by a synthesis of the explosive situation created according to the security criteria, i.e. it will allow receiving not only rational options of structures (elements) of the phenomena scheme, but also synthesizing the objective function (global safety test) from a variety of local criteria.

For this purpose, we need to study the influence of the processes occurring in nanostructures of gas-containing coal rock mass, in ensuring the safety of mining production with the establishment of the geomechanical and physico-chemical processes flow mechanism in the formation of outburst situation at the moment of transfer of nanostructures and nanoparticles from adsorbed to free state in the center of a gas-dynamic phenomena. In addition, it is planned to develop the physical and mathematical three-dimensional model of nanostructure of gas-dynamic phenomena center and the process of instantaneous desorption of gas and coal outburst and fine dust (nanoparticles).

As a result, a completely new approach in the study is built. It is based on an analysis of emission products (highly dispersed finely ground coal dust - “mad flour”) with the approbation of the physical and analytical models with numerical modeling of gas-dynamic phenomena allowing to reveal the essence of physical and chemical processes at their origin and course in the mountain range at the nanoscale.

The problem-oriented approach to research includes the following: a systematic scientific analysis of all occurred emissions, applied research of properties and structure of the gas containment zone of the gas-dynamic phenomena origin in coal bed, creation of a hierarchical approach to the development of the decomposition concept, construction and synthesis of gas dynamic phenomena structure using special knowledge of the fundamental sciences (physics, chemistry, theoretical mechanics, resistance of materials, mathematics), information technologies and software features.

4. The development of disposal technologies of CO_2 in the lithosphere in a specially formed geochemical reactors.

Due to the technogenic component, the carbon dioxide content in the atmosphere is gradually begun to increase. Thus, according to The Global Carbon Project the share of technogenic emissions is about 8% of the carbon dioxide emissions, its content in the Earth’s atmosphere is now less than 0.04%. The share of coal in the world energy balance has reached nearly 30%. Planned growth of coal consumption in the coming years (especially in India and China) will lead to a significant increase in carbon dioxide emissions (which is a greenhouse gas) into the atmosphere.

In 2008, in Germany (Ketzin) the first Europe's project to inject carbon dioxide into the lithosphere was launched. For this purpose, gaseous emissions of combustion undergo special treatment system, whereby the carbon dioxide is separated and liquefied (at this time volume is reduced by 500 times) and it is placed in bombs, which are delivered to the site of waste burial. There liquefied carbon dioxide is injected to a depth of 1000 m in porous rock. During the first 2 years, total injection of CO_2 was about 60 thousand tons.

Similar projects exist in many countries (Table 1). For example, in Australia, the Institute for the Study of capture technology prospects and burial of carbon dioxide was established. This technology is designed to minimize greenhouse gas emissions into the atmosphere by power plants. In particular, exhaust wells or porous rocks beneath the ocean bottom are planned to be used as a place for the burial.

Table 1. World projects of carbon dioxide burial

Project	Country	Source of CO_2	Amount of emissions, Mt/yr	Reservoir
Sleipner	Norway	Extraction and purification of gas		Highly mineralized water bearing bed
Weyburn	Canada	Coal gasification		Increasing of oil recovery factor
In Salah	Algeria	Extraction and purification of gas	1.2	Exhausted gas reservoir
K12-B	Netherlands		0.2	
Zama	Canada	Extraction and purification of gas	0.067	Highly mineralized water bearing bed
Snøhvit	Norway	CNG	0.7	Exhausted gas reservoir
Otway	Australia	Gas field	0.1	Exhausted gas reservoir
Ketzin	Germany	Hydrogen production	0.03	Terrigenous layer
Decatur	USA	Ethanol production	0.3	Highly mineralized water bearing bed
Jorgon	Australia	Extraction and purification of gas	3.3	
Cranefield	USA			
Antrada	USA		1.1	
Fort Nelson	Canada			
TAME	USA	Ethanol production	0.28	Terrigenous layer

The British company National Grid, which owns the UK electrical networks, also have announced their plans to build enterprises on injection of carbon dioxide produced by thermal power plants under the bottom of the North Sea in water-saturated layers of Johansen geological formations.

CO_2SINK – is a joint project of 18 different companies and organizations from 9 countries, the purpose of which is to develop a basis for the combustion products storage technology by injecting carbon dioxide in the highly mineralized water bearing beds. This project aims at increasing the efficiency of scientific and practical methods used for storage of carbon dioxide in the water bearing bed, as well as to reduce greenhouse gas emissions and the development of the future "geological" storage of carbon dioxide in Europe.

Currently, the most promising method of collecting CO_2 is absorbance method. A 30% aqueous monoethanolamine solution is used as the absorbent. The exhausted absorbent is sent to the regenerator, wherein as a result of steam heating almost pure CO_2 is distilled (with a concentration up to 99.95%) and the reduced absorbent is sent to the absorber again. The effectiveness of this method carbon capture is 85-95%.

Japanese corporation Toshiba has started the tests of a new burial technology of CO_2 at one of its plants. According to this technology, fuel gas produced at the plant in Mikawa (Fukuoka prefecture) is fed into the boiler, where it is mixed with amines and other liquid solvents. Under the sequential influence of high pressures and low temperatures, carbon dioxide is released and compressed into a liquid. Then the mixture obtained is fed into an exhausted underground oil reservoir or salt production working. Thus, there are carbon dioxide burial projects both in depleted hydrocarbon fields and in water-saturated formations. However, there is a concern that carbon dioxide will still leak into the atmosphere and it will lead to earthquakes or groundwater poisoning.

Since 1996, a similar technology has been used in the Norwegian gas field Sleipner. Natural gas produced here contains 4 -9.5% of CO_2, and the company Statoil Hydro has considered that more optimal is to clean the gas locally and to inject the separated carbon dioxide back into the ground increasing, at the same time, the pressure in the reservoir. Thus, annually more than 1 million tons of CO_2, are recycled. For all 15 years of this unit work there has been no leakage.

American researchers from the Pacific Northwest Laboratory of the US Department of Energy began to experiment on the carbon dioxide burial. To do this, they will inject 1 thousand tons of gas into the porous basalt layer at a depth of about 1 kilometer, then they will start studying the process of its absorption by rocks.

Geochemistry scientists suggest that the carbon dioxide will react with the substances constituents of the basalt and thereby, it will pass into insoluble form creating limestone deposits. Preliminary laboratory experiments and mathematical modeling has shown that during 10-15 years the basalt will absorb about 20-25% of the injected carbon dioxide.

The proposed solution exceeds the world level because it is supposed to not only bury carbon dioxide in the lithosphere, but also to create the conditions for the occurrence of controlled and targeted geochemical processes with the enclosing rock mass, for CO_2 recycling, as well as to give a massif new mineralogical, geochemical, physical and mechanical characteristics and properties.

Therefore, the development of a carbon dioxide storage technology in the collector is preceded by the following studies:

- analysis of the sources of emissions;
- detailed geological characteristics of the place of burial;
- simulation of geochemical reactions possible in the collector-bed and in the massif of overlying rock;
- modeling studies to predict the long-term storage of CO_2 in the bed;
- assessment of potential risks;
- assessment of transport technology of carbon dioxide from the source of emission to the storage place;
- technical and economic assessment of the project.

5. Development of recycling technologies of technological water in the biosphere

Currently, each person on a daily basis requires an average of 40 (20 to 50) liters of water for drinking, cooking and personal hygiene. However, according to the UN statistics, more than 25% of people in the world do not have permanent access to fresh and clean water, i.e. more than 2 billion people. It is estimated that by 2025, a third of the world's population will depend on the lack of water. In addition, it is expected that in the future (after 2020), the lack of fresh and clean water will act as one of the main problems hindering the further development of mankind.

Therefore, effective technologies of water recycling in the biosphere are very important. The researches of many scientists, as well as clubs and summits are dedicated to these problems. In particular, in September 2007 in Hungary, a summit on water technology foresight "Water Productivity in Industry" was held.

In Israel, which has fairly small reserves of natural water resources, 75% of industrial waste waters (of the volume of wastewater coming to the treatment) is cleaned and reused. By recycling technology, 2.5% of the total water used in Singapore is cleared.

Water recycling in the biosphere should consider the following components: the limits and possibilities of self-cleaning of polluted water, as well as technogenic cleaning of polluted waters (in this case, a consideration of the principles of water treatment depending on the type and the kind of pollution and the use of new effects and phenomena is of interest).

Suspended solids, oil, phosphorus, phenols, synthetic surfactants, compounds of copper, iron and zinc are the most common contaminants of wastewater. Naturally, the discharge of polluted wastewater into surface waters affects the quality of surface waters. Water of the vast majority of the major rivers of Russia belongs to the classes of "dirty" and "extremely dirty" (State report "On state and use of water resources of the Russian Federation in 2009", NIA-Priroda, Moscow - 2010). The main pollutants that are present in almost all surface waters include oil, iron compounds, copper, zinc, and difficult and easily oxidized organic matters, respectively, COD and BOD_5 and phenols.

The special tasks of cleaning waste water, for example, liquid radioactive waste and pharmaceutical industries stand apart. All of the above contaminants are macromolecular organic compounds.

Results of investigations of different research centers laboratories indicate the presence of significant amount of harmful dissolved substances in the almost all world water reservoirs, which in most cases does not allow to use water from open sources even for technical purposes.

To solve the problem of wastewater treatment and recycling of technological water in the biosphere, the use of advanced plasma-optical and ion flotation methods in the complex technologies of drinking and industrial water obtaining from sources of natural and technogenic origin is quite promising.

Considered subsoil use technologies have advanced character in almost all possible indicators and assessment criteria.

Conclusions

The current state of the subsoil use is often characterized by clearly insufficient level of the existing automation of technological processes of mining operations, and the use of obsolete and worn-out equipment (leading to a decrease in the volume of recovered products at exploited deposits and operating costs increase), increasing remoteness of developing mineral deposits from the developed areas, increasing the shear of refractory materials with the growth of technologically harmful impurities, etc.

All these problems are system-wide and in order to overcome such negative phenomena, special studies to stimulate the growth of new technological order are required, which rise can create a new long wave of economic growth.

As a result of scientific analysis and expert forecasts, the following approaches to subsoil use technologies with advanced character can be distinguished.

Creating the advanced technologies of subsoil use is focused on the basic principle of geo-resources or mineral resources use.

This principle implies the rejection of resource consuming technologies and, on the other hand, the widespread use of resource-saving technologies, which provide a reduction in the consumption of all economic resources per unit of finished products for the entire process chain, from geological exploration, delineation of economically sound commercial reserves of multicomponent ores, extraction, ore preparation and ore sorting, preliminary concentration, main concentration with discharge of collective and mono-mineral concentrates, their complex chemical and metallurgical processing until obtaining the final production of mineral complex.

References

1. Vorobyev A. E. (2000) Biosferouluchshayuschie geoekologicheskie tehnologii [Biosphere improving geo-ecological technology]. *Geoekologia* [Geoecology]. No 5, p.p. 387-394.
2. Vorobyev A. E., Dzhimieva R. B. (2008) Sovremennyie metodyi prognozirovaniya vozmozhnogo razvitiya tehnologiy nedropolzovaniya [Modern methods of predicting the possible development of subsoil use technologies]. *Materialyi VII Mezhdunarodnoy konferentsii «Resursovosproizvodyaschie, maloothodnyie i prirodoohrannyie tehnologii osvoeniya nedr», Moskva-Erevan* [Proceedings of the VII International Conference "Resources reproducing, low-waste and environmental technologies of mineral resources development", Moscow-Yerevan]. Moscow: People's Friendship University, p.p. 85-88.
3. Kapitsa S. P., Kurdyumov S. P., Malinetskiy G. G. (2003) *Sinergetika i prognozyi buduschego* [Synergetics and forecasts of the future]. Moscow: Editorial URSS. 288 p.
4. Arutyunov V. S, Lisichkin G. V., Malinetskiy G. G.(2009*) Nauka Rossii. Ot nastoyaschego k buduschemu / Buduschaya Rossiya* [Russian Science. From the present to the future / The future Russia]. Moscow: LIBROKOM. 512 p.
5. *CAE kak mif i realnost* [CAE as myth and reality] Available at: http://tsu.ru/university/rector_page/sae-kak-mif-i-realnost.