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Energy resource efficient and environmentally friendly land use planning principles for intensive remediation of solid waste landfills

A P Glinushkin¹, V V Vershinin², T N Kovaleva³, V V Chelnokov⁴, V P Meshalkin⁴, A V Matasov⁴, A S Makarova⁴, A N Glushko⁵, E A Nikulina⁵, D A Makarenkov⁵

¹All-Russia Research Institute for Phytopathology of the Russian Academy of Sciences, Big Vyazyomy, Moscow Region, 143050, Russia

²State University of Land Use Planning, Ulitsa Kazakova, 15, Moscow, 105064, Russia

³Gubkin Russian State University of Oil and Gas Leninskiy Prospekt, 65, Moscow, 119991, Russia

⁴D I Mendeleev Russian University of Chemical Technology, Miusskaya Ploshchad', 9, Moscow, 125047, Russia

⁵Nits "Kurchatovskiy Institut" – IREA, Ulitsa Bogorodskiy Val, 3, Moscow, 107076

Corresponding author's e-mail: glinalel@mail.ru

Abstract. Solving the problem of energy resources shortage is proposed in close connection to the problem of environmental pollution. The land use management is proposed as a basic tool. This is because the land use management implementation is focused on of land resources protection and has always been considered exclusively as the land resources rational and effective use.

1. Introduction

Currently, a world community concern is two global problems: lack of energy resources and environmental pollution. If the former has been manifesting itself for centuries and is the leading factor in all modern conflicts in the world now, the latter has shown its terrible "face" in the last few decades. Which of these problems is more important, it is difficult to say now [1, 2]. The growth of consumption leads to a removal of resources from the natural environment. The growth of waste in result of such consumption is much larger than the growth of consumption (Table 1). It is very important to understand, that the solution of the first problem, as a rule, aggravates the solution of the second problem. Table 1 showed that the extraction of fuel, energy and other minerals forms more than 90% of all waste.

Now Russia has accumulated more than 30 billion tons of production and consumption waste as a result of past economic and other activities. According to the results of territories inventory, the 340 objects of accumulated environmental damage were identified, which are a source of potential threat to the life and health of 17 million people. The authorized waste disposal facilities number is about 15 thousand. The facilities cover an area of approximately 40 thousand km². There are unauthorized waste disposal facilities. The total area of the waste disposal facilities increases annually by 300-400



thousand hectares [3, 4]. For comparison, this area is 2 times larger than the entire territory of Israel (20 thousand km²) or almost equal to the area of countries such as Switzerland (41 thousand km²) and the Netherlands (41 thousand km²).

Table 1. Industrial waste structure and dynamics in Russia [3, 4, 5]

No.	Branch of economy	Volumes by year, %		
		2005 r.	2015 r.	2020 r. (forecast)
1	Extraction of fuel and energy minerals	49	61	63
2	Extraction of other minerals	33	30	29
3	Manufacturing	10	6	5
4	Fuel and energy complex	2	1	1
5	Agriculture and forestry	1	1	1
6	Other industries	5	1	1
The total amount of waste, % / billion tons		100/3	100/5	100/5

2. Object of research and methodology

All living things in Nature are connected to each other insofar as they serve as food for each other. The trophic connection between them ensures the transfer of energy (energy resource) from one source (organism) to another in a closed circle: autotrophs — heterotrophs — destructors, and again autotrophs. The chain is closed, there is no waste. Anthropogenic contact with Nature always generates a by-product, which is commonly called waste. This is due to the fact that a person can take from Nature only that part of the energy (those resources) that the level of his technological development allows him. The rest of the energy is either still impossible to take, or it is not possible to use by a person. As a result, a certain part of the substance taken from the ecosphere, but unused, becomes waste.

With the development of civilization, the ratio of the consumed part of the resource of Nature and waste should steadily change in favor of the consumed part. Therefore, what we now call the waste, tomorrow we will call unclaimed energy (secondary resource) or deposited energy (resource).

In today's broad public consciousness, there is still no understanding that the results of human labor that have not been formed into the desired product of labor and are aimed at recycling are a deposited energy resource. As a result, when there is a shortage of energy resources, we are simultaneously faced with environmental pollutants, which are essentially unused energy resources.

Paraphrasing the well – known statement of Paracelsus about poisons, in our case it can be argued that there should be no waste in nature management. There are only used and unused or not fully used (deposited) resources. What should be done to ensure that waste should be already now considered as unclaimed energy (an unused resource)? This is the subject of this work.

3. Results and discussion

Industrial waste, or "secondary resources", has long been successfully used for economic purposes. Moreover, the waste is a significant part of raw materials for some types of products (Tables 2 and 3).

Table 2. Use of secondary raw materials in Russia [4, 6]

Type of secondary raw materials	Usage	Share in production
Ferrous scrap	83	23
Waste paper	36	12
Glass	34	10
Plastic	11	4
Rubber, including tires	10	3

Table 3. Use of secondary raw materials in leading European countries [4 6]

Secondary raw materials	Practice of recycling
Ferrous scrap	More than 45% of all steel in the EU is smelted from scrap metal
Waste paper	More than 50% of all paper and cardboard products are made from waste paper
Glass	Glass waste recycling exceeds 85%
Plastics	Plastic waste recycling has exceeded 50% (20% recycling, 30% incineration for energy)
Rubber, including tires	Rubber, including tires recycling (recycled or used as fuels) reaches 90%

Analysis of the morphological composition of solid waste landfills indicates a significant energy potential of this secondary source of raw materials. More than three — quarters of waste located in landfills is organic matter (table 4), that is, the source of the "simplest" energy resource-biogas.

Table 4. Average morphological composition of solid household waste (MSW) Russia [5 7]

No	Types of waste	%
1	Organic waste	41
2	Paper	35
3	Textiles	1
4	Glass	8
5	Plastic	8
6	Metals	3
7	Other	3
Total amount of waste, %		100

Let's look at the problems associated with the design, operation and reclamation of landfills.

The authors of this publication have studied the main regulatory documents for the design, operation and reclamation of solid waste landfills and have come to unsatisfactory results.

The documented data [8-12] defined that for many decades the design and operation of MSW were considered as "complexes of environmental protection structures intended for storage, isolation and disposal of MSW, providing protection from pollution of the atmosphere, soil, surface and ground water, preventing the spread of rodents, insects and pathogens" [12]. However, in recent years, the landfills themselves have become sources of environmental pollution. They have become the objects that perform the opposite function, in contrast to the one that they should carry out.

As our research has shown, there is number of reasons for this drastic change. We will focus only on two of them, which are quite enough to cause an alarm.

The first reason is the violations of rules (requirements) in the design, operation and reclamation of landfills. On the Rosprirodnadzor website (rpn.gov.ru Statistics) there is statistics on offenses in this area. We will leave these statistics without comment, noting only that the number of violations is growing every year.

The second reason is the lack of elaboration and validity of the existing design and operational documentation and the lack of methodological support and support for rapidly changing operating conditions of solid waste landfills as well.

In support of this thesis, we present only a small part of the shortcomings in the documentation for the design, operation and reclamation of landfills [12] concerning only the choice of location for the landfill. In this recommendation group:

- there are no clear instructions regarding the distance of solid waste landfills from localities other than "placement outside cities and localities". Remoteness of landfill from settlement is governed only by the size of sanitary-protective zone around the landfill. But the parameters of the sanitary-

protective zone are determined by one digit only – 500 meters. This is regardless of the area of land allocated for the landfill (landfill space), as well as the capacity of the polygon, the species composition of stored wastes and several other factors, in our view, to determine its size. It is also indicated that "the size of the sanitary protection zone can be adjusted to take into account the MPC of gaseous emissions". However, gaseous emissions are known to be unstable and depend on many natural and anthropogenic factors.

- there are no full-fledged and reasonable recommendations for monitoring the condition of the landfill. It is recommended only to monitor "over the waste areas of the landfill and on the border of the sanitary protection zone". We believe, this recommendation is absolutely not enough.

- there are contradictions in the recommendations for choosing the location of the landfill according to hydrogeological conditions: "the use of flooded territories for landfills is excluded". At the same time it is recommended to allocate for landfills the "spent quarries, ... ravines, and other territories".

We do not undertake in this publication to set out in detail and justify our recommendations for improving the choice of location for a landfill and other methodological shortcomings that we have noted. However, considering the problem as a whole, we believe that the most reasonable way is development and implementation of land management projects based on environmental and economic principles. Let us turn to the justification of this provision.

Currently, there is an active scientific and socio-professional debate about the role and content of the modern land management in the Russian Federation. More than a quarter of a century after the beginning of the land reform (1991), the country has developed new ideas about the role of land management in solving the problems of rational land use. There are new problems and tasks that had to be solved in the process of land transformation, and the content of previously developed land management projects has changed significantly.

Despite different points of view on the content of land management in the scientific and socio-professional debate, there is complete unanimity in understanding the role of modern land management – the rational and efficient use of the resource potential of the earth.

Land as a natural resource and the result of activities of many generations of people has always been the basis of the country's economy. Land, labor, capital, and in modern conditions of production also information, determine the main means of production. The main means of production are the main value of any state. It should be noted that the land that has been removed from the production process (from use or exploitation) loses its value as a used resource (loses its resource property) from the economic point of view.

It follows that the only way to preserve (protect) the land is to use it. A prerequisite for this "method" of land protection is the rationality and efficiency of its use. Rationality implies environment safety and efficiency – economic components of the basic principle of land management.

The problem of shortage of energy resources and the problem of environmental pollution should be considered as a single problem – the problem of the lack of rational and efficient use of the earth's resource potential. At the same time, it becomes obvious that land management is the state ecological and economic tool for implementing the state policy in the field of protection and use of this potential.

Let's consider the content of the land management part of the project of the landfill development. As is customary in land management design, drafting should be preceded by preparatory work, during which the following steps are to be made:

- collect and study the necessary materials including: existing surveys, soil, geobotanical and other surveys, the assessment of land projects of using territories of previous years, schemes of regional planning, as well as other materials;

- land management survey of the territory is carried out to obtain additional information about the state of the territory and the possibility of its use for the intended purposes;

- technical task is being developed for drafting the project.

In our opinion, the development of a land management project for a solid waste landfill should consist of the following three parts:

1. Formation and allocation of a land plot for a solid waste landfill, including:
 - calculation of the landfill capacity, storage area, sanitary protection, transport, operational, auxiliary and other zones;
 - calculation of parameters and placement of infrastructure;
 - calculation of vertical planning, improvement, and environmental protection structures;
 - development of a scheme for territorial linking of polygon objects;
 - placement of functional zones on the territory of the polygon;
 - placement of transport and other infrastructure;
 - development of the solid waste site plan and legal documentation.
2. Placement of the landfill operation system, which includes:
 - development of logistics schemes for transportation of solid household (municipal) waste;
 - development of the MSW storage system;
 - development of the MSW use system for obtaining various types of resources;
 - calculation of the business plan for the MSW of secondary energy resources use;
 - development of a monitoring and controlling system for environmental protection compliance;
 - calculation of economic indicators (economic efficiency) of landfill operation.
3. Development of the measures for reclamation of the landfill territory, including:
 - analysis and selection of reclamation methods;
 - development of technologies for reclamation;
 - development of options for reclamation of landfills for various types of further economic use;
 - calculation of economic indicators for reclamation;
 - preparation (development) of a land plot passport for various types of subsequent use.

The author's supervision is an essential condition for the implementation of a land management project. It should be noted a number of advantages of the developed approach to the land management project for the solid waste landfill compared to the current system of design, operation and reclamation of such landfills:

1. Proposed project as a single document will provide a systematic approach and complexity in solving the problems of operation and reclamation of land intended for temporary use as a landfill;
2. Single project document will also ensure proper economic and environmental control over the landfill operation and eliminate the corruption.
3. Project will include a calculation of the economic efficiency of each component of the project in a strict accordance to the environmental protection requirements;
4. Significant part of decisions will be made automatically (based on the modern digitalization capabilities: computer programs and models). This will allow you to make a quick management decision taking into account possible changes during the operation or reclamation of the landfill, as well as when regulatory requirements will change.
5. Basic concept of the project being developed: the obliged return of the territory to the previous state excluding the environmental losses according the principle: "the land protection means its rational use". This will ensure the preservation of the land resources of the country;
6. Project will be developed for all the operation stages ensuing clear prospects of the territory.

The land management project described above should be considered as the final stage of the "organizational and economic line" for the waste disposal and reclamation of landfills. Therefore, an effective solution should begin with the development of a General scheme for the use of land for landfills throughout the Russian Federation. Since this problem is of a state nature, as evidenced by the decree of the Government of the Russian Federation No. 84-R of January 25, 2018 [13], the General scheme should become the basis for the development of these land management projects. By its status, it should be a pre-project (forecast) document used for preparing scientifically based decisions on the placement of land plots for all objects intended for storage (burial) and processing of the MSW, as well as their reclamation and forecasting the subsequent use of these plots for other purposes [14].

One of the most important tasks of the General scheme should be to ensure a balance between the withdrawal of land for landfills and their return after the reclamation of landfills. Obviously, the lack of such a balance can lead to disastrous consequences. Along with the above, the General scheme should contain a forecast of the volume of energy resources obtained through waste processing (landfill reclamation).

The General scheme should show the location of not only landfills, but also incineration plants, ecotechnoparks, multifunctional complexes for industrial waste disposal, industrial waste processing facilities, sanitary protection zones and other facilities and infrastructure in this industry.

This General Scheme can be used to develop a comprehensive scientific and technical program of the productive forces development, the formation of the energy potential of the Russian Federation, issuing of sub-Federal, regional and municipal programs for the use of MSW and protection of natural resources.

It is recommended that such schemes be developed at the sub-Federal and municipal levels.

The proposed measures will allow you to build the following "organizational and economic line" for solving the problem of MSW: forecasting-design-operation — reclamation — economic use after reclamation. The proposed scheme provides for the development of fundamentally new approaches to solving the problem of conservation and reproduction of energy and the ecosphere [15, 16].

4. Conclusions

1. The problem of energy scarcity and the problem of environmental pollution should be viewed as a single problem — the problem of irrational use of resources (or unsustainable development).
2. Production and consumption waste should be considered as temporarily unclaimed (deposited) resources (or temporarily unused energy).
3. Collection, processing, utilization, neutralization, and reclamation of production and consumption waste are the components of a new independent branch of the national economy, the formation and development of which is currently underway.
4. Modern land management can act as an ecological and economic tool for implementing the state policy in solving problems of irrational use of natural and produced resources.
5. Solid waste landfills are significant sources of unused (deposited) energy resources.

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