FASCINATING PEAT STORY

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N.V. Grevtsev, A.N. Syomin, I.N. Grevtseva Zanimatelno o torfe (Fascinating Peat Story) / **N.V. Grevtsev, A.N. Syomin, I.N. Grevtseva** – Moscow: “Kadrovy Rezerv” Fund, 2020. – pp 192: illustrated.

The book tells a comprehensive and easy-to-read story about raw materials, global peat reserves, swamps all over the planet where peat comes from, peat types and kinds, flora and fauna of Russia’s swaps, and rational peat harvesting. It discloses specifics of innovative techniques available in peat harvesting and usage in heat and power engineering, agriculture, and medicine based on latest deliverables by researchers from Belarus, and the St. Petersburg, Tver, Vladimir, Urals and Siberia scientific schools.

Emphasis is put on the nature conservancy role of peat, remediation of peat resources, and technicalities of use of spent deposits.

The book is intended for the general public interested in nature and planning to start a business.

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1 ЧТО ТАКОЕ ТОРФ

WHAT PEAT IS

1. WHAT PEAT IS

1.1. Peat origin and history

Peat is a young combustible fossil resource.

Geologically speaking, this is an organic, watered resource of plant origin, a genetic precursor of coals characterized by the complex composition and the presence of a wide range of organic substances: bitumen, carbohydrates, humic acids, etc. It derives from natural death and incomplete decay of bog plants due to biochemical processes unfolding amid high humidity, lack of oxygen, and poor mineral nutrition. It is found in the surface layers of soil or under mineral deposits. Peat is a complex system of three elements: organic, mineral, and water.

In terms of physics and chemistry, peat is semi-colloidal high-molecular, multicomponent and polyfractional hydrophilic system manifesting signs of polyelectrolytes and micromosaic heterogeneity. Peat looks like a fibrous or plastic mass (depending on the degree of decomposition) of brown or black color (depending on the humus content).

Specific features of peat harvesting and usage led to the appearance of peat industry as a distinct economic sector.

Members of the St. Petersburg scientific school of peat industry mechanization (among them I.N. Khudyakova) from the St. Petersburg Mining University made a retrospective analysis of the development of the domestic peat industry.

The use of peat bogs in Russia started in ancient times. This is mentioned by the Karelian and Finnish epic poem Kalevala, which dates back to the final days of the tribal system. Rune 9 (song) of the epidemic poem speaks of bog ore mining in Karelia for the purpose of iron smelting and production of axes and spears.

Academy member B.A. Rybakov, who studied history of crafts in ancient Russia, pointed out that all East Slavic tribes and all latest Russian principalities existed within the area of ore deposits, bogs, and Russian smiths had access to relevant raw materials practically everywhere. In certain areas of Belarus and northwestern Russia, bog iron was used in metallurgical industry up to the 18th century.

Before 1917, Russia mostly had small-scale and artisanal peat production, mainly at textile factories. Peat was cut manually at first. Seeking to mechanize the process, peat cutting machines were created in the first half of the 19th century, but they were soon abandoned due to the difficulties created by wood pieces in the peat. Peat processing machines, the so-called presses, were invented to improve the quality of cut peat, and elevator scrapers were designed to raise labor productivity.

In this form, with all those problems and disadvantages (harvesting, uprooting of tree stumps in a quarry, transportation of peat to the drying field using wheelbarrows and carts) and low productivity (up to 3.5 thousand tonnes of air-dried peat in one season), the elevator scrapper survived for over half a century as the only peat machine in Russia available till the 1920s.

Two decrees, “On Peat Harvesting” and “On the Main Peat Committee,” were adopted on April 21, 1918, to start the broad use of peat in the national economy.

The State Commission for Electrification of Russia was founded on February 21, 1920, and tasked with drafting the GOELRO plan, which envisaged construction of 20 district peat and power plants, among them five plants using peat as a fuel. They were located in Shatura, Petrograd (currently St. Petersburg), Ivanovo-Voznesensk, Nizhny Novgorod, and Tver.

In 1920, celebrated Russian power engineer R.E. Klasson proposed that a new peat harvesting method, hydraulic invented by him and engineer V.D. Kirpichnikov back in 1914, be used in industrial production.

The hydraulic method of peat harvesting was a major technical achievement for that period, as it allowed to operate plants of higher capacity, to increase production concentration, and to cut cost of peat fuel. As many as 187 million tonnes of air-dried peat were produced by that method.

Heavy-duty hydraulic peat harvesting machines were designed and built in 1927. Each machine replaced 18 elevation scrappers in use before 1917. Hydraulic peat harvesting was accompanied with modernization of forming and elevator equipment that excavated peat from bogs. Later that year, the Central Research Institute of the Peat Industry (Instorf) presented an upgraded electric-drive elevator machine. The straight elevation scraper was replaced by a cranked plate conveyor, and the manual carriage of bricks was replaced by an original rope conveyor. The engineering solutions increased the elevation scraper’s output to 5,000-7,000 tonnes per season in case of two-shift work.

Instorf presented a multi-row, multi-bucket crawl excavator in 1927-1928.

In 1917, engineer I.A. Rogov suggested designing a machine that could mill both peat and residual wood. Later on (in 1923-1925), N.A. Ushakov and G.B. Krasin designed a machine for milling the surface layer and molding crumbs and declared the impossibility of making peat crumb fuel due to weather conditions. In 1923, I.A. Rogov presented a method of manufacturing powdered fuel from the surface layer of peat bogs.

In the following years (1925-1926), I.A. Rogov designed and built a machine, which milled surface-layer peat and residual wood.

That same year, engineer M.N. Korelin proposed his “crush" method of peat extraction: the surface layer was crashed to a depth of 100-175 mm with a Lanz agricultural cutter, and crumbs were turned and arranged into rows, 1-meter-tall heaps, and stacks.

The peat milling method became industrial in 1929 and started serving as the main peat industry method in 1951.

The milling method was widely used during the first five-year periods (1928-1937) to harvest peat, to perform other bog preparatory works, and to dry sod peat.

A new progressive area in machine-building – electrification of peat machines – emerged during the Great Patriotic War (1941-1945). The all-Russia Research Institute of Peat Industry (VNIITP) designed an electric dewatering screw press based on an electric caterpillar tractor with a mounted screw. Over the same period, VNIITP made an electric peat spreader. An electric reloading machine was widely used in the 1950s to harvest milled peat.

In 1952, VNIITP designed a mechanized complex to harvest sod peat; the complex consisted of the UKB harvester and the SKS-2 self-unloading self-propelled carriage. In 1956, the UMS machine was designed to turn and bale sod peat.

In 1949-1955, the Moscow Peat Institute developed (by S.G. Solopov) and laid down main principles of mechanization in the production of high-quality peat crumbs from low-humidity peat bogs and created a profound dewatering machine for intensive reduction of humanity levels.

Works continued in the post-war period, and such equipment as the BP pneumatic milling harvester, the ESL clearance and baling machine, etc., was designed.

Following a decline in the use of peat fuel, the main strategic area of the peat industry’s development was the shift from massive production of peat fuel and agricultural peat to profound peat processing and production of a broad range of multi-use products, i.e. the shift of the peat industry from harvesting to harvesting and processing. Given recurring crises in the national economy, peat could be in demand as a way to solve energy and food security problems.

Peat fuel reserves estimated at 68.3 billion tonnes of equivalent fuel exceed the overall oil and gas reserves.

The upcoming massive use of peat resources in Russia's market economy has a number of fundamental aspects, such as raw material, technological, ecological, and socioeconomic, and requires a series of peat harvesting, processing and innovative use projects.

Peat extraction and processing has established itself as a highly profitable and promising business all over the world.

Among vast natural resources of our country, peat plays a special role and can be found practically throughout the Russian territory.

Peat is an important energy, industrial and agro-chemical reserve for dealing with the aftereffects of sporadic economic crises and developing innovative technologies in power and manufacturing industries and agriculture.

Alongside dynamic development of science, peat becomes an important resource for biotechnology, healthcare and other types of innovative energy activity.

Thanks to the work done by domestic scientists in 1920-1990, our peat industry has become a global leader in terms of mechanization levels, organization of peat production and scientific potential.

In the beginning of perestroika (1985-1987), the Soviet peat industry was a well-governed extracting and processing industry with 100% mechanization of technological processes and a high level of geological survey and research.

In the 1990s, amid the reduced amount of peat harvesting and usage caused by economic issues, peat machine plants started manufacturing other types of equipment Peat production was continuously on decline due to the stopped government funding of the industry and the steep decline in solvent demand from the agricultural sector.

Nowadays, peat industry development is largely determined by project governance by the state. This approach implies the opening of project offices to help implement commercial and social projects.

To our mind, the peat industry project office should rely on the main principle, which defines unique natural surface formations, peat deposits, as national heritage.

As a result of photosynthesis, solar energy is accumulated in organic substances of **peat-forming** plants. Hence, peat could be described as a product of decomposition of those plants. It has pronounced agro-physical properties, and its chemical composition retains biologically active substances, which allow peat to be successfully used in crop farming, veterinary, pharmacology, balneology and a great variety of nature-conserving biotechnologies.

Against the backdrop of sporadically exacerbating crises in the global economy, peat could be the most relevant resource and serve as a foundation for multiple elements of Russia's national, energy, and food security.

National food security is directly related to the restoration of cropland fertility. The recent policy of intensification and chemicalization of agriculture and non-traditional methods of land cultivation reduced the content of humus and led to degrading water and physical properties of soils. Therefore, organic foods could be grown on condition of massive supply of fertile, ecologically pure soil mixtures and organic fertilizers based on peat.

The modern peat industry is actively using modern technologies, including digital ones. For instance, the development of peat bogs increasingly depends on sensors monitoring their condition, same as the condition of entire environment, and transmitting data to specialists via online applications. Unmanned peat harvesting machines are being designed. It is impossible to use such machines without cartographic and GPRS (geo-positioning) systems.

Economic cooperation between peat manufacturers and combination of various types of energy allow the implementation of nature-friendly and effective energy saving technologies.

Public-private partnership, which implies mutually advantageous cooperation between business and various levels of government, could be a promising form of an innovative peat business. Public-private partnership is particularly efficient in the extraction and processing of peat, considering that the government is interested in spatial development, business seeks profit, and workers of peat extracting and processing enterprises want stable income.

1.1.1. Synthesis and decomposition of organic matter

As we have said before, peat is a product of multiple chemical reactions and an organic compound.

Organic compounds are substances with a complex molecular structure of the carbon "skeleton" aligned to or deriving from hydrocarbons. Organic matter is fairly rarely found in the earth's crust, but all known life forms are based on organic compounds. The main classes of organic substances of biological origin are proteins, lipids, carbohydrates, and nucleic acids. In addition to carbon, they mainly contain hydrogen, nitrogen, oxygen, sulfur, and phosphorus.

Non-organic matters are simple substances and compounds that do not contain organic matter, i.e. carbon, as well as certain carbon-containing compounds. Non-organic matters do not have the carbon "skeleton" characteristic of organic compounds.

From the angle of chemistry, peat forms as a result of continuous photosynthesis processes and decomposition of organic matter (Fig. 1), which create **biotic turnover**.

Minor (biotic) turnover of substances **occurs** on the level of biocenosis[1]or bio-geo-chemical cycle. The thing is that soil nutrients, water and carbon get accumulated in plant matter and used to form plant bodies and to perform life processes of the plants themselves and other living organisms. Products of decomposition of organic substances return to the natural turnover through photosynthesis in plants.

[1]**Biocenosis** is a system of interactions and mutual influences of animals, plants and bacteria existing in the same territory.

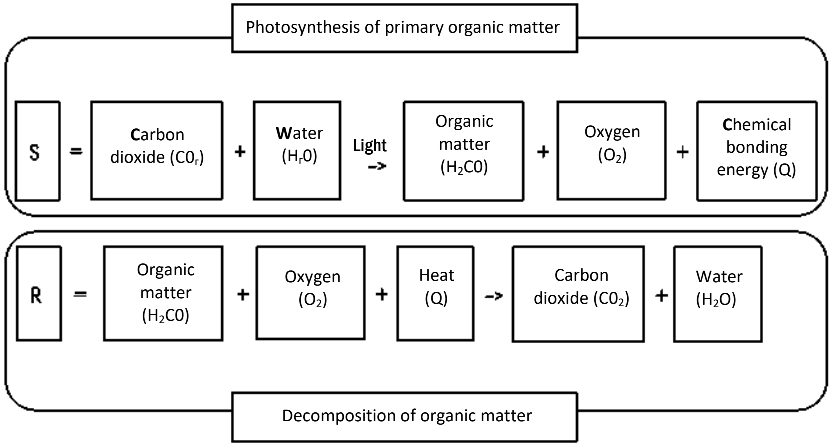

Fig. 1. Photosynthesis and decomposition of organic matter

Biotic turnover of carbon is the primary part of the major turnover; it is related to the life of organisms. In the form of carbon dioxide (CO_2), carbon serves as the "raw material" for plant **photosynthesis**, later on it is taken in together with the matter by consumers[2] of various trophic levels.

The vast share of primary organic matter on the Earth is a result of photosynthesis, the process in which cells of green plants create transform water and carbon dioxide into sugar molecules (including glucose molecules) under the influence of solar energy and as a result of complex chemical reactions, free oxygen gets released, and the energy of sunlight photons is converted into the energy of chemical bonds of organic matter (Q).

Carbondioxide ($6CO_2$) + water ($6H_2O$) + light $\rightarrow$ glucose ($C_6H_{12}O_6$) + oxygen ($6O_2$) + Q

Hence, plants that grow on our planet incessantly consume huge amounts of carbondioxide from the atmosphere - about 200 billion tonnes a year and release 145 billion tonnes of free oxygen, forming over 100 billion tonnes of organic matter.

[2] **Consumers**–are organisms (heterotrophs) taking inorganic substances created by other organisms (autotrophs).

A certain part of primary organic matter is created by bacteria as a result of **chemosynthesis**. Their source of carbon is carbon dioxide restored with molecular hydrogen or hydrogen from hydrogen sulfide or another non-organic substance. Synthesis of organic matter by bacteria could happen with or without light.

Carbon dioxide ($6CO_2$) + hydrogen sulfide ($12H_2S$) $\rightarrow$ glucose ($C_6H_{12}O_6$)+ sulfur (12S) + water ($6H_2O$)

When plants and animals breath and dead organic matter decomposes (destructors (reducers) are at work), carbon dioxide (CO_2) returns to the atmosphere. The presence of oxygen and high temperature is necessary for decomposition of organic matter.

Glucose ($C_6H_{12}O_6$) + oxygen ($6O_2$) + heat (Q) $\rightarrow$ carbon dioxide ($6CO_2$) + water ($6H_2O$)

Some photosynthesis products are not taken in by primary consumers and are not decomposed by destructors. They are deposited (stored) in lithosphere as dead organic matter and become fossils. **Peat and coal are deposited organic matter, a product of photosynthesis in plants from former geological epochs.**

1.1.2. Microorganisms, their life cycle and peat

Many plants have bigger roots than stems. For instance, the ratio is 130 to one for winter rye. The total length of a winter rye plant (without root fibrils) is 623 kilometers! The life cycle of one root fibril is several days, fibrils keep dying and new ones keep emerging.

This means that all plant and animal residue decomposes under the influence of bacteria and microorganisms[3] and forms new substances of humus.

Microorganisms or microbes (Greek. μικρος – small and βιος – life) is the collective name of living organisms, which are so small they can be seen only with a microscope. Microorganisms are typically less than 0.1 mm in size). These include prokaryotes whose cells lack a nucleus: bacteria, archaea, and eukaryotes: some fungi and protists (except for viruses, which are isolated into a separate group).

Most microorganisms are one-cell bodies but there are multi-cell microorganisms, as well.

The Earth hosts about $5 \cdot 10^{30}$ bacteria whose overall biomass exceeds the aggregate biomass of animals and plants.

Plenty of microorganisms appeared on the Earth over millions of years of the evolution: they live everywhere and keep adapting to new conditions. Their habitat includes the surface, the air, deep inside the Earth crust, and the oceanic bottom, mountain ridges and Arctic ice. Presumably, bacteria live even in the 11-kilometer-deep Mariana Trench. There have been reports of bacteria living in rocks 580 meters below the sea bottom, at the depth of 2.6 kilometers.

One gram of soil contains approximately 40 million bacterial cells, and a million bacterial cells could be found in one milliliter of fresh water.

Microorganisms are rapidly adjusting multirole chemical compounds, which undergo hundreds of chemical reactions. For instance, the same mold fungi can synthesize either antibiotics or enzymes and form citric, gluconic and other acids, depending on conditions of its habitat.

[3]**Producers** (Latin roducens – creators) are organisms capable of transforming non-organic substances into organic ones. These are green plants and certain species of chemotrophic bacteria.

Reducers (Latin reduco - return, restore) are organisms (bacteria and fungi) destroying remains of living organisms and transforming them into non-organic and primary organic compounds.

Consumers (Latin consume – take in) are organisms taking in organic substances created by producers. In contrast to reducers, consumers are unable to decompose organic substances into non-organic ones.

Destructors (Latin destruo – destroy), saprotrophs (Greek σαπρος –rrot and τροφη – food), saprophiles (-+ φιλια –urge), and saprophites (-+ φυτον – plant).

Microbes are capable of producing a broad range of the most complex polymers with a great variety of properties such as color, elasticity, strength, and heat resistance. While synthesizing a particular type of substances, the cell’s biochemical apparatus operates with the amazing consistency, energy consumption is minimized, and the functioning regime is optimal. As inhabitants of various media, they participate in the turnover of sulfur, iron, phosphorus and other elements and the decomposition of animal, plant and abiogenic substances (such as methane and paraffin) and ensure self-cleaning of water in reservoirs.

Microorganisms live on a variety of nutrients: some need complex plant or animal proteins, others feed on residual wood, and some consume atmospheric nitrogen and carbon dioxide. Microbes constitute a vast collection of chemical reagents, which, however, have the best chance to be preserved and reproduced only in microbes’ bodies. Microorganisms live practically in all waters. They are an important link in the metabolism of eco-systems, mostly acting are destructors (destroy), reducers (return), and producers (create).

The process of decomposition of plant remains consists of mineralization – decomposition of plant proteins, fat and carbons into simple chemicals (carbon dioxide, water and mineral salts) and humification – bio-synthesis of humic acids. Under normal conditions, microorganisms produce strong acids, which decompose matter and transform non-organic (mineral) soil substances into ones that could be consumed by plants. They create the so-called bio-humus – nutrient soil substrate (fertility). The type and rate of decomposition depend on three main factors: the makeup of plant material, the hydro-thermal regime, and the complex of organisms. In the course of decomposition, some substances are fully mineralized and the other is incorporated into humus.

Hence, under normal conditions soil is created and plants grow in the presence of a large amount of mineral substances and oxygen, a relatively small amount of water, and particular types of micro-flora, which ensures the turnover of organic and non-organic substances.

The rate of humus accumulation depends on the quantity and type of organic materials. For instance, 6% of plant litter transforms into humic substances, and 2.5% constitutes humus, which remains stable for a relatively long period of time, and "net stock" of carbon in soils. Calculations indicate that on the average the speed of mineralization is 16 times higher than the speed of humification or even 40 times higher in case of net stock in stable humus.

In swaps, the speed of mineralization is 20 times higher than the speed of humification. The concentration of regular and "stable" carbon reaches maximum amounts there, which proves that in swamp soils every transformation of organic substances proceeds at the speed minimal for all bio-geosystems of the Earth.

As were member, peat is formed under the influence of bio-chemical processes in specific conditions:

1) High humidity;
2) Shortage of oxygen;
3) Low mineral supply.

Swamps are the only place where such specific conditions occur: water prevents plants from complete decomposition, and the biotaexistent in the "water environment" (historical combination of species of living organisms) processes flora and fauna organic matter in away, which leads to mechanical dispersion (grinding) of decomposing plant remains alongside profound transformation of their composition.

1.1.3. Biochemical processes in swamps

A variety of processes is taking place inside the peat bog (peat layers are sometimes 10-12 meters thick) under the impact of multiple species of microorganisms.

The peat mass in a swamp is also called peat (peat-forming) horizon. Its structure is presented in Fig. 2.

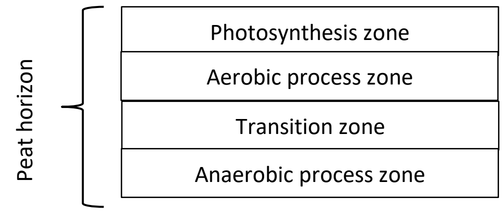

Fig. 2. Peat horizon structure

Peat horizon can be conditionally divided into four zones:

1 – **photosynthesis zone** is the lit level where biomass is accumulated; its size is limited to the depth of solar light penetration.

2 – **aerobiczone (with oxygen)** is the level of maximum micro-biological activity. Plant remains undergo the most significant physical and chemical transformations in this area under the influence of microorganisms and free oxygen.

3 – **transition zone** is the level where activity of microorganisms may change significantly under various weather patterns.

4 – **anaerobic zone (without oxygen)** – this is the level where the supply of free oxygenis inconsiderable and partial conservation of organic substances occurs.

The biological element of peat is extremely sensitive to changing conditions. For instance, their activity may increase 300-400% in higher temperatures and lower humidity.

Research indicates that peat is bio-chemically active throughout its depths but there are differences in the size of micro-flora of particular physiological groups, both in terms of landscape and the depth of deposit.

Dynamics of the activity of biochemical processes is determined by hydro-thermal conditions. The biggest number of aerobic cellulose-disintegrating microorganisms exists in dry years, while anaerobic cellulose-disintegrating microorganisms prevail in wet seasons.

The size of microbe biomass increases in lower levels of peat, which proves that the microbe complex remains viable in big depths.

Hence, the entire peat bog, which passed through the stage of bog soil formation, contains a certain amount of nutrients of biogenic origin, microorganisms, and enzymes and has potential fertility.

1.2. Peat as unique natural resource

In its natural state, peat is a more or less homogenous mass of various shades of black or brown color, which usually contains 85 to 95% of water and up to 50% of mineral ingredients in its dry part. The peat composition is presented in Fig. 3.

The type, the degree of decomposition and the ash content are the main properties of peat used for its initial appraisal. There is a great diversity of peat types by general technical and agrochemical properties, caloric value, bituminous content, composition of mineral impurities, and many other characteristics, which requires detailed and comprehensive studies of peat composition and features.

The degree of decomposition stands for the percentage of peat in the structureless part made up of decay products of the original plant mass and tiny remains of plant mass tissues that have lost the cellular structure. It may vary on a broad range of 1% to 70%. The elementary structure of peat is mostly carbon (50–60%), oxygen (30–40%), and hydrogen (5–6.5%).There are insignificant quantities of nitrogen and sulfur (0.1–3%).

The phase composition of peat is mainly humic acids (15–50%), easily hydrolyzable compounds (20–40%), lignin (5–20%), bitumens (2–10%) and water-soluble substances (1–5%).

The organic part (mass) of peat consists of five main elements: carbon (48-65%), oxygen (25-45%), hydrogen (4.7-7.3%), nitrogen (0.6-3.8), and sulfur (mostly up to 1%, rarely up to 6-7%).

The element composition of peat reflects the type of transformation undergone by organic matter in the course of peat formation. The organic part can be conditionally divided into four groups:

a) Substances extracted from peat by organic solvents (bitumens);

b) Substances extracted from peat by water and dissolved in water as a result of hydrolysis in the presence of mineral acids(the so-called water-soluble and easily hydrolyzable compounds, cellulose);

c) Humic substances extracted from peat by means of alkalis (humic and fulvic acids);

d) non-hydrolyzable substances (lignin).

The content of various groups of such compounds in peat depends on the latter’s type and the degree of decomposition.

The various **bitumosity** of peat results from various initial contents of butimens in plants and secondary processes unfolding in peat; what is more, it is higher in upper peat layers than in lower ones. The content of bitumens extracted by means of benzene varies from 1.2% to 17.7%.The highest concentration of bitumens is found in certain types of upper-layer beat, which serves as raw material in the production of wax and other valuable industrial substances.

The proportion of water-soluble and easily hydrolysable substances found in peat ranges from 7% to 60%, and the degree of decomposition increases in all types of peat as the level of decomposition rises. Most water-soluble and easily hydrolysable substances are found in peat moss (50-60%), and the content is minimal in peat wood (10-20%). This group of substances has a highly diverse chemical composition. Products of peat material hydrolysis contain a significant amount of simple carbohydrates (sugar), which allows them to be used in the production of feed yeast and other products. The content is minimal (4-6%) in strongly decomposed peat and maximal (40-75%) in upper-layer peat moss.

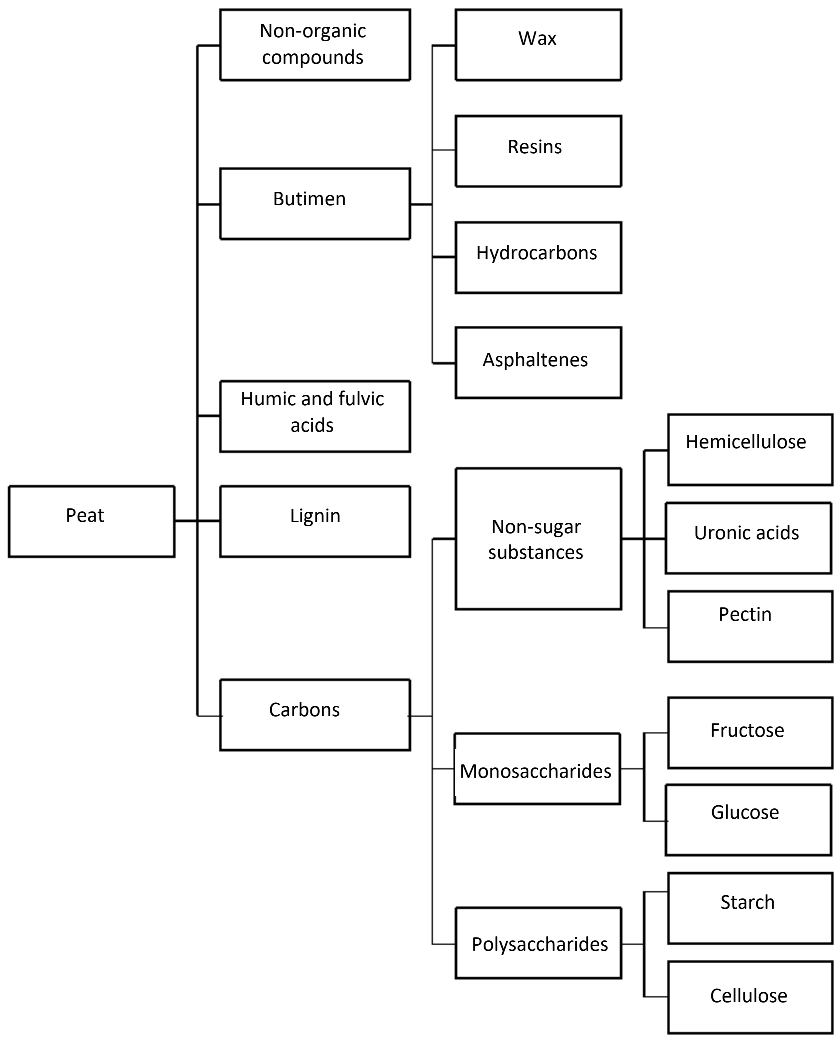

Fig. 3. Peat composition

Humic substances comprise from 20 to 70% of peat's organic part, including 5-50% of humic acids. Most of these substances are found in peat reed decomposed 40% or more. The higher decomposition is, the higher is the lignin residue. Hence, the degree of decomposition is the main factor, which determines the chemical makeup of this kind of peat.

Ash content is a key indicator of peat's suitability for various purposes. When raw peat is dried up, the dry residue consists of organic and mineral parts.

The mineral part consists of oxides of calcium, iron, silicon, phosphorus, potassium, sodium, aluminum, manganese, magnesium, sulfur and other elements, the content of which varies considerably. The ash content of peat depends on the ratio of residue formed during calcination to the total weight of the sample.

The content of minerals depends on the type of peat, conditions of its occurrence and feeding of peat deposits with ground, sewage and atmospheric precipitation; it amounts up to 50% Highly mineralized peat is formed as a result of both primary and secondary salinization.

The ash content of 50% (per dry matter) is believed to be the borderline between peat and organic-mineral sediment that is formed in case of a high ash content (50% through 85%). Organic-mineral sediment is mostly found under peat deposits and rarely forms inter layers or overlaps the surface. Peat ash and organic-mineral sediment can be of various compositions and, in addition to ballast substances (SiO_2, Al_2O_3), contain valuable (P_2O_5, CaO, etc.).

Sediment with the ash content higher than 85% belongs to the mineral soil category. Peat deposits in river valleys can be overlain by mineral sediment (silt, clay, sandy). Mineral soil is found in the form of interlayers in low-lying peat deposits.

Depending on deposit formation, occurrence and feeding, peat contains various mineral formations (swamp phosphates, gypsum, sapropel, etc.).

Swamp phosphates are natural mixtures of peat and vivianite. Vivianite is a type of mineral formations from the group of bog phosphates genetically related to peat deposits. At the same time, its derivatives are often found in the peat deposit - beraunite, picite and others, each of which has its own definite place in the section of the peat deposit due to oxidation-reduction conditions of the environment. Vivianite itself (phosphate iron oxide) in fresh samples has a light gray to white color and creamy consistency. When exposed to air, it oxidizes and turns blue, forming powdery aggregates upon drying. It always lies below the water table.

Depending on the peat-to-vivanite ratio, which derives from the content of phosphorous, there is vivianite peat (0.5-2.5% P_2O_5) and peat vivianites (2.5-15% P_2O_5). Swamp phosphates form lenses and interlayers throughout the peat deposit with a thickness of 0.3 to 2.0 m. Sometimes, monomineral interlayers of pure vivianite are found with the P_2O_5 content of 16-28%. There are also peat deposits drenched in vivianite, which are called vivianite peat. The accumulations of bog phosphates in peats are quite common; they are mainly found in floodplains and low river terraces above floodplain.

Gypsum (freshwater lime) means freshwater bog-lacustrine bio-geochemogenic sediments of calcium carbonate, whose content reaches 90%. It looks like loose, fairly light and porous mass of white and light gray color. In the presence of iron oxides, gypsum has a light brown color, and humus contributes to its dark gray color. It mostly occurs on the bottom and less frequently inside the peat deposit. Gypsum forms layers and lenses with a thickness of 0.5-1.5 meters, less often up to 2.0-2.5 meters. Other mineral formations present in peat deposits include iron ocher, limonite and siderite.

Buried sapropel is found beneath peat deposits, mainly of lacustrine origin. **Sapropel** is sediments of freshwater reservoirs formed from dead plant and animal organisms, minerals of biochemical, geochemical origin and mineral components of an imported nature, with an ash content of no more than 85%.

1.3. Swamp as peat cradle

In the course of Russia’s industrialization (1929-1941) peat was widely used in the economy, and its properties, specific features and formation conditions were actively studied for that reason.

It appeared that peat from various deposits not only looked different but also had different physical properties, elements and chemical composition depending on the way of peat formation and plants that made up the peat mass. Peat studies attribute a principal role to **genesis.** Peat forms as a result of the swamping process, so history and specific features of the swamp origin determine its qualities.

Development of science always leads to the appearance of new terms and definitions. From the scientific angle, the term “swamp” depends on the factors studied by a particular scientific branch.

Swamp is studied by several scientific branches, which means it has a number of definitions. Here is how it is described by Tomsk scientists in the “Swamp Practice Book”:

Swamp is an eco-system consisting of three main components: water, distinct swamp plants and peat, which makes it the subject matter of several independent areas of study. Botanists and geo-botanists study the uniqueness of bog vegetation, focus on the stratigraphy of peat deposits - climatic characteristics of the peat accumulation period, and define them as bogs; geologists estimate reserves of commercial deposits and call swamps peat deposits; foresters study swamps from the angle of improved forest value of the forest stand and call them forest bogs, and soil scientists view swamps from the point of agricultural land and call them peat soils on organic rocks. Each branch has its own swamp area. Discrepancies between the concepts of "peat deposits", "peat bogs", "wetlands" do not allow obtaining specific figures for their areas.

Peat bogs could be commercial resources, an element of landscape, agricultural land, forest land, or hydrological sites.

Peat bogs are unique natural sites, which play an important role in biosphere. They store huge reserves of freshwater, shape up water and hydrological systems of the territory to a large extent, and serve as giant natural filters, which absorb toxic elements from the atmosphere. The strong influence of peat bots on the biospheric climate has been proven in the recent period.

We choose the following definition from answers to the question “What is the swamp?”

Swamp is a plot of land abundantly moistened either permanently or for a long period of time, covered with specific vegetation and characterized by a soil-forming process, which results in the accumulation of undecomposed organic matter, which then turns into peat.

A swamp is deemed to be an area where the layer of peat is at least 30 cm thick, while areas accumulating lesser amounts of peat may stop being swamps, i.e. may fall into a reverse process (Fig. 4).

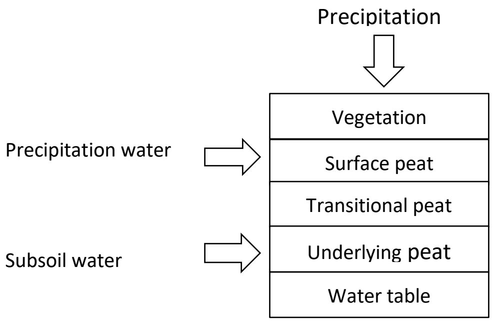

Fig. 4. Swamp structure

“Mineral feeding” is the factor that determines how the swamp will develop. In fact, the conditions in which swamp plants grow and peat forms depend on the amount of minerals in the swamp system. There are two main ways of swamping: raised and low-lying.

The raised way implies the appearance of raised swamps in areas where the amount of precipitation stably exceeds the amount of evaporation.

The low-lying way implies the appearance of low-lying swamps through the release of subsoil water to the surface.

The degree of mineralization of feeding waters determines the type of vegetation and peat.

Plants with ground or alluvial feeding are called eutrophic and form a low-lying type of peat. Plants with a mineral feeding deficiency (atmospheric) are called oligotrophic and form raised peat. Depleted mineral supply forms oligotrophic, eutrophic or mesotrophic vegetation, which gives rise to transitional peat.[4]

Raised (oligotrophic) swamps are usually found on flat watersheds, they feed only on atmospheric precipitation with few minerals, and their water is highly acidic. The main vegetation is sphagnum mosses; there are lots of shrubs - heather, wild rosemary, cassandra, blueberry, cranberry; cotton grass, scheuchzeria, as well as boggy forms of larch and pine, and dwarf birches.

Low-lying (eutrophic) swamps have lots of water and minerals. They are found on river floodplains, along the shores of lakes, in the place of former freshwater reservoirs or springs, and on lowlands. Typical vegetation includes alder, birch, sedge, reed, cattail, and green mosses. Transitional (mesotrophic) swaps are somewhere in between low-lying and raised bogs by type of vegetation and moderate mineral nutrition. There birch, pine, and larch are common trees. The grasses are the same as in the low-lying swamps, but not so abundant; there are shrubs and sphagnum and green mosses.

Fallen and decayed vegetation forms a new layer every year. From 6% to 30% of the dead organic material transforms into peat and continuously creates new peat layers.

Swamps form under a variety of factors (Fig. 5).

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[4]**Eurotrophy** – (Greek) ευτροφια –good nutrition.
Mesotrophy – (Greek) μεσοςφια – medium nutrition.
Oligotrophy – (Greek) ολιγοςφια – lpoor nutrition.

Climate. As known, swamps are either non-existent or extremely rare and devoid of peat in the areas with a hot and dry climate. Meanwhile, there are swamps everywhere in the areas with a cool and wet climate and they have developed peat deposits. Conditions that lead to the formation of swamps include constant or regular atmospheric precipitation, which exceeds the amount of evaporation. So the extremely moist areas, where precipitation is abundant and exceeds the amount of evaporation, house over 70% of all swamps.

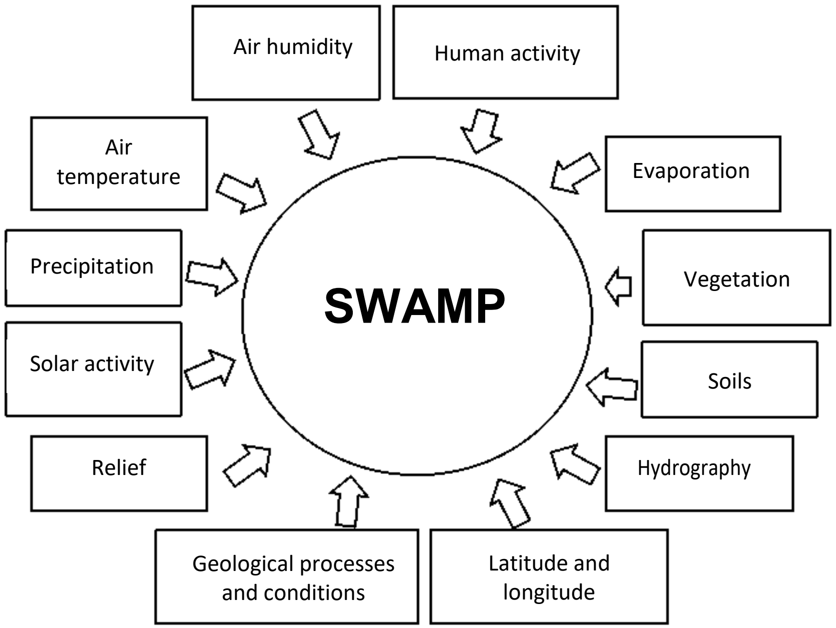


Fig. 5. Factors influencing swamp formation and functioning

There are also other factors that do not depend on current climate. Excessively moist soil is sometimes insufficient for swamping. Besides abundant moisture, swamping requires low-lying relief which traps the flow-off, and the water table: soil with low permeability caused by close occurrence of subsoil water or sapropel formations.

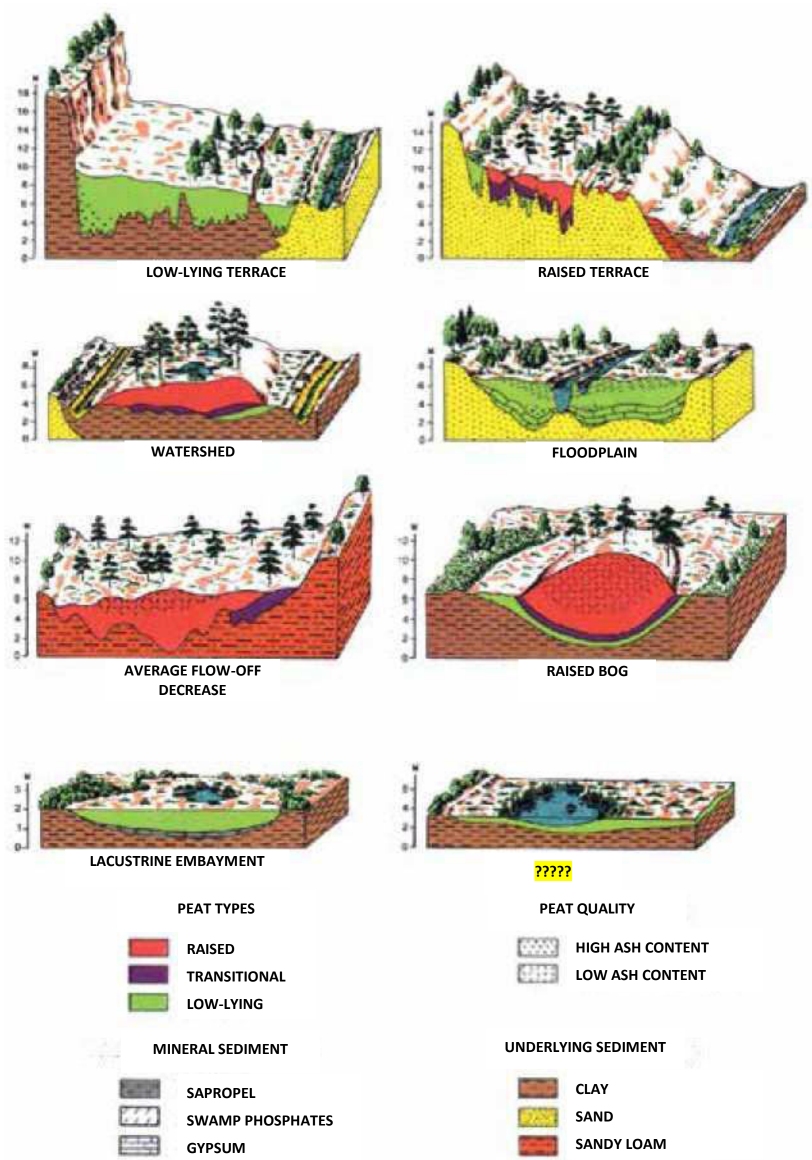


Fig. 6. Geomorphological types of peat deposits

Geological structure and tectonic processes have a huge influence on the territory’s water regime. Large troughs of the Earth's crust, formed by a thick stratum of sedimentary rocks, where surface and subsoil waters flow from the adjacent heights, are the swampiest. These waters, together with atmospheric precipitation, create excessive moisture. Poor sand deposits and felsic granites are the places where raised bogs predominantly form. Clay sediments are dominated by low-lying and transitional bogs.

Whenever water and mineral supply is abundant, swamps remain low-lying for a long time. Flatland sinking under the influence of modern tectonic processes also leads to swamping.

See Fig. 6 forgeomorphological types of peat deposits.

Geomorphological conditions include relief, the degree of natural drainage, the density of the river network, the depth of incision of the river channels, which determine the degree of swampiness. River floodplains, closed and low-flow depressions and steep plains, where surface waters stagnate, are the swampiest.

Hydrogeological conditions. A distinctive feature of bogs is the shallow subsoil water levels on the first water table. They are formed due to the filtered atmospheric precipitation –ground water.

There are three types of water based on conditions of their formation: surface, ground and pressure (artesian) waters. The surface water is formed during periods of rains on the lenses of low-permeability layers at a shallow depth; ground waters occur on the first water table, they are formed by atmospheric precipitation and create the first subsoil water-bearing horizon, while artesian waters occur in water-bearing horizons overlapped and underlain by impervious strata. Ground waters are found at the depth of up to 25 meters. They are formed by various freshwater reservoirs and snow and rain precipitation, which oozes into the ground and accumulates there. Ground waters differ from subsoil ones by the lack of pressure.

Another difference is ground waters’ sensitively to atmospheric changes. Subsoil water flows from the area of formation to the area of discharge, such as low-lying swamps and rivers where subsoil water partially evaporates and transforms into the river flow.

Hydrography. The swamping process is best developed in the areas of many lakes, channels, oxbows, and shallow waters that are easily overgrown. Swamps often originate near springs (the so-called spring swamping). Spring swamps feature a higher degree of peat mineralization due to the increased calcium content.

Human activity in the construction of dam also often results in swamping. The same process is sometimes caused by the activity of beavers.

Of all the numerous swamping factors, the geomorphology of terrain and its water and mineral conditions are the most important.

1.3.1. Swamp plants

Swamp conditions do not suite some plants, which makes their flora specific. However, swamp flora is characterized with a high diversity of living forms: mosses and lichens, evergreen shrubs, summer-green narrow-leaved and broad-leaved grasses, trees and shrubs. There are also lots of algae and fungi. Swamps are covered by **ecomorphic plants** – depauperate trees and shrubs. Swamp flora belongs to different ecogenetic groups.

Only a few of the species were formed under these peculiar conditions - these are bogbean, swamp robin, swamp strawberry and some others. Most of the species of swamp flora are aliens from other habitats (mountainous, aquatic, forest, etc.).

Plants that prevail in the vegetation cover of bogs are called **peat-formers**.

Mosses and lichens. Mosses are one of the most important groups of peat-forming plants. Leafy mosses are most common in swamps: brieva (green mosses) and sphagnum (white or peat mosses). Liverworts are found in small numbers.

Brie mosses are annual and perennial plants, varying in size from 1 mm to 50 cm. Brie mosses are sensitive to mineral nutrition, which makes them rare on raised (oligotrophic) swamps. Some of these mosses contribute to overgrowing of water bodies. They grow all over the world from tundra and forest-tundra to steppes and deserts. The growth is most intensive in low humid areas in tundra, forests and swamps - both separately and in groups, clumps or continuous cover.

Sphagnum mosses are the main annual plant production of swamps. Individual sphagnum plants are combined into more or less dense sod, often forming a continuous cover of the swamp surface. The covers of sphagnum mosses are whitish in color with various shades: greenish, brownish, pinkish, violet-brown.

"Sphagnos" is translated from the Greek as "sponge". The name was given to the mosses because of their ability to absorb water in amounts 20 times more than their dry weight. Sphagnum mosses have high moisture capacity, are insensitive to water-mineral nutrition, show acidophilicity and antibacterial properties, and grow rapidly. Because of that, they largely transform the environment and serve as **edificators**[5] of plant communities. Sphagnum mosses also have bactericidal properties - **they contain a special anti-rotting agent, sphagnol.**

Liverworms. In swamps, they are found everywhere as a small admixture to mosses. Liverworts are not peat-formers, but play a very important role in the life of swamps. Spots of these plants, which appear on raised bogs and occupy an area of 1–2 m^2, indicate the development of regressive phenomena: the temporary cessation of peat formation. In depleted peat lands, they are indicators of secondary swamping.

Lichens. These are symbiotic associations of fungi (mycobiont) and microscopic green algae and cyanobacteria.

Trees. They grow in swamps wherever their root systems are supplied with oxygen. Only a few of tree species can withstand such specific habitat conditions. Thus, one mostly sees Scots pines, cedars, and occasionally downy birches in raised swamps.

[5] **Edificator** is an organism whose activity creates or seriously changes the environment.

A distinctive feature of the growth of Scots pine in raised bogs is its inability to give additional roots as sphagnum sod and peat grow. Therefore, it is oppressed by sphagnum mosses and forms a number of ecological forms, differing in height, growth pattern, length and width of cones, etc.

In low-lying swamps, there are also spruce, larch, fir, and birch trees growing as shrubs.

Shrubs. Shrubs are most typical for low-lying peat bogs, where they are represented by numerous species of willow. There are also shrub alder, dwarf birch, etc. The species composition of shrubs in raised bogs is limited; dwarf birch grows here. The dominants of the vegetation cover are usually shrubs, which, together with sphagnum mosses, make up the landscape of raised bogs.

Evergreen shrubs from the heather family are also widely represented: marsh wild rosemary, white-leaved multifoliate, marsh myrtle or cassandra. From the lingonberry family - marsh and small-fruited cranberries, blueberries, common lingonberries. Bog shrubs are extremely oligotrophic and acidophilic plants. They have a superficial root system consisting of adventitious roots. Marsh shrubs are characterized by signs of a xeromorphic[6] structure: stiffness and pubescence of leaves (rosemary), waxy bloom (blueberries, whitewash), heavily cutinized thick epidermis (cranberries, lingonberries), evergreen, as well as strong development of mechanical tissue in the leaves.

Herbaceous plants. Swamp grasses have long adapted to insufficient aeration of the peat substrate: their aboveground and underground organs are characterized by a highly developed system of intercellular spaces and air cavities. Some marsh grasses are characterized by the features of xeromorphic plants (narrow, hard leaves, waxy coating with a well-developed cuticle, deep location of stomata).

[6]**Xenomorphism** (Greek xērós – dry, and morphē – form) are morphological and anatomical features inherent in xerophytic plants - inhabitants of arid places: a decrease in the leaf surface, small cells, a large number of small stomata, a dense network of veins, the presence of hairs on the leaves, wax plaque, submerged stomata - all this allows reduce water evaporation.

Among herbaceous plants of raised bogs, the most frequent is sheuchzeria from the rump grass family, sedges such as vaginal cotton grass, and spherical and marsh sedges; cloudberry from the Rosaceae family, and round-leaved and English sundew from the sundew family.

The most characteristic plants of low-lying bog's grass cover are hairy, double-stalked, soddy and other sedges, cotton grass and cereal species such as woodreed, common reed, and marsh horsetail. Among the forbs, there are bog bean, marsh calla from the arum family, marsh cinquefoil from the Rosaceae family, etc. Almost all herbaceous plants of low-lying bogs are perennials with powerful roots, often forming thickets.

1.3.2. Swamps of the Earth

As you may remember from history lessons, our planet was covered with water for a long time and its atmosphere consisted of ammonia and carbon dioxide. Life originated and the primary organic world underwent its evolution in the ocean. Primitive organisms were both photosynthetics, creating organic matter, and nitrogen fixers, utilizing nitrogen. The algae and other plants that appeared at the bottom contributed to the accumulation of rich organic soils under water and the release of oxygen into the Earth's atmosphere. Life ventured out onto dry land. On one hand, a swamp could be described as a freshwater reservoir where water interacts with organic matter and, on the other hand, a surface made up of 80-90% of water and 20-10% of dry matter, which made it a bridge between **water and ground life**.

Most of modern swamps are located in sub-Arctic areas, including those in Russia and Canada, where permafrost, a major reason for swamping and peat formation, exists. The current degree of planetary swampness is estimated at 2-6% of all ground**, according to various sources** (Table 1).

Post-Ice Age peat deposits are one of the youngest geological formations of the Earth's crust from the geological point of view. Their age does not exceed 10,000-12,000, which is comparable with the age of coral reefs. For instance, three-meter peat deposit in a sedge swamp is 4,000 years old.

A **peat deposit** is a vertical (layered) formation of one or several peat types, which stretches out from the swamp surface to the mineral bottom or underlying lacustrial sediment (sapropel)**.**

Table 1

Swamp area by world regions

Regions	Swamp area, thousand km^2	%
Central and North America	1762	44,3
Asia	1490	37,5
Europe	525	13,2
South America	131	3,3
Africa	56	1,4
Antarctica, Australia, and Oceania	8	0,2
TOTAL	3973	100

The biggest Pantanal swamp (about 200,000 km^2) lies in the delta of the Paraguay and Cuiaba rivers in South America. The largest peat deposits are found in the Vasyuganskoye swamp of 53,000 km^2, which stretches out for 537 km from the west to the east, and 320 km from the north to the south; it is located in West Siberia in the territory of the Tomsk, Omsk, and Novosibirsk regions. The Philippi swamp in northern Greece is the deepest, and has the peat layer of 70 m or more.

1.4. Peat types and kinds

Peat characteristics are determined by its genesis. As we remember, there are three regimes of water and mineral feeding in a swamp: low-lying, raised, and transitional. So, peat is divided into the same types, in addition to the mixed one (Fig. 7).

Raised peat is the peat formed by oligotrophic plants with no more than 5% admixture of remains of eutrophic plants.

Low-lying peat is the peat formed by eutrophic plants with no more than 5% admixture of remains of oligotrophic plants.

Transitional peat is peat formed by mesotrophic plants with no more than 5% admixture of remains of oligotrophic and eurotrophic plants.

The chemical composition and properties of peat depend on its type. For instance, in contrast to raised peat, low-lying peat contains fewer organic substances and, therefore, has bigger ash content, with a high concentration of CaO, Fe_2O_3, nitrogen, P_2O_5, K_2O. Low-lying peat has low acidity (pH) in contrast to raised peat. Transitional peat is somewhere in the middle between low-lying and raised peat.

Peat characteristics are also influenced by types and kinds of plants, which form peat deposits. The influence can be so big that it affects the end peat products. For instance, sphagnum peat with a degree of decomposition of 5-15 percent is used to make hollow peat pots because this peat kind contains antiseptic substances and protects seedlings from diseases. Substrate peat blocks could be made of peat, which contains no more than 60% of plant residue but no more than 10% of sheuchzeria because large amounts inhibit the growth of seedlings.

There is a reference book, which specialists could use to precisely determine the kind of plants that form the peat (Table 2).

There is a huge difference between plant species in terms of the humus content, which leads to its various concentrations in peat. The latter is essential for peat fertilizers.

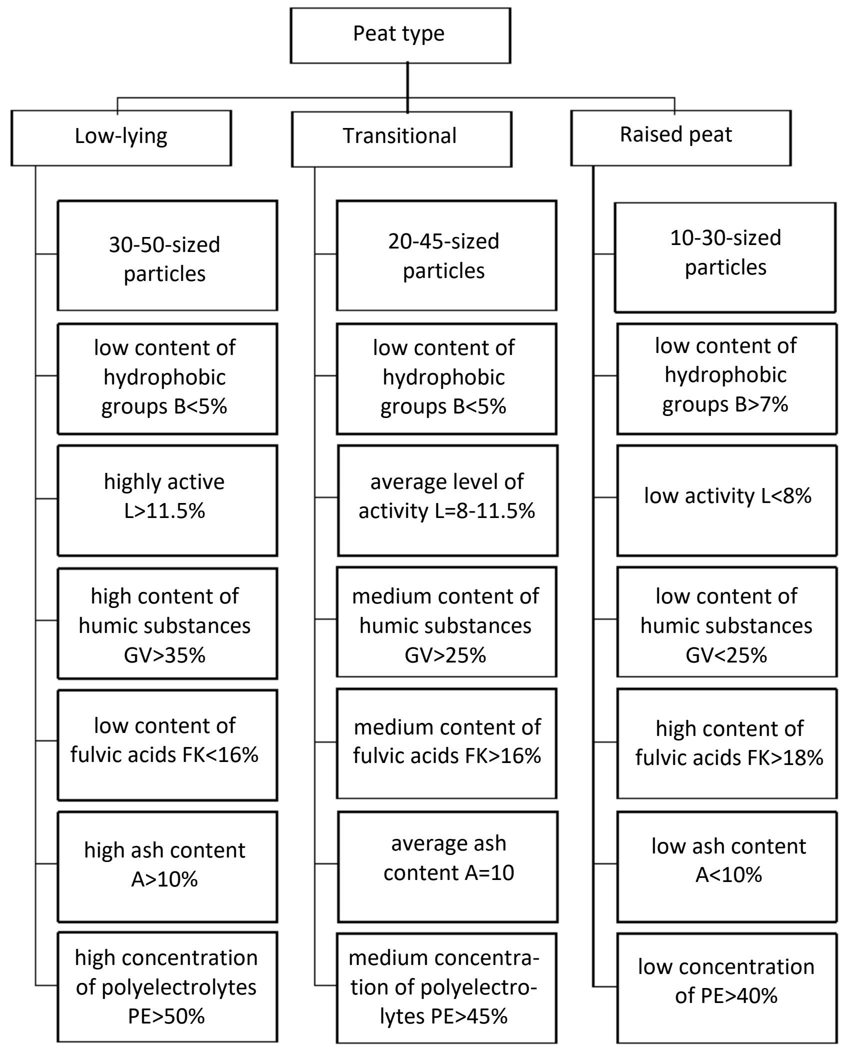


Fig. 7. Peat types

Table 2

Peat classification by peat forming plants

Peat kind	Peat type		
	Low-lying	**Transitional**	**Raised**
Wooden	Alder, Birch, Spruce, Pine, Willow	Wooden	Pine
Wooden/herbal	Wooden/reed, wooden/sedge	Wooden/sedge	Pine/cotton seed
Wooden/moss	Wooden/hypnum, wooden/sphagnum	Wooden/sphagnum	Pine/sphagnum
Herbal	Horsetail, reed, sedge, bog bean, sheuchzeria	Horsetale, scheuchzeria	Cotton seed/ scheuchzeria
Herbal/moss	Sedge/hypnum, sage/ sphagnum	Sedge/sphagnum	Cottonseed/ scheuchzeria/ sphagnum
Moss	Hypnum, sphagnum	Hypnum, sphagnum	Medium, fuscum, combined, sphagnum/ridge pool

The main reason for the intensive decomposition of peat forming plants and peat itself is not the length of decay (age) but the organic composition with different micro-biological and fermentative stability.

For instance, foliage of alder, birch and other tree species, containing up to 7% ash and up to 4% nitrogen, serves as a good substrate for microorganisms. The ash contentintrunks amounts to only 0.25-0.3%, however, the filament of microorganisms provides the necessary catalytic instrument. This is the reason for the high degree of decomposition of studied peats.

On the other hand, poor water and mineral feeding of moss bogs leads to the extremely limited decomposition of peat. Multi-meter layers of poorly decomposed sphagnus peat are an illustrative example.

The peat classification is based on two criteria: the peat type and the degree of its decomposition.

Depending on the degree of decomposition, peats are divided into:

- Poorly decomposed – up to 20%;
- Medium decomposed – 20-35%;
- Strongly decomposed – over 35%.

The peat classification comprises 40 kinds of peat divided into three types, namely low-lying, transitional, and raised. There are three sub-types in every type: forest, forest/swap, and swamp.

Peat of the forest sub-type has a high degree of decomposition (R), which sometimes reaches 80%, swamp peat has the minimal degree of decomposition, and forest/swamp holds the intermediate position.

Sub-types are divided into groups: there is a wooden group in the forest sub-type, forest/herbal and forest/moss groups in the forest/swamp sub-type, and herbal, herbal/moss, and moss in the swap sub-type.

1.5. Global peat reserves

It is extremely difficult to precisely estimate global peat reserves because of poor passability of bogs and heterogeneity of the relief of underlying rocks. According to various sources, the modern world has about 250 billion to 500 billion tonnes (in 40% humidity).

There is much more peat in the northern hemisphere than in the southern one. Peats increase in number as one moves from the equator to the north, and the percentage of raised peat bogs increases, as well (Fig. 8).

According to the Canadian media outlet Peat Resources, Canada tops the global list in terms of peat reserves, 170 billion tonnes, and Russia ranks second with 150 billion tonnes. There are fairly large peat reserves in Ukraine (Morochne 1), as well as in Indonesia and the UK.

Peat bogs occupy 4.8% of Germany's territory, 14% of Sweden’s territory, and 30.6% of Finland’s territory.

Peat production is massive in Finland, Belarus, Ireland, Sweden, Canada, and Latvia.

More than 70% of the global peat products are used in agriculture, and this proportion is growing.

1. What peat is

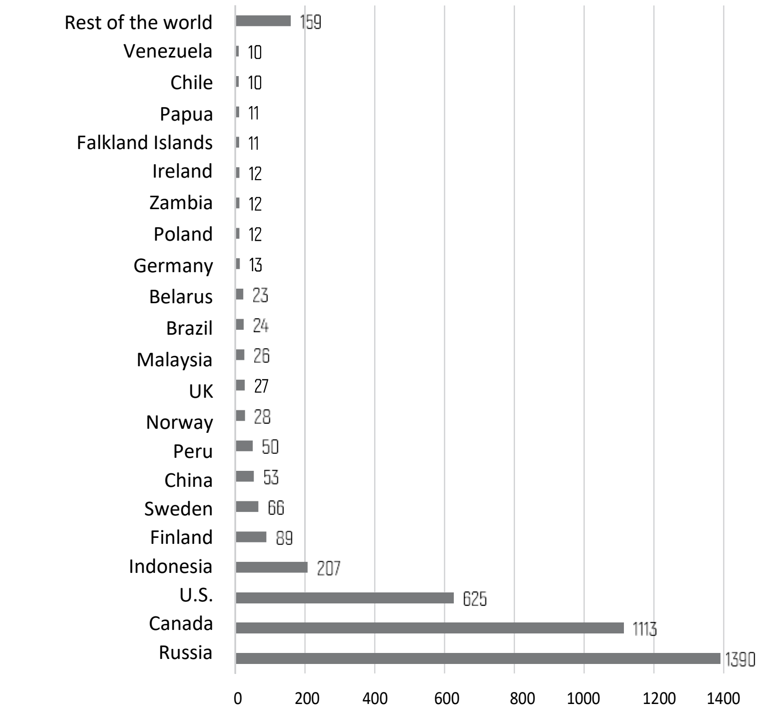


Fig. 8. Swamp area by country, thousand m^2

Peat land in our country occupies 31.8% of the Tomsk region (Vasyganskiye swamps) and 12.5% of the Vologda region. There areal so large peat deposits in Karelia, the Komi Republic, and a number of western regions, especially the Ryazan, Moscow and Vladimir regions).

Domestic specialists estimate the overall peat reserves of Russia at 166.9 billion tonnes (476,000 km^2). However, research performed by means of newest topographic and special maps, aerial filming and satellite images indicate that the actual peat reserves in our country may be as big as 250 billion tonnes, primarily, with new peat deposits in East Siberia, the Far East, and the sub-Arctic region.

Russia’s peat reserves grow by approximately 260-280 million tonnes per year.

2. Main areas of peat usage

2.1. Brief profile of multi spectral peat products

Due to its unique natural features, peat traditionally draws attention as a fuel for the energy sector and utilities, as well as a raw material for the production of organic and organomineral fertilizers, biostimulants and growth substances, bacterial preparations, fodder yeast, carbohydrate fodders and additives, greenhouse seedlings for agricultural enterprises; high-quality chemical raw material for the production of dyes, special anticorrosive additives, rust converters, carbon-alkali reagents for drilling equipment, waxes, model compositions for precision casting in mechanical engineering and release agents in the production of products from polyurethane foams, household chemicals; raw materials for thermal processing, production of gas, coke, semi-coke, thermal briquettes, peat briquettes for use in metallurgy; raw material for the production of building, heat-insulating materials and water repellents; raw material for sorbents-absorbers of harmful substances, including radionuclides, ions of heavy metals and other carcinogenic compounds from gaseous and aqueous media; as well as raw material for medicines, cosmetics; printing and other products.

There are dozens of peat products. Products based on peat raw materials are regulated by a variety of standards and technical conditions. There is also classification by the technological principle (prevail in elements of production processes), which, being fairly conventional same as any other classification nevertheless gives a rather full impression of the structure of the modern peat processing industry and its existent and future products.

Consistent with this classification, all types of peat processing industries and all types of products put on the market are divided into four large technological groups:

- mechanical (baled peat; fertilizers, including granulated soils; mixtures and substrates - loose and pressed);
- mechanothermal (all of the above products and, in addition, briquettes, thermo briquettes, coke, semi-coke, insulating building materials and pots for growing seedlings);
- thermo chemical (humic fertilizers, mountain wax, activated carbons, reagents, alcohol, furfural, dyes, etc.);
- biochemical (feed yeast, molasses, feed sugar, growth substances and biostimulants; rhizotorfin, rhizophil).

Bale peat is used for the preparation of soils and substrates and mulching soils; it is transportable over long distances and can be exported.

In peat-ammonia and peat-mineral-ammonia fertilizers, the effective use of peat as fertilizer is based on its activation with ammonia water or liquid synthetic ammonia, together with or without mineral components.

Peat nutrient briquettes are also popular. These are dry-pressed peat substrates complete with the full set of micro- and macro-fertilizers, as well as round briquettes of various diameters and heights, which are placed in hollow peat pots and are used for growing seedlings of vegetables, flowers and other crops with subsequent transplantation to a permanent place without damaging the root system.

Substrate peat blocks - rectangular slabs consisting of seed (planting) cells separated by furrows, widely used for growing seedlings.

Dry-pressed blocks made of calcified peat mass that does not contain mineral elements (they are introduced when using slabs in greenhouses) are broadly used to prepare a substrate suitable for all plants grown in greenhouses.

Peat-bird dropping fertilizers are highly efficient composed made of peat and bird dropping, which scraps organic waste of modern poultry farms.

Hollow peat pots are used for growing seedlings of vegetable and flower plants. The efficiency of using the pots directly depends on the filler soil, the optimal variant of which is light, air-permeable peat substrates containing most of the elements of mineral nutrition.

The advantage of peat pots is the high quality of seedlings, complete plant survival during transplantation, the ability to automate operations when using pots, saving labor, increasing vegetable yields with a shorter production time, and enriching the soil with organic matter of peat and filler soil.

Peat briquettes are fuel used mainly by public utilities (heating of residential buildings). They are produced by stamp-pressing milled peat dried in various types of units (pneumatic gas, pneumatic steam, etc.) in order to regulate moisture content.

Thermo briquette is a compressed bertinate obtained by high-speed peat pyrolysis (473-573 K), which reduces the oxygen content in the combustible mass of peat by 10% and a relevant increase in carbon. In this case, the heat of combustion of the working fuel rises to 21-23 mJ/kg. It is characterized by increased strength, reduced water absorption and smokelessness.

The products of the technological and energy use of milled peat are gas, semi-coke and tar, they are obtained by high-speed pyrolysis of peat in aerofoil reactors with an upward flow of solid coolant and flue gases. Depending on the mode of the process, the yield of pyrolysis products and their heat of combustion can be different.

In fact, all products of peat thermal decomposition can be used as fuel, some of them are used in this capacity in a variety of areas. Still, coke proves to be more efficient in certain cases as carbonaceous reductant in metallurgy or gas, as a fuel reagent in a blast furnaces, household fuel or tar as raw material for chemical production.

Insulating building materials made of peat are not inferior to thermal insulation products made of mineral and fiberglass, perlite, vermiculite, since dried up low-decomposed raw peat, while retaining porosity, has high heat and sound insulation properties, is an ecological material.

Peat isoplates can be used not only in refrigerators, vegetable stores and other facilities, as it mostly happened before, but also in housing and public utility construction.

In addition to ordinary peat isoplites, it is possible to produce their improved types: waterproof, containing water repellents; flame-resistant with antipyrine; biostable, containing antiseptics; complex (fire-resistant, fire-waterproof, fire-retardant and water-resistant). In combination with peat, scientists propose to use water glass, resole and formaldehyde oligomer, expanded perlite, clay suspension, and instead of expanded clay - peat granules in water-resistant and fire-resistant shells.

In construction, peat sod carpets can be used as elastic pieces of sod from perennial grasses grown on drained peat massifs of the raised type, 5-6 days after laying they take root well and do not require special care. Such carpets are used to strengthen the slopes of embankments of roads, canals, reservoirs, for arranging decorative lawns and remediating industrial facilities.

Physicochemical activation of humic substances in peat by ammonization without denitrification serve for making peat-humic fertilizers. Ammonization is carried out by absorbed ammonia nitrogen, mobilized peat nitrogen, as well as biologically active ammonium humates. The use of such fertilizers is more effective than the usual mineral and peat in equivalent doses: yields significantly increase (grains - by 12-17%, potatoes - by 25%), the effects manifest themselves in the second and third years, while peat consumption decreases and humus reserves in the parent soil are replenished.

Raw peat wax (brown) is obtained by extraction with gasoline (treatment with condensate is possible) of bituminous peat species. It is used as model compounds for precision casting in mechanical engineering and instrument making;

release agents for polyurethane foams in the automotive industry; lubricants for the production of phenol-formaldehyde press powders (the possibilities of using such lubricants in the shoe industry and for medical instruments are being eyed); production of metalized printing foil, wax compositions for electro photographic purposes production of antiandigesitic lubricants, medical preparations using physiologically active substances contained in peat wax - stearins, as well as products of the perfumery industry - soaps, shampoos, creams, hand sanitizers, and Torfenal ointments.

Deresined peat (dark brown) wax is used for manufacturing polishing and protective compounds, shoe creams, technical papers, tapes for typewriters, as a filler for leather and for finishing furniture.

Refined wax (light yellow) is used in the production of light varnishes, varnishes, crayons, tracing paper, and thermal copy paper.

Esterified wax (yellow) is meant for the production of emulsions, shoe creams, paper glue and other goods. Crude peat wax modified with ethylene oxide ("Oxivosk-8") is intended for use as a grinding material in the processing of woolen and semi-woolen yarn.

The thermal alkaline reagent is obtained by interaction of peat with a high degree of decomposition (at least 30 percent) or extracted peat with a solution of sodium hydroxide. It looks like an inconspicuous free-flowing powder (0-3 mm) of dark brown or black color. Bulk density 0.7-0.8 t/cm^3, humidity 25-30%, humic substances content - not less than 35 percent and caustic soda - not less than 20.

But the area of its application is impressive: it improves quality of drilling fluids (increasing dispersion and resistance to aggressive influences, reducing fluid loss, regulating viscosity) in the oil and gas industry and increases the strength of products made of reinforced concrete structures; and helps liquefy sludge in cement, chalk, lime plants.

Peat humic dye is the result of processing peat (raised or low-lying) with alkaline reagents; and represents them in the form of an aqueous solution

(concentration 5-12%) or a dark brown powder with a moisture content of about 15%. Specific consumption of peat with 50% moisture content per 1 ton of dye is 6 tons.

This product is meant for dyeing furniture boards, fiberboards and other wood products. In combination with synthetic dyes, it is possible to obtain compositions of various color shades. The material is non-toxic, easily washed off your hands.

Activated carbons of grades SKT (SKT-1 - SKT-7, SKT-10) based on peat are used as sorbents. Their area of application (except for SKT-3 coals) is separation of hydrocarbon gases; fine air purification from carbon disulfide; capture of vapors of organic solvents; and clarification, purification of water and solutions; it is also good as a catalyst for polymerization, as well as for other chemical processes. Besides, it serves as a filler for odor-absorbers in refrigerators. Coal SKT-3 is used to recover vapors of organic solvents and capture hydrocarbon gases.

Peat bertinat. Tests showed that bertinate could be an effective sorbent for oil and oil products spills on water. The labor-intensity of spill collection decreases 3-10 times.

Peat molasses (peat hydrolysis fodder molasses) is a hydrolysis product of low-decomposed raised peat with concentrated sulfuric acid. It is a thick, viscous, opaque brown liquid, bitter, with a sweet taste and caramel smell, easily absorbed by farm animals and birds, which has a positive effect on their physiological processes and, together with other active substances in the molasses (amino acids , humic substances, vitamins, hormones, etc.) leads to a versatile positive zootechnical effect.

Another peat supplement to the diet of animals is fodder peat sugar with a content of at least 30 percent of dry and at least 15 percent of reducing substances. It optimizes the ratio of sugar and protein in the ration, increases the milk production of cows, the increase in live weight, and also reduces the cost per 1 kg of weight gain.

Feed yeast is a product synthesized on a peat hydrolyzate medium - peat molasses used as a nutrient substrate. Feed yeast is used as a complete protein nutritional product in the diets of various animals.

Sugared peat is a hydrocarbon-containing feed additive obtained from raised peat with a decomposition rate below 20%. It makes up for the lack of coarse and concentrated feed, saves feed, increases live weight, and improves health and safety of livestock.

New types of peat products - *biologically active substances: huminates, nitrogumates, peat biostimulants and oxyhumates*.

Huminate are sodium salts of humic acids obtained from low-lying sedge and reed peat by the method of alkaline extraction. It is used as a feed additive to increase the meat productivity of cattle. In fact, it is a biogenic stimulant that activates the functions of the animal system and does not have any pathological effects.

Seed treatment with huminate leads to yield increases and increases plant resistance to adverse weather conditions, soil salinity, excessive doses of mineral fertilizers, etc.

Nitrohumic growth stimulants (NGS). Liquid NGS is used for soaking seeds and spraying crops; powdered NGS is a feed additive in animal husbandry and fur farming.

The stimulant hydrohumate was obtained by a two-stage peat hydrolysis in acidic and alkaline media. It is highly effective in yeast production, when growing vegetables on artificial soil and in greenhouses.

The biologically active substance, oxyhumate, is a product of oxidative degradation in an alkaline medium in the presence of oxygen. Accelerates plant rooting and protects them from diseases.

BAS growth stimulator is based on peat oxidation with atmospheric oxygen. It is used in the form of a paste, in a crystalline state. The product stimulates an increase in the biomass yield of protein yeast and an improvement of its quality. It helps assimilation of nutrients in animal feed by animals, the growth of their productivity, and has a beneficial effect on reproductive function. The substance is harmless.

The tar release agent is another product of alkaline peat processing, which helps the release of resin when tapping pine. The product is non-toxic and retains its properties during long-term storage.

It is based on physiologically active substances from peat and has been used as the raw material for a number of drugs, such as the Torfon *drug for injections*, the *Guminat* product that stimulates weight gain and nonspecific resistance of farm animals and birds, as well as *Pyrodoxophot*, a well-known antioxidant.

Research is underway to produce peat-based cancer drugs - water-soluble brown products, non-toxic, not carcinogenic and non- cumulative. The yield of the drug is 45-60% of the peat organic matter. It has been tested on animals, and further clinical trials have been planned.

Antiviral drugs based on peat and peat-forming plants are also appearing on the market (45-65% yield).

Peat is of great importance for environmental protection as filter for the purification of industrial waters contaminated with large volumes of mercury, copper, cadmium, zinc and other metals.

Of particular interest is the use of peat and peat-based sorbents for cleaning large water areas from oil.

In Scotland, peat is used to refine the famous whiskey.

Now we will dwell on the main areas of peat usage and aspects that may be of particular interest to readers.

2.2. Agricultural usage of peat

Nowadays, peat is being used to restore soil fertility, to develop innovative technologies in agricultural production, to heat and generate electricity in the countryside, to create jobs, to reduce social tensions, to give an export future to rural territories, and to improve environmental protection. The prospective amount of peat use in agriculture approximately stands at 15-20 million tonnes a year. The existent number of cattle and poultry does not provide the necessary amount of organic fertilizers. This is why many regions of the country should assign a large place for peat and peat products in the structure of organic fertilizers.

Peat products have been used in agriculture for years and can be divided into two groups.

Crop growing products include a variety of composts, complex fertilizers, milled bedding, peat-ammonium fertilizers (PAF), peat-mineral-ammonium fertilizers (PMAF), peat-mineral fertilizers (PMF), complex granular fertilizers (CGF), peat nutrient soils, peat carpets, etc.

Factory products include peat pots, substrate peat blocks, complex peat organo-mineral fertilizers, moss peat, dry-pressed plates, peat-based feed, plant and animal growth stimulators, nutrient briquettes, soils and mixtures, etc.

2.2.1. Open-ground peat usage

Peat was mostly used as a raw material in the end of the previous century. The government was funding peat production. Peat was mostly used in agriculture as is, as well as for production of composts, mixtures including manure and bird droppings, and as well as bedding for animals.

The self-financing period harmed the peat industry a lot. The peat usage as fertilizers dropped from 96 million tonnes in 1985 to 0.448 million tonnes in 2006. The peat share in the production of organic fertilizers reduced from 19% in the 1980s to 1-2% in the beginning of the new century.

Meanwhile, many regions of Russia are suffering from a humus deficit, which impacts soil fertility. Up to 13 tonnes of organic fertilizers per 1 hectare of soil need to be used on cropland every year to complete for humus depletion through harvest. Most central areas of Russia's non-Black Earth zone use no more than 1-2 tonnes of organic fertilizer per 1 hectare while at least 5-6 tonnes are necessary. It is practically impossible to balance the humus level of sod-podzolic soils without using peat.

The main trend in agricultural development in the 21st century is biologization and greening of agriculture. The complex task could be achieved by use of biologically active organic-mineral fertilizers based on peat.

Numerous studies show that it is the optimal plant-based raw material for fertilizers and ameliorants. Scientists focused on the creation of new highly effective fertilizer compounds, ameliorants, and granulated fertilizers based on peat, manure, and bird droppings. The relatively small output of workshops is characteristic of such production.

The use of innovative types of peat-based fertilizers will reduce their dosage, increase fertility of cropland, and improve the quality of products. Many developed countries adhere to the alternate system of organic agriculture, in which the use of mineral fertilizers is either strictly limited or ruled out.

However, modern high technologies can deliver a broad range of peat products. In the 21st century peat should be used as a growth stimulant and bio-filter, as well as way to remove radionuclides.

It is proven that peat is a biologically active substance, which contains vitamins, amino acids, microelements, and hydrocarbons. The presence of nitric and phosphorous compounds in peat has a special significance for agriculture.

Peat has proven its value as a fertilizer element in plant-based composts. This is the greenest organic fertilizer, which has high fertilizing properties and can be successfully used as greenhouse soil. For the purpose of reduction of transportation costs for remote cropland, there is a technology of production of peat composts near peat bogs and on reclaimed peat bog.

Due to the surge in peat harvesting costs, we believe that deep peat processing for greenhouse use would be the most promising area.

2.2.2. Greenhouse peat usage

In recent years, greenhouses have been largely relying on hydroponics in low-volume production vegetable crops; this technology replaces soil with a special substrate and applies drip irrigation and artificial lighting. In contrast to traditional technologies, low-volume vegetable production drastically increases labor productivity by excluding labor-intensive preparation and replacement of greenhouse soil and cuts substrate needs 10-15 times; in addition, irrigation and preparation and use of nutrient solutions are automated, and labor conditions are significantly improved.

Scandinavian countries are using the new technology to grow vegetables in over 80% of their greenhouses, and the Netherlands are using low-volume substrates on an area exceeding 2,000 hectares.

Greenhouses, which have been renovated in Russia in recent years, are also implementing the low-volume technology, whose key element is the use of special substrates (Fig. 9). The most widely used substrates are mineral wool, expanded clay, zeolite, perlite, etc.

While having positive properties, artificial substrates have a number of shortcomings, such as low capacity to retain the nutrient solution, weak buffering, and relatively low porosity, which leads to insufficient aeration and rapid salinization.

Disposal of spent mineral substrates is also a major environmental problem, since there are no factories in Russia for their recycling into building materials.

Fig. 9. Technology of vegetable and berry growing on peat substrates

Peat-based substrates are mostly free from such shortcomings. Raised peat has a significant degree of buffering and high absorption capacity, which is why larger amounts of mineral fertilizers can be used to regulate nutrition on a broad range without creating salt concentrations harmful for plants. Peat allows to saturate greenhouse substrates with microbiological substances having biofungicidal, immunomodulatory and growth-stimulating effects and to reduce the need for pesticides. Spent peat substrates can be used for production of organic fertilizers and soils for urban, subsidiary and dacha landscaping. So, production and use of peat-based substrates is absolutely waste-free, and their scrapping solves many ecological problems.

Peat pellets, which fully automate growing of greenhouse vegetable seedlings, and peat-mineral mixtures for subsidiary holdings are promising products.

Specialists from the all-Russian Research Institute of Reclaimed Lands (VNIIMZ) has developed and patented a number of express adjustable peat processing technologies, which use microorganisms for activation. This approach allows production of a wide range of goods and raises efficiency of agricultural production (Fig. 10).

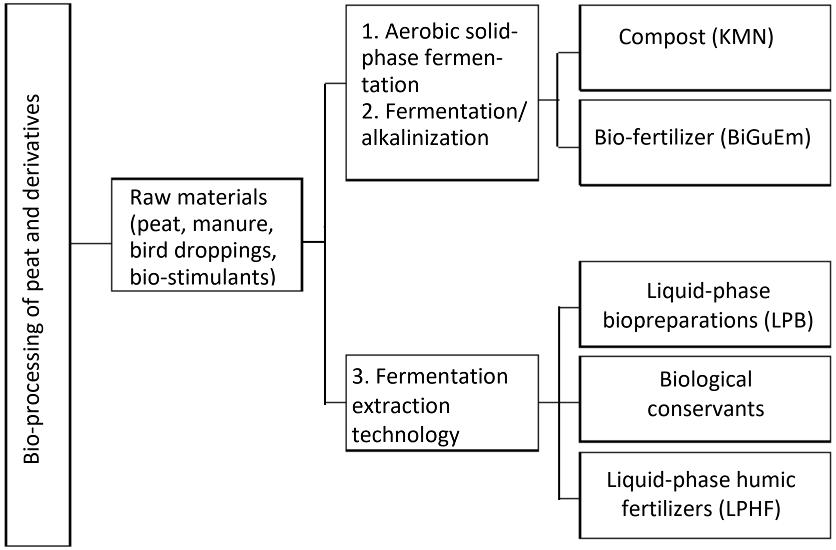


Fig. 10. Main VNIIMZ products of bioprocessing of peat and derivatives

The use of various types and kinds of peat as raw materials has allowed to develop technologies of production of solid-phase and liquid-phase goods. The solid-phase fermentation technology deserves a special mention, as it helps produce multifunctional compost. The solid-phase fermentation process is based on the method of passive aeration in open-air composting facilities and active aeration in special chambers – biofermentators. The use of these devices significantly cuts the period of compositing process.

New biological conversation technologies develop the research and development works of VNIIMZ. These include the fermentation extraction technology, which could be used in the basic and modernized forms. This process has three main stages and delivers the following products: liquid-phase biopreparations for plant growing and land cultivation, liquid-phase humic fertilizers, and bio-conservants.

The bio-fertilizes and bio-preparations are being widely used in plant growing and land cultivation (Fig. 11).

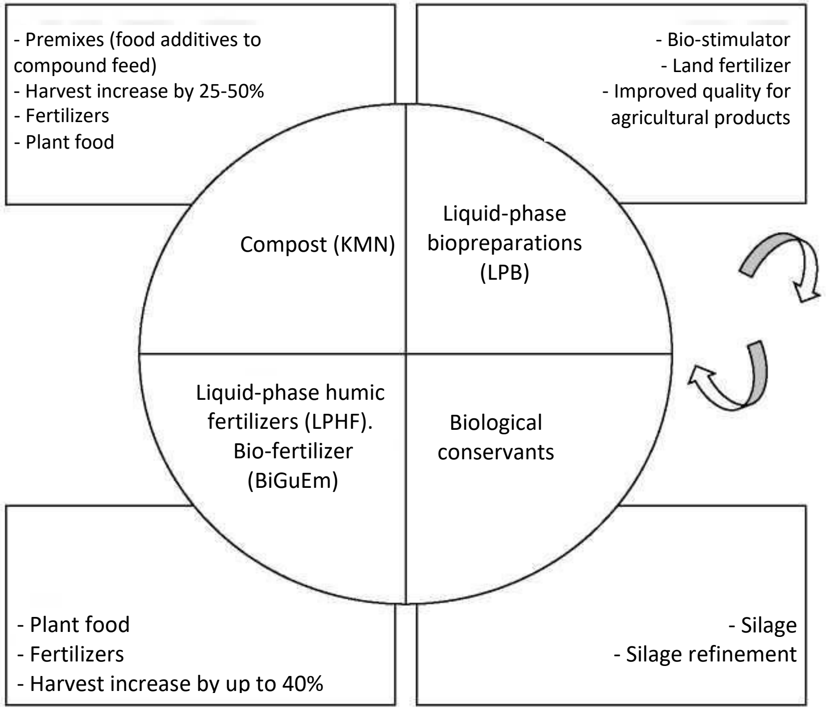


Fig. 11. Range of use and efficiency of certain types of products received from bioprocessing of peat and derivatives

For instance, multifunctional compost contains a variety of ergonomically useful microorganisms and the full set of plant food elements and can significantly reduce soil need for mineral feed. It is recommended for use on all crops. Fertility of treated soils increases by 15-20% on the average. The efficiency of compost has been proven not only in vegetable growing but also in floriculture, horticulture, as well as in the greenhouse industry.

The combined use of multifunctional compost and liquid-phase preparations provides high productivity of crop production, significantly improves the quality of vegetables by reducing the content of nitrates. It also optimizes the content of biogenic elements and physiologically useful substances: fiber - from 7 to 15% in various vegetables, protein - by 25-30% in potato, fat - by 6-8% in daikon, vitamin C and monosaccharides in cucumber - by 10% and 9-10%, respectively.

The norm of multi-functional compost use varies from 3-5 t/h to 15-20 t/h. They activate soil micro flora by approximately 2-3 times and create conditions for mobilizing harvest-forming biogenic elements by 25% on the average.

Hence, all afore said technologies have a high resource-saving effect due to use of renewable raw materials (peat and biomass) and derivatives (manure and bird droppings). The waste-free use, the simplicity of technical solutions, the scaling-up possibility, multifunctionality, fast implementation, and organic nature of products significantly increase their competitiveness compared to domestic and foreign analogues. The absence of additional chemical components in the biologically processed products allow their use in various agricultural areas: crop production, landscaping, intensified composting, recultivation of damaged land, etc. The use of bioconservants as silage elements also has a vast innovation potential in the production of premixes for cattle.

2.2.3. Peat use in gardening, horticulture, and mushroom growing

Gardening and horticulture are very popular with residents. About 60 million people in Russia have orchards and vegetable gardens.

The use of peat-based soil largely determines the quality of seedlings and yield of agricultural crops.

The uniqueness of peat as a raw material stems from its properties: the deposit structure, the ash content of no more than 10%, the high moisture capacity of at least 600%, and the moist content of at least 80%.

Its lumpy, fibrous structure capable of absorbing and retaining large volumes of moisture is also an essential factor. Mushroom peat does not contain mineral elements, such as sand, which indicates the purity of peat deposit.

Mushroom growing is a popular gardening area, and the consumer demand for mushrooms increases year upon year. A major process in champignon growing, the formation of fruiting bodies, occurs in the casing soil. Champignon grows in a nutrient-rich substrate, which is compost, and its fruiting bodies (mushrooms) appear where rich substrate turns into poor one, the casing soil.

The casings oil made of various types of peat with and mixture of lime components (lime, chalk, lime scum), is mandatory for the formation of champignon fruiting bodies.

The casings oil for mushrooms (Fig. 12) is a special peat mixture with particular levels of huminity and pH and the lumpy structure.

Fig. 12. Mushroom growing on peat cover

Casing soil functions*:*

- Provision of conditions for the formation of mushroom fruiting bodies is the main function of the casing soil. These include the presence of bacteria of certain species in the casing soil, which are the natural peat microflora. Fruiting bodies are not formed in a sterile casing soil, where there is a high probability of the development of microscopic fungi from spores that are always present in the air of cultivation rooms. Moisture, pH of the medium, temperature, structure and other characteristics of the casing soil create optimal conditions for the development of bacteria necessary for the formation of champignon fruiting bodies.
- Protection of the compost sprouted by mycelium from drying out and the rapid disappearance of metabolic products secreted by the mycelium. Preserving the moisture is essential considering that water carries nutrients into the mycelium and ensures its development and growth of fruiting bodies. The water in the casing soil also helps the development of the mycelium and mushroom growing.
- Provision of favorable macro- and micro-climate in mushroom growing facilities through the humidity and lumpy structure of the casing soil;
- Provision of the necessary gas exchange between the compost and the air in the facility thanks to the lumpy and porous structure of the casing soil, which promotes the formation of stringy mycelium in the casing soil.

In order to fulfill those tasks, the casing soil should have particular characteristics:

The moisture retention capacity of the casing oil should be about 80% and the initial moisture content should be 68-70%.

The casings oil should have a particular pH level (7.2–7.6). The pH level lower than 6.8 causes growth of competing green molds. The salinity level of the casing soil should be no more than 0.9 g/l NaCl. A high level of casing soil salinity (above 1.5 g/l NaCl) reduces the yield of mushrooms and hinders the appearance of first-wave products.

The casing soil should retain its lumpy structure during watering and tillage. This kind of structure ensures gas exchange and improves the mycelium growth towards the surface, contributes to the formation of string mycelium heavy mycelium and prevents the excessive development of thin mycelium in the casing soil and ensures its capacity for retaining large amounts of water. The peat structure for casing soil should have macro- and micro pores in order to properly absorb and retain water, and to easily discharge it. This is why a mixture of various peat kinds, both raised and low-lying, is used.

The casings oil must be free from diseases and pests. Soil needs to be disinfected if there are doubts about its cleanness.

2.3. Peat usage in heat and power generation

It is a matter of common knowledge that peat is a local fuel. Peat briquettes and lump peat are traditionally used as utility fuel by the population and public utility services. Russian scientists have developed efficient methods, which enable broader usage of peat as a fuel. Peat has been used for heat and power generation both inside and outside Russia for years. Global practices show that peat fuel prices are fairly stable, compared to the constantly fluctuating hydrocarbon prices. Russia was annually harvesting up to 175 million tonnes of peat until the 1990s, and 70% of those amounts were used by power plants. Nowadays, large generation facilities are reducing the use of peat.

The use of local resources, including peat, has been widely spread in power generation of the former Soviet republics. For instance, Belarus has the state program called “Peat”. The program promotes broader use of peat, development of peat extracting and processing enterprises serving the power industry, and construction of heat and power plants using peat as a fuel.

In Russia, peat has grown important utility boiler houses and recovery of distributed power generation and major power generating facilities. There are several types of peat fuel (Table 3).

The following types of peat products are used as a fuel: milled fuel peat, lump peat, peat briquette, semi-briquette, and composite briquette.

Composite peat briquettes made up of peat and numerous types of production waste have a potential. Such briquettes are made by press-molding a mixture of milled peat and filler. The composition of the mixture largely determines characteristics of composite briquettes (Table 4).

Table 3

Brief characteristics of certain types of biofuel

Parameters	Lump peat	Milled peat	Briquettes	Firewood
Humidity, %	38,2	47,6	15,7	25-30
Ash content, %	9,8	11,8	13,4	-
Net calorific value, MJ/kg:	23,3	23,2	23,5	23,2
Ash content per as-fired fuel, %	1.46-2.54	2.04-4.104	4.0-15.0	0.60

Table 4

Characteristics of various types of composite extrusion briquettes

Parameters	Lump peat	Composition				
		Peat and coal	Peat and charcoal	Peat and petroleum coke	Peat and coke breeze	Peat and carbon waste
Component ratio	-	1:2	1:2	1:2	1:2	1:3,3
Component mass fraction, %						
peat	100	33	33	33	33	23
filler	-	67	67	67	67	77
Net calorific value, MJ/kg:						
peat	11,4	10,7	10,7	9,8	11,4	11,4
filler	-	23,8	22,5	32,2	31,2	27,0
composition	-	19,2	18,3	25,3	22,3	20,5

Alongside relative cheapness, another indisputable advantage of peat fuel is its green characteristics, which make peat highly attractive in the light of the Kyoto Agreement due to the minimal discharge of carbon dioxide, sulfur dioxide and other greenhouse gases. Peat ash can be used in agriculture 100% due to its composition. Peat-based absorbents could be used in public utilities, food industry, and non-ferrous metallurgy.

Heat supply to public utilities and the social sector is an important issue for most Russian regions. The increased use of local fuel in the fuel-and-energy balance is a significant way to achieve the goal, and peat could be a solution.

Technologies of biomass transformation into standard fuel and burning of such fuel have successfully used for a long time. Some Russian companies are producing modern and reliable equipment. LLC NESEN Engineering has developed a concept and implemented several projects to convert milled peat into peat briquettes. The process is based on the briquette complex – a full-cycle facility, which starts raw materials and ends with peat fuel briquettes. The complex is easy to build, construction costs are minor, and outdoor operation is possible both in summer and in winter.

LLC Ecoprom has tested burning of coal and peat briquettes at heating boiler houses.

The tests showed that burning of a peat briquette in a boiler with a U-shaped arrangement of wall tubes generates more heat and is much more cost effective (in terms of fuel consumption and the cost of 1 Gcal of generated heat energy). The first stage of implementation of the innovative technological projects of the production of utility fuel focused on the replacement of coal, which does not present any substantial technological, resource or financial difficulties. Depending on the situation in a particular territory, it is possible to produce composite fuel from peat, sawdust briquettes, process chips, and molded fuel in field and shop conditions.

In recent years, Belarus has successfully implemented projects based on modern bioenergy technologies.

Follows the list of completed projects that built or renovated peat processing plants:

- Reconstruction of the peat briquetting plant (a branch of Minskoblgaz' Berezinskoye company) - 30 thousand tons/year;
- Construction of a mini-briquette plant (OJSC Lidskiy) - 20 thousand tons/year;

- Renovation of the peat briquetting plant (branch of Mingaz' Sergeevichskoe company) - 80 thousand tons/year;
- Construction of a briquette shop at JSC Braslavsky with a capacity of 40 thousand tons of fuel briquettes per year.

2.4. Peat usage in metallurgy

There are a number of reasons why peat should be used in metallurgy.

First of all, most areas with the developed metallurgical industry that runs on hydrocarbon fuel delivered from afar have substantial local peat reserves.

Secondly, peat has a lot content of sulfur and phosphorous. Raised peat has relatively low ash content. Average ash content in peat does not exceed 4-5. Raised beat extracted by the milling method yields strong and dense products – lumps of the required form and size. Such lumps are good raw materials for making peat coke.

Thirdly, a number of specific features of peat coke and semi-coke (high reactivity and absorption capacity, easy to activate, have high electrical resistance) make them more efficient than charcoal and coal coke as a carbonaceous reducer.

Peat is being used in metallurgical processes in the following known ways:

- the use of peat coke and semi-coke as a lean component of the charge;
- for the agglomeration of iron ores;
- in the production of ferroalloys;
- use of milled peat for thermal decomposition in an aero fountain type reactor with subsequent injection of the obtained pulverized peat coke in mining blast furnaces for partial replacement of coal coke;
- production of fuel and smelting materials based on peat and thermo briquettes for the blast furnace process and peat ore briquettes - for non-blast furnace production of steel in a fluidized slag bed and the production of sponge iron with subsequent remelting into steel in induction furnaces;

- as a raw material for the production of active coals, a carburizing agent for steel carburizing, forging fuel and other industries.

A number of research institutes have been working together with metallurgical plants for years to consider the comprehensive use of peat and products of its thermal processing in metallurgical processes.

For example, the Leningrad Polytechnic Institute, operating together with the Cherepovets Metallurgical Plant (CMP), performed a series of research works on the energy-technological use of peat extracted from the fuel base of the Cherepovets SDPP. At the same time, it was proposed to burn the gas of peat pyrolysis at the station, and to use the pulverized peat semi-coke for blowing into the hearth of blast furnaces.

The Institute of Fossil Fuels, the A.A. Baikov Institute of Metallurgy, and the Novotulsky Metallurgical Plant looked into the possibility of using peat coke to obtain fuel-ore granules in the direct reduction of iron and as a raw material for the blast furnace process. The degree of iron reduction from granules in a fluidized bed within 3-5 minutes was 95-97%!

VNIITP achieved a positive result of using peat coke in coke charge. The Leningrad Coke and Gas Plant produced coke of same quality as industrial-grade coke (the composition of the charge: peat coke – 10%, coal grade Zh-10 - 90). The use of thermo briquettes in metallurgical processes was studied in detail by the peat laboratory of the Tomsk Polytechnic Institute. Thermal briquetting involves preheating the fuel to the plasticization temperature, followed by pressing and cooling. Thermo briquettes increases combustion heat, high strength, heat resistance and low water absorption. Thus, the conducted tests of fuel and smelting briquettes confirm the feasibility and efficiency of their use in metallurgical processes.

The efficiency of sod peat and peat carbon-containing compositions was used in smelting crystalline silicon at the Ural Aluminum Plant JSC (Kamensk-Uralsky). The factory trials were held in anelectrothermal shop using single-phase ore-thermal furnaces with a capacity of 6.5 MW by comparing the dynamics of technical and economic indicators of furnaces before the experiment and at the time of its execution. In total, about 1,000 tonnes of carbon-containing compositions were tested.

The analysis of technical and economic results testifies to the efficacy of using peat compositions in the silicon smelting process. The usage of molded peat amid a constant furnace productivity of 530 kg/h decreased consumption coefficients by 1 ton of siliconm while quartzite consumption reduced 3.4% percent, charcoal consumption by 11.5%, petroleum coke conduction by 5.8%, and electricity consumption by 2.3$. The silica to solid carbon ratio increased 8%, while silicon products were of the same grade.

In order to confirm the effectiveness of the use of fuel and smelting compositions obtained by the proposed technology of molding metal-containing materials with peat, experimental melting was carried out in laboratories and workshops of JSC Uralelectromed, JSC Verkh- Neyvinsky Non-ferrous Metal Plant and the Kirovohrad metallurgical company.

For the purpose of obtaining information about heat resistance of peat copper-containing compositions and the efficiency of relevant copper smelting, experimental melts were carried out in the laboratory of the Uralelectromed plant. An analysis of the alloy’s chemical composition manifested an increase in the content of the copper-containing component and higher efficiency of copper extraction. So, with a 1:11.24 dry matter ratio of the briquette's copper component, the extraction of copper was 99.17%, the ratio stood at 80.01% in case of the 1: 7.58 ratio, and 58.61% in case of the 1:3.93 ratio (Table 5).

Thermal stability of compositions was observed during trials. It appeared that peat-containing compositions retain their shape up to a temperature of 1,000 degrees Celsius, after which they melt without prior destruction. The results indicate a sufficient degree of the composition’s thermal stability.

2. Main areas of peat usage

Table 5

Chemical composition of copper-containing peat briquettes

Mixture composition by weight, kg(f), t/kg	Chemicals, %											Extraction, %
	Cu	Au	Ag	Ni	Fe	Pb	Sn	Zn	As	Sb	S	
Yield of experimental melts												
1:11.24	93.24	9.3	384.4	0.13	0.15	4.64	0.53	0.70	0.96	0.29	0.04	99.17
1:7.49	84.15	18.8	534.5	0.16	0.12	7.75	0.82	3.86	1.11	0.33	0.54	80.01
1:3.91	82.85	17.5	431.3	0.16	0.58	8.09	0.89	5.58	1.16	0.34	-	58.61
Mate phase of experimental melts												
1:11.24	No phase											
1:7.49	71.33	-	-	0.022	1.31	2.67	0.022	4.38	0.17	0.16	9.81	19.63
1:3.91	62.33	-	-	0.333	4.21	2.62	0.062	4.61	0.25	0.16	10.36	11.19

Industrial melting of peat copper-containing compositions was carried out in the anode furnaces of the copper-smelting shop of the Uralelekromed plant and in the shaft furnaces of the Kirovgrad copper-smelting plant. The slag yield is 13% in molded dust smelting. In case of 1 ton of dust processed in anode furnaces, the losses amount to 38.8 kilograms of copper with slag, but 253.2 kilograms of metal could be extracted from slag. One ton of briquetted dust contains 367.7 kilograms of copper, including in slag - 10.3%, in copper from slag - 67.25%, and in anode copper - 22.55%. These parameters correspond to normal melting conditions.

Tests of fuel and smelting compositions based on peat and lead dust were carried out at the Verkh-Neyvinsky Non-Ferrous Metal Plant. The compositions were melted in an operating shaft furnace in the ratio of 70% of battery scrap and 30% of molded briquettes.

At this ratio, lead recovery was 83%, about the average kiln performance level, 1677 kg/h*m^3. The chemical composition of the slag, matte and black lead of the smelting did not change either. The usage of lead dust recovered from bag filters in the form of molded compositions with peat does not affect the course of the smelting process, does not change the quantitative and quality indicators and composition of the received products, which is good for low-waste technology.

The molding of dispersed concentrates and metallurgical waste with peat yields fuel-smelting and carbon-containing compositions of the required quality. New types of peat compositions with fillers of petroleum coke, roasted copper concentrate, gas cleaning dust of a copper smelting shop, lead dust were tested in industrial conditions at metallurgical plants in the Urals. The tests confirmed the feasibility and high efficiency of using the composite materials in metallurgical processes.

2.5. Peat use as anticaking agent for mineral fertilizers

The long-standing practice of production and use of mineral fertilizers shows that caking is the worst feature of these goods, which is hard to deal with. In the course of storage and transportation, powdered and granulated mineral fertilizers turn into solid agglomerates. High humidity and pressure coming from upper layers (orbags) of fertilizers on lower layers add to the problem. Temperature fluctuations are a factor of the cyclic process of dissolution and new crystallization, which leads to the appearance of crystallic bridges between granules.

Flowability of fertilizers could be increased with dusting mineral additives obtained from hydrophilic dispersed powders: gypsum, diatomaceous earth, diatomite, kaolin and other materials with a high specific surface area. The mechanism of their action on the insulated material is based on the adsorption of moisture from the air.

Such additives partially absorb free water, reducing its content in fertilizer participles. A protective shell created on the surface of granules prevents interphase contact between fertilizer particles. Water absorption properties of inert additives are increased by hygroscopic compounds (for example, calcium chloride or nitrate). However, the use of inert additives has a number of disadvantages associated with their relatively high concentration in the fertilizer mixture. As a result, the content of nutrients decreases, the dustiness of industrial premises increases, and the efficiency reduces as additives fall off the surface of granules and have a limited water retaining capacity.

The disadvantages could be fixed with anti-caking additives.

Peat-based hydrophobic-modifying additives are the product of low-temperature thermo chemical destruction of dispersed peat’s organic matter (particles no more than 50 microns in size). The additive production method is based on scientific principles, which give anti-caking properties to fertilizers.

A hydrophobic semi-finished product made of raised cotton grass-sphagnum peat with a decomposition rate of 25-30% is mixed with the powder of a mineral material (kaolin). This this kind of peat is used due to the sufficient content of native bituminous compounds and the fact that it is fairly widespread in Russia.

The concentration of the peat additive reached 10%. Seeking to increase the dispersion of particles and their mixing uniformity and to create conditions for forming of initial adhesion contacts, the mixture was placed in a ceramic ball mill for five minutes of additional grinding at a speed of 56-60 rev/min. The parameters depended on the mill features and the optimal quality characteristics of the organic-mineral mixture.

The two-component mixture was activated in a laboratory reactor facility. In the cause of activitation, the surface of kaolin mineral particles of the treated material covered with a protective water-repellent film from bituminous compounds released during heat treatment. The film does not negatively affect the flowability of the powder.

The hydrophobic composite was used to treat mineral fertilizers-ammonium nitrate and carbamide. The tests proved that the compositions made of environmentally friendly anti-caking additives based on peat and kaolin reduce the caking of mineral fertilizers and increase their shelf life without lowering the content of nutrients. In addition, hydrophobic modifying additives allow industrial production of fertilizers without adjustment of technological processes.

2.6. Peat usage in construction

The tendency to form organomineral complexes of various compositions and structures and the capacity for a variety of various ion-exchange processes lead to high reactivity of peat and the possibility of its usage as an effective building material. There are objective prerequisites for rationally using peat in the construction industry: low thermal conductivity of raw materials, high porosity, and antiseptic properties. Peat can be used in production of building materials as the main and modifying component. The type of peat and its chemical composition determine how it could be used in the production of construction materials. For example, raised peat decomposed less than 20% should be used as an active filler for peat-bitumen binder for road asphalt concrete with increased strength and shear resistance. The positive effect stems from active functional groups and fibrous inclusions present in peat. Polymer-modified peat-bitumen binders are also used to make roofing and insulating mastics with increased heat resistance.

Raised peat was used to make Geokarbuilding blocks, a structural and thermal insulation material for residential buildings. The strength of blocks allows them to be used for the construction of load-bearing walls in low-rise construction. The blocks create the wooden house effect – the house is cool in summer and warm in winter. The heat and soundproofing characteristics of peat blocks reduce the thickness of walls, cutting costs and labor-intensivity.

The Tver State Technical University created a lightweight aggregate by molding granules from wet peat, on which a thin layer of clay was applied, drying and firing. Such aggregate for lightweight concrete can be produced from almost any peat and clay material. Concrete made with this aggregate has a low density of 800-850 kg/m^3.

The Tomsk State University of Architecture and Civil Engineering has developed technologies to make various types of building materials with low-lying peat: non-fired granular concrete aggregate; peat-wood thermal insulation boards; heat-insulating plates and structural and heat-insulating blocks based on modified binders from low-lying peat, organic fillers with pore-forming and reinforcing additives.

The project yielded products with an average density of 150 to 400 kg/m^3, thermal conductivity coefficient from 0.05 to 0.09 W/(m•°C), compressive strength from 0.6 to 4.5 MPa, and water absorption from 20 to 160 percent. The production is based on mechanochemical activation of the mineral part of low-lying peat, which initiates its astringent properties. The chemical processing of peat organic matter yields compounds capable of improving hydrophobicnye and rheological characteristics of cement compositions.

Preliminary studies indicate that the method could be successfully applied to hydro phobization of other bulk mineral materials: lime, gypsum, sand, clay, etc., which opens new vistas for their usage in other industries. Books suggest that the addition of traditional water repellents into slaked lime upon grinding does not prevent the loss of its activity during long-term storage.

Successful experiments are being carried out to expand the raw material base of hydrophobic modifying additives. Good results have been achieved in using peat that has undergone self-heating, organic sapropel, wood residues extracted from peat deposits, wood processing waste, etc.

These studies lay the foundation for new technologies of hydrophobization of mineral dispersed materials (Fig. 13).

Fig.13. Drops of water on the surface of samples made of hydropophic Portland cement

They help elaborate new scientific approach to the regulation and targeted structural transformation of materials containing mineral cementious materials and organic additives. The diverse composition and the practically unlimited raw material base of organic materials allows to create building materials with high hydrophobic properties. By using the rationally selected mixture of peat-wooden filler with polymeter binder and using thermo-extruded technology, it is possible to manufacture various molded products, such as timber, window frames and door blocks, doors and other high performance products.

Production of directed peat-based additives is a new and promising line of research in the field of building materials.

For example, a natural science university in Estonia is developing a technology for building houses from peat using 3D printing.

Together with oil shale and silica, peat acquires new physical properties. This mixture completely hardens within a day after preparation. During this time, builders can stack bricks and trigger diffusion. No additional building mixture is required to hold the blocks together.

The result is a strong and hard structure without any gaps. Developers say that a two-story house could be erected within a day or two using the mixture and the 3D printing technology. Multiple studies indicate that nanotechnology applied to the physicochemical processing of peat broaden its use as a building material. Soon enough, it will be possible to build a house exclusively of peat.

2.7. Peat usage for purifying industrial waste water

Cleaning of industrial wastewater from toxic ions of heavy and non-ferrous metals is an important aspect of environmental protection from the harmful impact of industrial activity. The use of synthetic ion-exchange resins for these purposes is limited by their high cost. Meanwhile, the use of peat, a renewable mineral of plant origin and a natural ion exchanger and sorbent, is a very promising direction.

The main disadvantage of peat is its low exchange capacity. This feature determines two extreme variants of its application: minimal preparation for one-time use followed by incineration in order to recover absorbed metals and maximum preparation, including the removal of ions absorbed during the deposit’s formation (or their replacement with ions of alkali or alkaline earth metals), hydrolysis (removal of chemically unstable components), debituminization of the material (i.e. removal of inactive ballast) and chemical modification of the residue (sulfonation, phosphating, etc.).

This kind of peat could be used multiple times.

Practical aspects of its usage in the wastewater treatment process have been studied by the adsorption of copper ions by raw peat (containing H^+, Ca^{2+}, Mg^{2+} ions). Studies show that the adsorption capacity of peat decreases in the order Pb>Ca>Cu>Mg, Zn.

In order to clean wastewater from some heavy metals, peat has to be treated with calcium salts and the natural component of hardness enters the water; in this case, it is possible to remove impurities with a concentration of less than 10 mM.

A number of peat preparation methods have been patented. For instance, it is proposed using hydrolyzed, debituminized, and sulfonated peat. This product can purify wastewater from ions of copper, nickel, chromium, lead and manganese. Raw peat is directly sulfonated and the product is dried up and mixed with untreated raw peat and a binder before it is used to purify wastewater from heavy metal ions. In order to remove easily hydrolyzable components, peat samples were boiled with a dilute sulfuric acid solution. Bituminous products were removed by extraction with a mixture of organic solvents (isopropanol-toluene - 1:2).

As result, the highest total value of the static exchange capacity (SEC) is achieved for low-lying peat, the amount of absorbed copper does not depend on the type of peat, and nickel is absorbed to the highest extent by transitional peat

Given that wastewater itself is quite hard, a slight increase in the concentration of calcium ions would not matter. However, peat calcination would significantly increase the SEC value, as it will prevent deoxidation of the treated water. The authors have proven by the example of raised peat that such processing could actually be useful in the case of nickel. The amount of absorbed metal more than doubles, although the SEC amount mostly increases through the absorption of magnesium.

The calculation of the ash content in washed peat sand its comparison with the quantity of absorbed copper and nickel makes it possible to calculate the content of these elements in it (Table 6).

Table 6

Copper and nickel content in peat ash after waste water treatment

Peat	% peat ash	% copper in ash	% nickel is ash
Raised	2.5	3.8	5.8
Transitional	4.8	2.0	4.8
Low-lying	16.3	0.6	1.1

Industrially processed ores usually contain 0.7-3 percent copper, 0.3-2 percent nickel, so “man-made ores” made as a result of burning peat sorbed by non-ferrous metals will be quite rich.

From the angle of non-ferrous metals extraction, it is best to use raised peat, and for wastewater treatment purposes it is advisable to use peat for economic considerations (the proximity of the deposit to the object of treatment). Peat preparation should consist in acid washing of naturally sorbed ions and water-soluble compounds. A deeper preparation is required only for repeated use of the sorbent and, probably, should include chemical modification of peat. If necessary, peat may be calcinated to increase the percentage of sorbed nickel. Since the wash water left after peat preparation contains biologically useful components, they can also be used as fertilizers after neutralization with lime.

2.8. Use of peat and peat sorbents for remediation of oil-contaminated lands

Oil spills remain a pressing ecological problem. Oil production, transportation and processing are frequently accompanied with spills, accidents and numerous ecological disasters.

The Khanty-Mansi Autonomous District ranks first in Russia both in terms of oil production and by the number of production site and pipeline accidents. An analysis of official data regarding oil sector accidents that occurred in the Khanty-Mansi Autonomous District – Yugra over the past 14 years indicates that from 1,600 to 2,000 emergencies happen there each year on the average. Many researchers say that most oil-contaminated territories in the Khanty-Mansi Autonomous District – Yugra is sphagnum bogs with thick peat layers. As a natural geo-system, a peat bog is capable of handing any man-made impact. At the same time, a peat bog burdened with crude oil spills is a man-made and natural system, which is less stable than the original and whose natural self-regulatory mechanism is broken. People estimate the time needed by oil-contaminated peat bogs to cure themselves as impermissibly long.

The remediation of oil-contaminated bogs should be based on soft technologies that do not affect the main bioproductive peat layer. These technologies include backfilling pf contaminated bogs with biologically and sorption-active dispersed peat, which has already passed a certain level of approbation. In this case, the active bioproductive (peat) layer of the deposit is freed from the man-made impact at least twice as fast and is able to continue to produce plant mass.

Research on the impact of oil products on swamps is still miniscule despite the fact that numerous oil fields in our country are located in highly swampy areas. Everyone knows that the oil film makes it difficult and even stops the enrichment of water with oxygen. The solubility of oil in water is low, and it also decomposes slowly, especially at low temperatures.

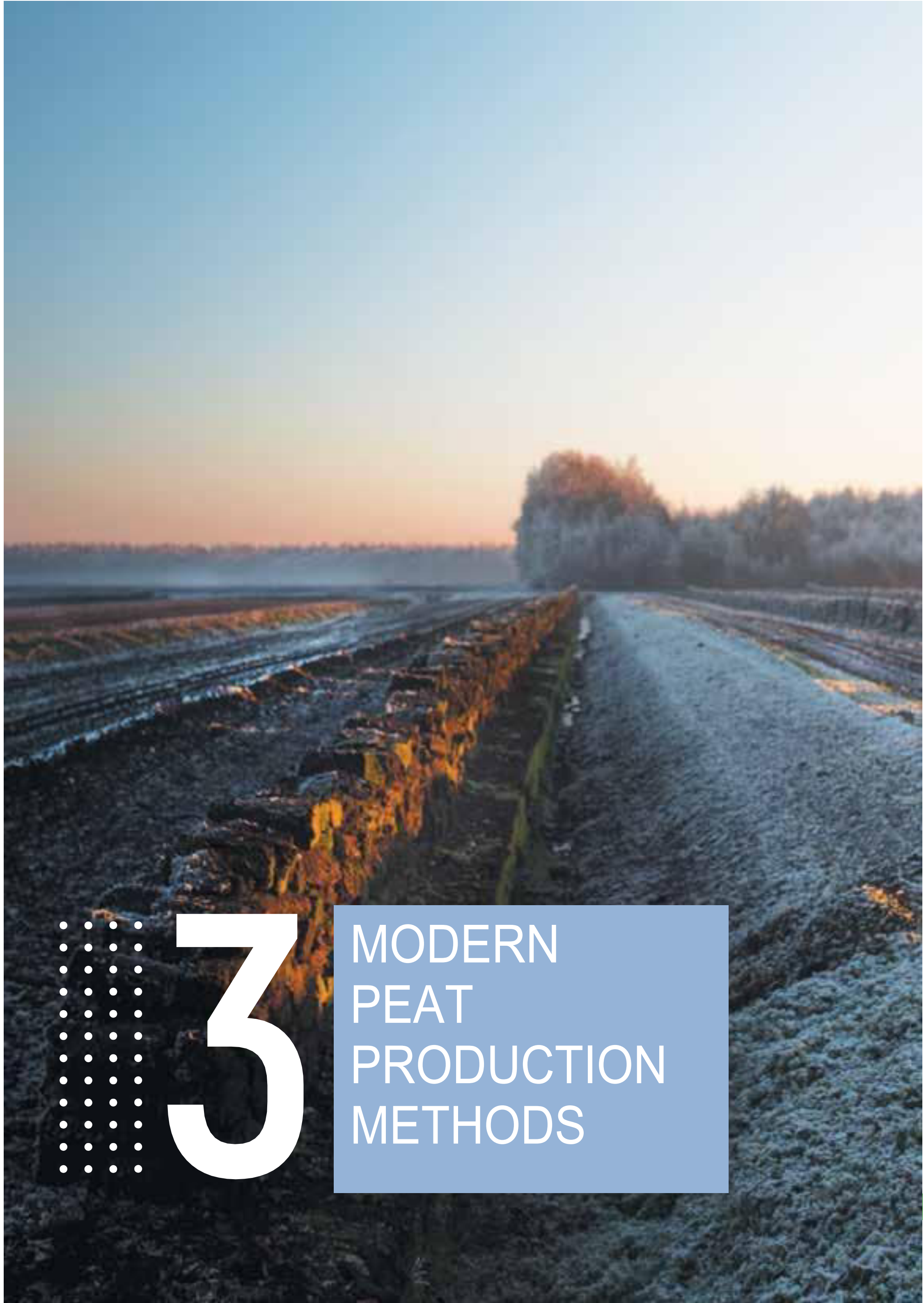
The difficulty in self-healing of soils contaminated with oil and oil products mostly results from the high concentration of oil products in the affected land, which slows down the biochemical processes of oxidation and biodegradation. It is possible to reduce the concentration in local systems with the sorption of oil products with sorbent particles or macro-molecules. It is also important that the sorbent decays as time passes.

A fairly effective and useful measure is mulching the contaminated soil surface with a thin layer (3-5 cm) of dried peat crumb. This is done after collecting the bulk of the spilled oil and decreasing the residual concentration of hydrocarbons in the area due to the high sorption capacity of peat chips and improving the water-air regime and microbiological indicators on the reclaimed soil surface. Peat is known to be a heteroporous (inhomogeneous porous) system. It is necessary to distinguish between macro and microstructures. The latter characterizes the internal volume of particles - loose aggregates (associates) arising from humic substances and a carbohydrate complex of peat. It is a non-toxic, widely available, cheap natural sorbent, easily amenable to mechanical and chemical processing. Due to the developed surface and the presence of hydrocarbon-acidifying microorganisms, peat can serve as both a sorbent of oil components and their destructor. The sorption capacity of peat in relation to oil depends on the degree of decomposition and is 8-10 grams for high peat, for low-lying peat - 3-6 grams of oil per 1 gram of absolutely dry peat matter (dry matter).

An equally important aspect of solving environmental problems is the presence of hydrocarbon-oxidizing microorganisms, the number of which is 4-5 times higher than the analogous indicator for mineral soils, which significantly increases the efficiency of biodegradation of sorbed oil products. After the physicochemical activation of peat, the number of microorganisms increases 20–100 times and averages 5–1010 cells/1 g of dry matter. The hydrocarbon-oxidizing community of peat is generally diverse in terms of species; it is based on mesophilic bacilli, actinomycetes, and proactinomycetes. When choosing a technology for the extraction and processing of peat raw materials for the production of sorbents, it is necessary to take into account the peculiarities of the interaction between peat and oil products, the differences in the structural-mechanical and physical-chemical properties of various types of peat products. The scientific and methodological approach to the assessment of the sorption of oil and oil products by peat makes it possible to formulate recommendations for obtaining high-quality and effective products for environmental purposes.

Studies of the peat moisture effect on oil capacity indicate the possibility of a significant increase in its value, provided that peat is dried and granulated.

Peat is able to create not only material wealth, it also influenced the spiritual life, the creativity of many people. There are lots of literary works associated with peat and numerous secrets of swamps. Philately has also paid attention to this unique natural product, but this is what we'll talk about later.



3 MODERN PEAT PRODUCTION METHODS

3. Modern peat production methods

3.1. Drying and preparation of peat deposits

Peat deposits are heavily watered in their natural state. There is more than 8 kilograms of water per one kilograms of dry matter. Groundwater is close to the surface and even often flows out. A water-saturated peat deposit has a low bearing capacity, a low yield of air-dry peat from 1 m^3 of the deposit. When peat is harvested amid the natural drying process, all excess moisture must be removed by evaporation. The lower the moisture content is, the higher the production efficiency will be.

Preparation of a peat deposit for exploitation can be divided into two stages: drainage and preparation of production areas. Excess water is discharged from the peat deposit by drainage.

The goal of drainage is to prepare the peat deposit for further development. Draining is carried out by means of hydraulic engineering measures that create the following main elements: a water intake, a settling tank, main canals, catch ditches, and field drains. Rivers or freshwater reservoirs, lakes, into which water from a drained peat deposit is diverted, could also serve as a water intake.

If a river or lake serves as a water intake, dredgers and excavators with draglines on pontoon installations are used to regulate the intake amount.

The sequence of creation of the drainage network is based on the plan for bog preparation and commissioning of the areas: preliminary drainage is carried out at first, and operational drainage follows.

In accordance with the peat industry's open canal drying system, the standard moisture content of the milled layers stands at 79-82% for raised deposits, depending on the year of operation. At the same time, the moisture content of the layer (0.4 m) affected by the raised peat preparation is 85-86%. The normative values of humidity are achieved when the groundwater level stands at 0.8-1 meter from the surface.

At the initial stage, conditions are created for laying a drainage network and preparing excavation areas. At the second stage, all the elements of the drainage network are brought up to design dimensions and conditions are created for peat production.

Work begins with preparing the drainage network layout followed by adjustment of water intakes, digging of main and catch ditches, and construction of secondary and field drains. All channels of the conductive and containment network are designed with a bottom slope: 0.0003-0.001 for main ditches, 0.0003-0.005 for secondary and field drain, and 0.0003-0.002 for catch ditches. The slope is not specially assigned for field drain: it depends on the slope towards the relevant catch ditch. If the slope towards a main canal exceeds 0.0005, field drains are dead-ends discharging water into secondary drain. In this case, the number of bridges across field drains is halved.

The usual depth of drains after deposit settlement stands at not less than 3.5 meters for main canals, 2.5-2.8 meters for secondary drain, and 1.7-1.8 meters for field drains. The maximum water level, which prevents backup water from forming in the drainage, is 0.4meters above the secondary drain level in main canals, 0.2 meters below the field drain bottom in secondary drain, 0.2 meters below drain bottom in collecting canals, and 0.1 meters above the bottom interface in catch drains. There should be no mater in field drain. Whenever it is planned to store firewater in field drain, their depth is increased by approximately 0.6 meters.

The following parameters are set for canals with due account of their longitudinal and transverse deformation during the deposit shrinkage: there are no limitations for main canals, 3-4 kilometers for secondary drain, and up to 1,000 meters for field drain. Main canals must be built on the lowest points of the deposit bottom.

Secondary drain is built perpendicularly to the main canal. The distance is 500 meters between secondary drains and 40 meters between field drains. Water from secondary drains of a peat deposit flows into the main canal.

In the central part of European Russia, peats are dried up within a year (Table 7).

Table 7

Peat deposit drying period

Types of work	January	February	March	April	May	June	July	August	September	October	November	December
Water intake adjustment	■	■	■	■	■	■	■	■	■	■	■	■
Excavation of main canals and secondary drain	■	■	■	■	■	■	■	■	■	■	■	■
Excavation of catch ditches					■	■	■	■	■	■	■	
Excavation of field drain					■	■	■	■	■	■	■	
Drain pipe laying					■	■	■	■	■	■		

Depending on the scope of works and weather conditions, the excavation could be done from January through December.

The drainage network is built and repaired using earthmoving machines of the cyclic or continuous mode of operation. The most common single-bucket excavators are those of the TE type specially designed for the peat industry, as well as excavators E-352, E-304 and E-357. Main canals, secondary and field drains and catch ditches are built and repaired with the help of peat excavators. The main and most frequently used working bodies of single-bucket excavators are the backhoe and dragline, while the soil is thrown into the dump. Peat excavators are often used both for loading and unloading operations (wood, stumps, bulk materials), and for uprooting wood residues from the deposit.

The excavators are equipped with crane gear or a lifting hook for that purpose.

Field drains are dug on a peat deposit capable of bearing tractors and excavators and field drains are deepened to the specified levels by MTP-71 single-bucket excavators and MTP-32A continuous-operation machines.

Peat milling requires preparation of the deposit’supperlayers: it is necessary to create a flat and dense surface, remove tree and shrub vegetation, as well as bumps, stumps and a layer of poorly decomposed peat, unsuitable for fuel use.

3.1.1. Deposit preparation for harvesting

Main works done to prepare the deposit 'supper layer for use are:

1. Removal of trees and shrubs
2. Trunk processing, collection, loading and removal outside the deposit
3. Collection and incineration of branches and shrubs
4. Removal of tree stump sand buried wood
5. Collection, loading and transportation outside the depositor remote tree stumps and wood
6. Surface preparation and leveling-off
7. Removal and processing of poorly decomposed peat
8. Preparation of ground for laying drainage and rail tracks
9. Various sorts of finishing operations and post- settlement repairs

The sequence and scope of these works largely depend on the type of surface and mechanisms used for its preparation. The type of surface depends on flora and the local relief.

Consistent with the current classification of peat deposits, there are three types of peat bog plant groups: low-lying, transitional, and raised. In turn, all groups are divided into two categories depending on preparation and afforestation particularities. The first one mainly refers to the afforested surface of the forest subtype, and the second, to the treeless marsh subtype. The largest number of surface preparation operations is carried out on peat deposits covered with large forest or willows. There are much fewer trees on swamp-type deposits.

Preparations constitute a set of technological operations performed in a particular sequence consistent with technical requirements for the purpose of enabling normal operation of peat harvesting equipment.

The technical condition of the production area means a combination of the local relief, the degree of deposit dryness, and the presence of tree stumps in the developed layer.

The choice of a particular technological method primarily depends on the type of the surface, the vegetation, and the type of deposit. The main feature of a peat deposit is the amount of trees. Depending on the degree of decomposition, the presence of tree stumps, the moisture levels, and the deposit stratigraphy there will be different number of preparatory operations.

The technological method also depends on the way of peat production, primarily the harvesting way, either mechanical or pneumatic. Requirements for peat quality and the content of wooden inclusions, as well as the production scale are also taken into consideration.

Previously, peat harvesting equipment was made at specialized machine building plants. There is no such production now. The equipment is made in Belarus, Finland, and Canada. It is proven to be highly efficient in clearing the area from shrubs, tree stumps, and young trees (with the diameter of up to 15 centimeters). For instance, MeriCrushers' milling drum it grinds shrubs with an upper soil layer up to 20 cm deep, destroying the root system, and its compacting drum bends trees up to 10 centimeters and compacts the soil.

Field preparation machines are mounted on tractors and bulldozers either in the front or in the back. The Meri Crushers machine could be mounted on any type of tractor or bulldozer (made in Russia, CIS member states or Europe) that must have power take-off shaft from 80 to 180 hp; fastening of attachments at three points ("triangle"); low gear, i.e. the ability to move at a speed of less than 3 km/h; at least one bi-directional hydraulic hose (to drive the compacting drum).

Peat deposits are prepared for operation within periods that ensure the best use of equipment and work quality. The approximate periods of peat deposit preparation are given in Table 8.

Table 8

Peat deposit preparation periods

Types of works	Periods of works						
	May	**June**	**July**	**August**	**September**	**October**	**November**
Deposit milling							
Surface layout and planning							
Removal of small-sized tree residue							
Tree residue loading and transportation outside field							

Areas, which are put out of circulation for repairs, must be kept in mind in estimating the size of production territory. The areas will amount up to 1.5-5% in case of low presence of tree stumps, up to 1.5% in case of medium presence of tree stumps, and 10% in case of raised deposits.

The costs depend on hydrological characteristics, the presence of tree stumps, the degree of peat decomposition, and other factors.

Russia does not make specialized equipment of the sort, but it could be exported.

Firewater supply implies the continuous supply of water through a self-flowing or of pressure network, which, together with hydraulic structures (dams, sluices, pumping stations), constitutes a water supply system.

Peat deposits are usually elongated shape with a 0.001 bottom slope, which makes the gravity water supply scheme the most suitable. A reservoir serves as a source for the gravity water supply. The network comprises a reservoir, gravity water canals, an internal water supply network –fields drains, a dam built at the water source, and an internal system of sluices. The minimum depth pf firewater channels is 0.8 meters.

3.1.2. Maintenance of production areas

Repairs are required by the following factors: peat could be middle on areas that meet certain conditions. Fields have to be well dried, the surface has to be flat, and the excavatated layer has to be free from tree residue.

The deposit milling process is quite intensive. Each year the peat layer depletes by 15-20 centimeters or even more if peat is harvested for agriculture (such as fertilizer). The peat deposit has various degrees of significance, decomposition and density, which leads to different speeds of production in various deposit parts. The deposit is not developed at all in storage areas and along field drains. The surface is gradually transforming from convex into flat and even concave.

The area along field trains often exceeds others in size, which hinders the flow of ground water into them. Water gets absorbed and filtered by the deposit, increasing the moisture content and extending the period of spring and seasonal preparations after heavy precipitation.

Heavy machines (Fig. 14) create pits, bump and ditches near turning heads or approaches to storage areas. The peat deposit is not excavated in those areas, which make them much more elevated than the rest of the deposit in one or two years and creates difficulty for machines and hinders access to stacks and unloading operations.

Another problem is wood residue, which is initially found at the depth of20-30 centimeters but raises to the surface and litter the working area. This is the cause of frequent breakdowns, lesser milling depth, unevenly spread crumbs, reduced peat yield from 1 hectare of territory, lower performance of machines, and contamination of products with small-sized wood residue.

These and other factors also affect the functioning of the drain network. Milling chips are washed by pouring rains and fanned by high winds into drainage and clog bridge pipes. The excessive content of water in spring, fall, and during periods of intensive summer rains increase the flow of water in drains and lead to the rapid washing out of their bottom and sides. The sides of secondary drains and main canals collapse quite frequently. The water flow slows down a lot in dry summer periods and drains silt up.

The machines have a negative impact on the eco-system. Heavy traffic along field drains cause collapses of their sides, which is particularly noticeable in production areas with the poorly functioning drain network and in low-lying deposits.

All those factors affect performance of the drain network, increase the deposit's huminity, reduce the cyclic and seasonal yield, and cut equipment productivity.

Finnish Suokone ditcher OJ-0.7 K, OJ-1.0 K and OJ-1.3 K

Land clearing attachments for land clearing

MP-3mb stump plucker

Agner profiler AT-51

Fig. 14. Peat deposit drying and clearing machines

Maintenance of production areas should include the following operations:

1. Canal cleaning and deepening
2. Bridge cleaning
3. Milling or stump removal from the excavated layer
4. Stump collection, loading and removal outside fields
5. Traverse surface profiling
6. Longitudal surface profiling
7. Deposit cutting, preparation of storage and turning head areas
8. Leveling off soil removed from drains and from under stacks
9. Other operations depending on production needs.

Peat production will be successful only on the condition of regular maintenance of production areas. The regular maintenance implies periods upon which the production area is again treated by maintenance machines.

3.2. Peat milling technologies

The peat history has come a long way from manual to fully mechanized production methods.

The predominant modern method is top-layer milling.

There are three stages in the peat milling process: obtaining peat chips by milling the top layer of a peat deposit to a depth of 6-20 millimeters with milling drums, drying a layer of milling chips on the surface of the operating area to the specified moisture content and collecting finished products into field storage units - stacks. After milling, drying and harvesting one layer of milled peat in the production area, a new milling is carried out and thus all production stages are repeated in the specified sequence. The completed set of works on milling peat deposits, drying and harvesting finished products is called the technological cycle of milled peat production. In good (dry) weather, the cycle usually does not exceed 2 days at a given milling depth; there are 17-28 cycles per season, depending on the geographic location of the developed peat deposit.

All peat milling operations are performed on properly prepared and dried square areas called extraction fields, which are limited by field drains and secondary drains on their perimeter. The extraction field is 20 meters wide (for raised deposits) and 40 meters wide (for low-lying deposit). Their standard length is 500 meters. The length may differ depending on the peat deposit's configuration and excavation system. Bridges are built from one field drain to another with a length of 30-40 meters for machines.

A peat layer with a thickness of 15-20 centimeters is annually harvested (per undrained deposit). When peat is harvested to the intended depth (leaving the lower protective layer of peat for the subsequent use of this area in agriculture or forestry), peat extraction begins on other sites prepared for exploitation. After the deposit is fully developed and remediated, the area is used for growing crops or as meadows, pastures or forest lands.

Today there are two basic technological methods of milled peat production: one of them uses bunker harvesting machines and the other method is swathing: the first method uses mechanical and pneumatic peat harvesting machines.

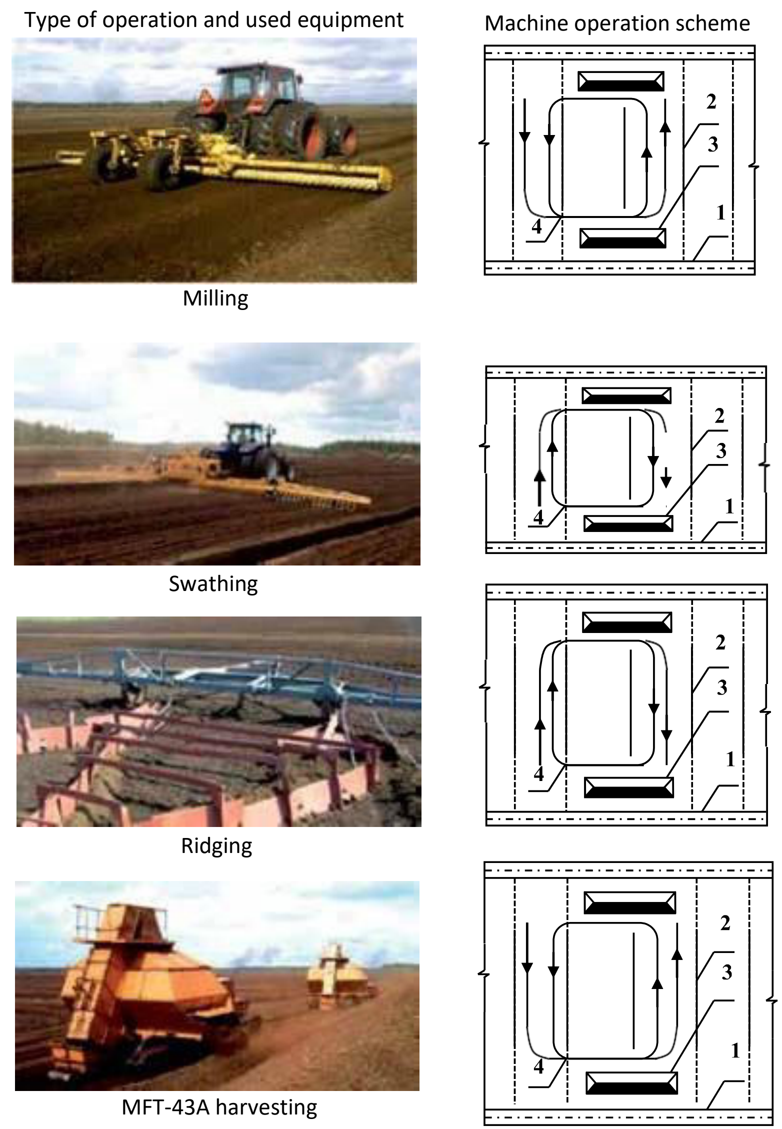


Fig. 15. Technological schemes for the production of milled peat

Note: 1 - secondary drain; 2 - field drain; 3 - storage area; 4 - access route

Mechanical peat harvesting by bunker machines

Milled peat is harvested while moving along the swath, in which the peat is collected by a scraper with a bucket elevator into a bunker and transposed to a stack located at the end of the swaths, where peat is unloaded from the bunker in bulk onto the side slope of the stack and is spread evenly over the surface by a stacking unit.

Drying is one of the main operations of the milled peat extraction technology, which determines every technical and economic production parameter. The top layer is dried as a result of the following operations:

- Milling–breaking and crumbing of the thin upper layer by milling attachments to swamp-toe tractors DT-75B. Usually, MTF-11, 12, 13, 14 million machines are used.
- Turning–it begins three to four hours after the surface layer dries to the depth of 5-8 millimeters and ends2hours before the end of the day drying period to lessen peat moisturing overnight. The operation involves VF-19 (MTF-22) and VF-9.5 (MTF-21) turning machines.
- Swathing increases productivity of harvesting machines and uses MTF-31 and33B equipment.
- Harvesting – collection of dry crumbs from swaths or spread and transportation to the storage areas by bunker harvesting machines MTF-41 and MTF-43A. The harvesting is done on four excavation fields accommodating two stacks from two adjoining excavation fields. First peat is removed from storage areas and then swaths are removed from excavation fields.
- Stacking (Fig. 16) stacking by means of OF-8 (MTF-71) and ShF-1 machines.

Peat pneumatic harvesting by bunker machines

There are two main types of pneumatic bunker machines: a bunker pneumatic combine harvester and a pneumatic harvester.

Peat excavation by self-propelled pneumatic combine harvesters of the BPF type combined two operations: harvesting and milling. The first pneumatic harvesting machines were made in the Soviet Union in 1930. Towed pneumatic peat harvesting machines of low productivity were used abroad.

3. Modern peat production methods

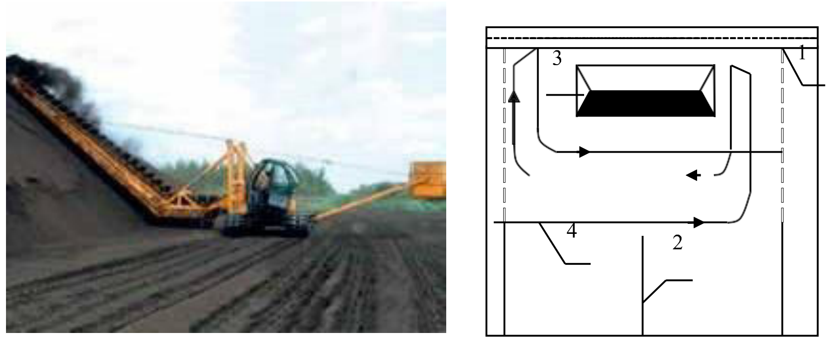


Fig. 16. AMKODOR-30 stacking

A bunker pneumatic harvester is a self-propelled machine, consisting of a working body, a crawler frame on which a bunker and unloading device are mounted, a trailed milling drum and a transmission with an engine. The working body is a suction-type pneumatic unit with four suction nozzles with pipes, two cyclones for separating peat from the air flow, and a centrifugal fan. Peat is sucked in by rectangular nozzles on an articulated suspension installed in front of the machine. When harvesting peat with a large amount of wood inclusions, a special comb is attached to the bottom sheet of the nozzle to protect the inlet slot of the nozzle from clogging. When removing loose peat, the nozzle rests on the spread with its lower plane, and when fibrous peat harvested, rollers are installed on the sides to regulate the distance between the spread and the nozzle inlet slot, to prevent the accumulation of peat lumps in front of the nozzle, and to harvest the driest particles. The nozzles are connected in pairs by pipes to two vertical cyclones. The amount of peat collected from the spread is controlled by the suction speed and the forward speed of the machine. When the fan is running, vacuum is created in the machine and the outside air rushes into the inlet slot of the nozzle moving along the spread, dragging the milling chips along with it. Having passed the nozzle, the mixture of air with peat enters the pipe and then the peat separator, which is a system of cyclones installed on the hopper and interconnected with it.

Pneumatic-wheeled peat milling machine mtf-43a-k

Bunker pneumatic combine harvester BPF 4.8

Pneumatic peat harvesting machine

Pneumatic harvesting machine JIK-40DF

Pneumatic bunker combine harvester

Milled peat loader

Fig. 17. Peat milling machines

The peat-air mixture acquires a helical motion in the cyclone. Driven by centrifugal force, peat particles get pressed against the walls and settle down in the bunker. Some 95-98% of peat sucked into the cyclone is deposited in the peat separator. The lower belt of the bunker serves as the frame of the belt conveyor, whose upper part runs along the bottom of the bunker, and the lower (idle) one runs under the bunker on rollers. The peat density in the bunker increases 18-20% due to the high feeding speed, and further increases in the course of the combine's movement.

The Soviet Union was using combined harvesters with a working width of 4.8-6.4 meters, a bunker volume 25-29 m^3 and engine power 125-158 kW. The harvesters had productivity of 2.0-2.4 ha/h.

The pneumatic harvesting machine is a tractor attachment designed to harvest peat mostly for bedding. Unlike the combine harvester, it has 2 suction nozzles and 1 vertical cyclone. Machines have a bunker volume of 14-15 m3 and a working width of 2.4-3 meters. Their productivity stands at 1.9-2.3 ha/h. The machine also mills fuel peat by using an inlet slot of 50 mm.

Another production method is swathing

Whenever peat is milled by the swathing method, stacks of 3 to 5 swaths are placed in the middle of the excavation field. There are two stages in the technological process: the first one is milling, drying and swathing, and the second one is loading of peat from swaths. The transportation to the storage area and the stacking are technologically unrelated to the first stage and is carried out on the condition of good passability.

In contrast to bunker harvesting machines, the capacity of trailers is used to the fullest extent. Productivity of harvesting machines practically does not depend on the weather. The location of the stacks is determined by the distance of peat transportation to the stack and the ability to provide year-round transportation of peat to the consumer; the dimensions of the stacks increase 10-20 times.

The length of bridges across field drains is shortened to 12 meters. In some cases the layout may have dead-ends on one side, while there may be no bridges at all one excavation fields with a width of 40 meters.

The choice of the production method depends on the field size and configuration and the type of product. Peat deposits with a rugged coastline, inner dry lands, shallow areas, and uneven bottom topography should be excavated by MTF-41 and MTF-43A harvesting machines, while reloading vehicles should be use on large fields with a uniform depth of deposits and a convenient field configuration. Pneumatic harvesting is expedient whenever peat is used as fuel or for agricultural purposes.

Modern peat enterprises in Russia mostly buy foreign harvesting equipment made by VAPO OY, SUOKONE OY, ECOFIELD OY, and RAISELIFT OY (Finland), Premier Tech (Canada), Bord na Móna and DIFCO (Ireland) and in former Soviet republics – JSC Amkodor, JSC Bolshevik and another nine manufacturers of peat harvesting equipment located in Belarus, Ukraine, and the Baltic republics. A key change in the design of foreign-made peat harvesting equipment is the shift from tracked to wheeled vehicles. The appearance of heavy wheeled tractors had an effect on economic aspects of the peat harvesting process and broadened the effective use of towed vehicles. Wheeled tractors allow cost effective transportation of machines and equipment on paved roads, and machines become cheaper and of a more universal nature.

The main peat milling indicators are the length of cycle and excavation season, the depth of milling, and the cyclic and seasonal peat yield per 1 hectare. The technological cycle stands for the period between milling and harvesting.

The milling depth depends on the duration of the cycle and the type of harvested products.

The cycle yield is the amount of milled peat of a particular humidity level harvested per 1 hectare of the work area within the cycle. The cycle yield determines every other parameter of the peat enterprise's operation, including the seasonal yield, labor productivity, fuel and metal consumption, investment, and the peat cost price. Technological norms set the following duration of peat harvesting operations: milling 16 hours; turning 8 hours; swathing 12 hours; harvesting 16 hours; stacking 16 hours.

The seasonal yield is the amount of milled peat of a particular humidity level harvested per 1 hectare of the work area within the season.

Milled peat is a quality raw material for production of practically every type of peat derivatives.

3. Modern peat production methods

3.3. General aspects of milling method

It is possible to mill sod peat from raised and transitional deposits, both open at milling fields and newly prepared areas (Fig. 18). However, sod peat milling is limited by the lack of domestic equipment. For now, sod peat is milled by use of Finnish equipment.

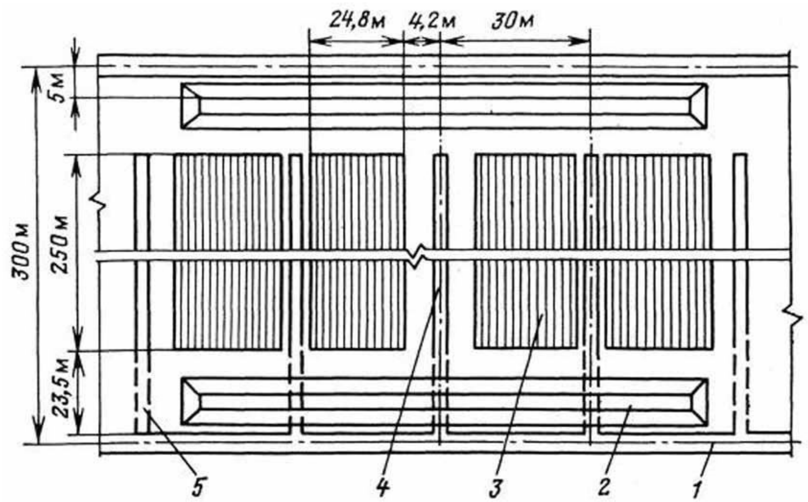


Fig. 18. Production layout for milling and bunker harvesting machines:

1 – secondary drain, 2 - stack; 3 -sod peat spread; 4 - field drain; 5 - field drain bridge

Peat is excavated mostly in low-lying peat deposits clear of tree stumps and containing non-crumbling peat decomposed at over 15%. The depth of such deposits should be at least 1.5 meters after drying.

The deposit is dried by means of a traditional network of canals, which dump water into ditches before the production begins and directly into an open pit after the work is over. Ditches are combined into a network by the main canal, which brings water to the collection area. The absence of bridges across field drains is the specific feature of this system.

Peat could be harvested by a multibucket excavator in multiple passes to the pit to ensure the full-length deposit development (maximally 4.5 meters) or a single - bucket excavator. A pit made in one pass is called working. The pit widens after additional passes and stretches out across the entire deposit area.

Just like in the milling process, dried peat is stored in stacks on drying fields or specially assigned areas. Whenever peat is stored on drying fields, stacks are located 20 meters from the spread part of the excavation field on the other side of the pit and stacks are formed on every excavation field in this case (Fig. 19).

Peat is excavated from one- or two-way pits. Whenever production amounts are inconsiderable or two-way pits prove impossible, a one-way pit is made. There can be no two-side pit when there is no place for spread fields on either side of the pit.

Excavators operate on the same line in a one-way pit. As their work is completed, they return to the original position at the beginning of the pit in an idle run. In a two-way pit excavators work on both sides and there is no idle running. Two-way pits are excavated when there are equal amounts of peat in all parts of the field. This kind of peats significantly intensifies harvesting, which is important for large production amounts.

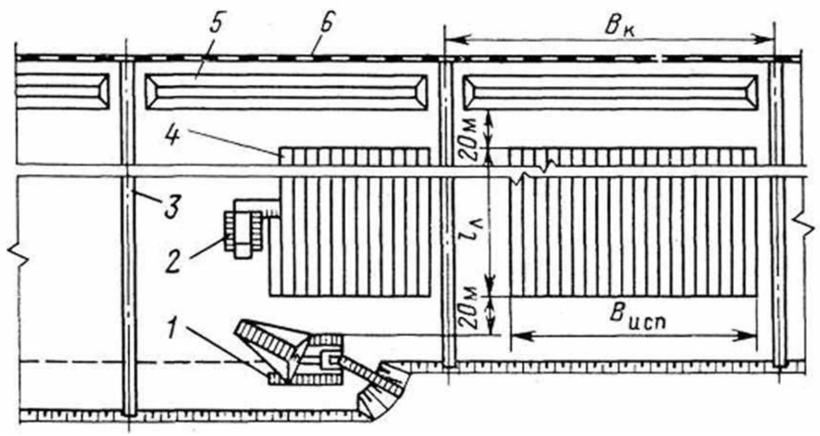


Fig. 19. Approximate layout of production area in sod peat excavation:

1 - excavator; 2 - spreader; 3 – field drain; 4 – peat lines on drying field; 5 - stack; 6 - stack access routes (motor or rail)

As a rule, several pits are made on a peat deposit. Their location depends on the deposit form, depth and size, as well as the direction of slope of the deposit surface and bottom. Whenever deposits are large and have a simple configuration, pit axes are located in parallel, and their direction coincides with the general slope of the peat deposit. With a complex configuration of a peat deposit, pits can be located in different directions (parallel, perpendicular, T-shaped, zigzag) and be developed in one-way and two-way directions.

Milling machine
PK-1SL C5 (SUOKONE OY)

Turning machine
KNH-18 (SOUKONE OY)

KA-4.0T swathing machine

Milling-molding machine

Fig. 20. Sod peat harvesting machines

3.4. Sod peat production technologies

There are two ways of sod peat production: milling-molding and excavation.

Field production of sod peat is the easiest way to make utility fuel.

Compared to milling, sod peat production has a number of advantages:

This technological process is less dependent on climatic conditions.

This circumstance allows to significantly broaden the sod peat production geography (trials have been held in Naryan-Mar, Sakhalin, and Kamchatka).

Sod peat has higher quality than milled peat.

Sod peat does not change its chemical properties during storage which makes it particularly valuable resource for the chemical industry.

Bulk density of sod peat is approximately one and a half times higher than that of milled peat, which allows to significantly reduce transport costs during delivery.

Sod peat could be dried in the field up to 35% of humidity, and the drying process continues in stacks due to their high porosity.

There is no self-heating in sod peat, while this circumstance is a serious problem for milled peat producers.

The cycle yield is much higher for sod pead, which allows to harvest it from smaller areas and, respectively, from small-sized peat deposits.

Due to the lower humidity and high density, sod peat has a much higher thermal value.

The absence of dust and strong vibration in machine cabins and their low speeds make sod peat production more comfortable.

3. Modern peat production methods

The disadvantages of sod peat production include:

The need for evaporation of larger amounts of water due to the initial humidity of the peat mass of 80-88%;

Substantial energy-intensity of the mechanical processing of peat mass;

Complexity and relatively low productivity of harvesting equipment;

Appearance of pits after sod peat excavation.

Sod peat production includes the following operations:

Peat processing by mixing and dispersing the solid phase;

Molding mass by extrusion through molding nozzles under pressure (extrusion);

Drying, which includes two or three mechanized operations;

Harvesting of dried peat combined with its cleaning of fines and crumbs of less than 0.025 meters in size;

Field stacking for storage until peat is sold.

4 INNOVATIVE PEAT PRODUCTION AND PROCESSING TECHNOLOGIES

4. Innovative peat production and processing technologies

Since day one of the peat industry, scientists and manufacturers in many countries have been trying to solve peat production problems.

The most common production method (layer milling) has been experiencing serious difficulties due to low product quality, unreliable supplies, and a high fire, environmental and economic risk.

First of all, the production method requires huge areas for production, drying, and storing of peat.

Secondly, there is need for substantial material and temporal investment in preparing swamps, including their drying with an open network and drains, removal of vegetation and tree stumps, and leveling off the surface.

Thirdly, there is need for a large fleet of specialized machines for swamp preparation and peat harvesting.

This kind of production activity disrupts the natural hydro-geological regime of swamps and affects the ecology in general. Besides, the method is highly dependent on weather conditions, which makes the business seasonal (three months, from May till August if the weather is good). The peat quality depends on the amount of precipitation in the working season.

Being aware of the imperfections of the technology, there is need to introduce new fuel peat production techniques, which, in our opinion, should develop in two main areas:

- Extension of the peat harvesting season;
- Peat excavation and artificial dehydration at the factory.

Suggested below are a number of most original and promising peat production technologies.

4.1. Borehole hydraulic peat production

Borehole hydraulic peat production (BHPP) is a new theoretical and *technological peat production method*. This is the physical process of peat hydrodispersion (deep disintegration of dispersed material) directly in the deposit. In this case, peat extraction is carried out by erosion of the peat deposit, simultaneous suction of peat slurry and its transportation to workshop modules with special equipment installed there. At the same time, the production units of the BHPP are highly mobile.

BHPP and the related complex achieve maximal ecological safety by preserving the active top layer. The peat extraction coefficient grows to 0.9 in BHPP as against 0.5 in milling. Once the works are over, the peat deposit regains its initial peat land condition within a geologically short period of time. The BHPP system has a closed water use cycle.

Peat slurry, harvested using the PHPP technology, is brought to modular shops for fractioning and distribution to parallel processing lines (Fig. 21).

The high-tech complex eliminates the costly component of transportation of various peat raw materials to enterprises and allows to make peat-based products practically all the year round, which significantly (more than 15 times) reduces the total costs of raw material extraction. The process of peat extraction from undrained peat lands makes green any method of field eco-system management. The new technology of extraction of wet peat eliminates a number of problems caused by the milling technology. The drying and harvesting of peat according to modern technologies requires draining of huge areas and long-term changing of the natural functions of bogs. The new mining technology allows the ecosystems of peat deposits to return to their natural state and quickly recover, while the use of environmental remediation leads to the resumption of the process of carbon accumulation.

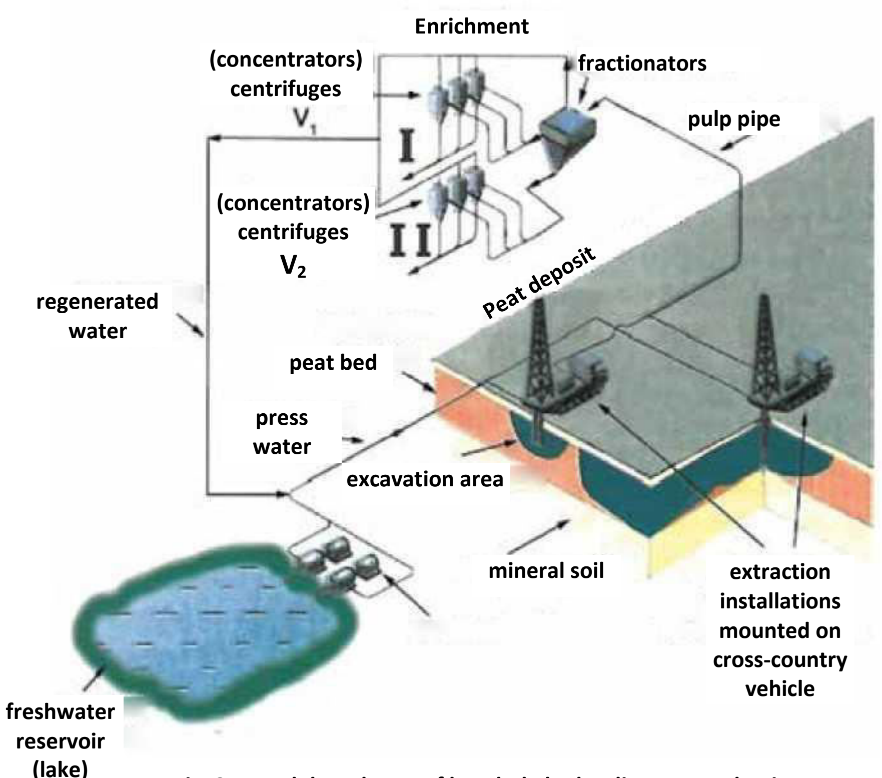


Fig. 21. Modular scheme of borehole hydraulic peat production

4.2. Molded peat production technology

The Peat Industry Research Institute has proposed a molded peat production technology combining the advantages of milled and sod peat production. The new technology implies layer-by-layer mining of the deposit, peat excavation, separation of wood inclusions, peat molding at relatively low pressures, peat laying on the field in tall drying stacks (Fig. 22).

4. Innovative peat production and processing technologies

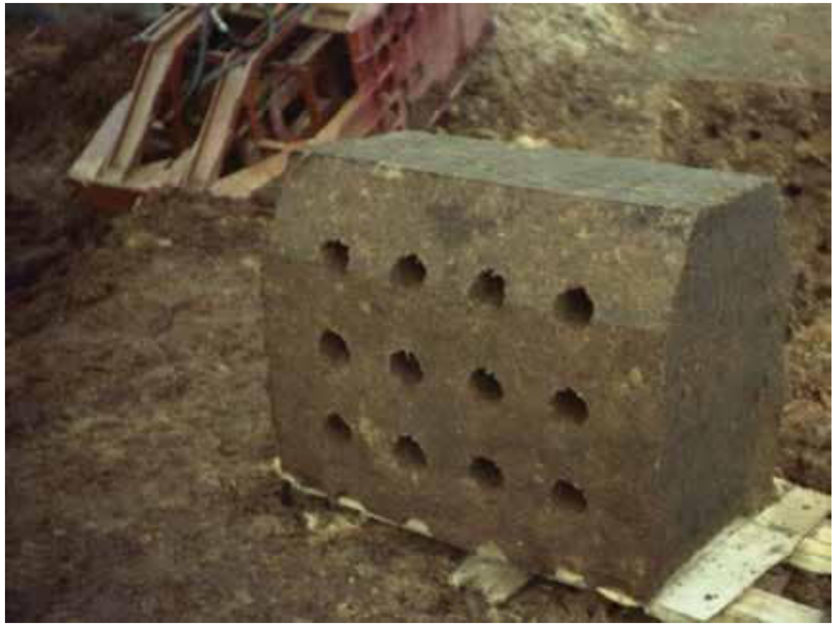


Fig. 22. Molded peat

This form increases the intensity of water evaporation from raw materials to 90%, decreases the dependence of the drying process on weather conditions, extends the production period into spring and fall months, expends the drying period all through the year, including winter freezing of the moist, and minimizes internal transportation costs.

The purpose of this invention (patent RU 2024756C1) is to improve conditions for drying of molded peat and to significantly increase its quality. The goal is achieved by excavation of peat simultaneously with separation of wooden inclusions, molding of excavacated materials, and mold staking for drying into shapes with ventilation shafts. Excavated peat is swathed and kept that way until the humidity reaches 80-90%, while drying stacks are formed of 0.75-0.85 layers to the height limited by the strength of molds drying beneath. Molds are placed on the south-north axis, while ventilation shafts have the west-east axis.

Molding peat production is possible in various parts of the country, including areas with seasonal freezing such as in the Khanty-Mansi Autonomous District.

4.3. Staged peat excavation technology

The St. Petersburg Mining University has developed a staged peat excavation technology (Fig. 23).

Field peat drying play a significant role in this production process. The method of peat excavation and staged drying includes heat harvesting and interrelated stages of gravitational dehydration and drying of peat in a natural environment. Technological parameters of stacks were the peat undergoes gravitational dehydration are crucial for the duration of the harvesting season, labor productivity, seasonal yield stability, and quality.

Dehydration as the initial stage of drying excavated peat is carried out by spreading a peat layer with a thickness of 80 to 175 mm. The spread width is determined by theater conductivity coefficient, the degree of decomposition, and the peat humidity. The measures achieve maximum intensity of dehydration, extend the harvesting season, ensure stability of the production process, and diversify products.

As aerated peat spreads are processed layer upon year as a result of gravitational dehydration, drying, and harvesting, the field drying potential is unlocked to the fullest extent. The method used on small- sized and shallow deposits increases the peat yield by 1.8-2.5 times compared to the known field production technologies.

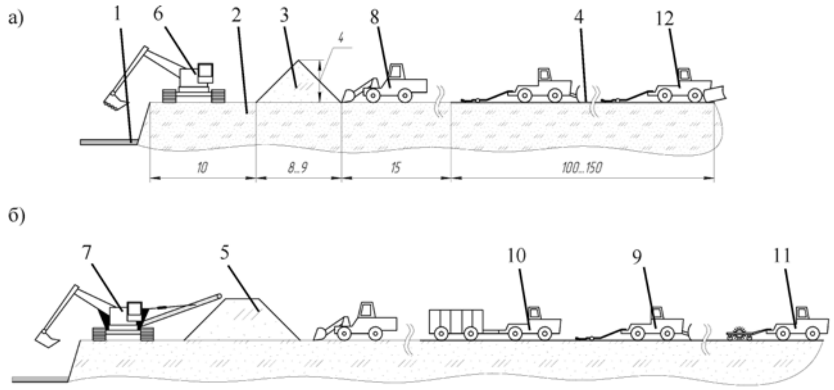


Fig. 23. Technical equipment of certain peat excavation operations

Note: for production area with a drying field length of over 150 meters(b) and up to 150 meters (a): 1 - peat pit; 2 - prepared peat deposit; 3 - gravitational dehydration stack; 4 - drying field; 5 - enlarged gravitational dehydration stack; 6 -hydraulic excavator (backhoe) combined with bucket crusher; 7 - modular peat excavator; 8 - peat fork lift; 9 - traction drive tractor spreader; 10 - Tr-PMTA; 11 - traction drive brush tractor for with layer-by-layer spreading; 12 - traction drive tractor combined with scraper and RFT ripper for layer-by-layer spreading and ripping

4.4. Heavy watered peat deposit development technology

Whenever peat deposits are heavily watered, the known production technologies include partial or complete land reclamation in addition to complete deforestation and stubbing. However, this kind of activity disrupts the natural hydro-geological regime and affects the ecological situation. These aspects have been studied by scientists E.A. Kremcheyev, A.V. Mikhailov, A.Ye. Afanasyev, and others. Modern peat processing methods allow to use raw materials of a relatively high humidity level. Obviously, field drying measures look excessive in such cases.

At the same time, the available technologies do not allow harvesting peat without land reclamation, which makes the development of new production methods and self-propelled harvesting machines and complexes a priority. Considering the location of peat deposits in areas difficult to access by motor transport and the impossibility to use another harvesting and transportation method, machines have to be amphibious, self-propelled, and universal.

The new harvesting complex uses pontoons as the source of its amphibiousness. There are three types of vehicles providing mechanized peat production on heavily watered fields:

1. Self-propelled amphibious harvesters;
2. Self-propelled amphibious universal machines preparing field for peat production;
3. Self-propelled amphibious cargo pontoons transporting peat from excavation area to storage or loading area.

Peat can be excavacated by machines of cyclic or continuous action. Both methods are taken into account in the development of a self-propelled amphibious harvesting machine.

Peat harvesting by self-propelled amphibious machines implies peat harvesting from under the water layer. The use of traditional excavation methods could be quite effective on shallow depths. However, larger depths create a problem of partial or complete erosion of the harvested resource, especially if it is dragged from the harvesting area to a transport vehicle through water. The continuous production method implies the peat condition, which will make possible its delivery by a special hydro transport directly from water. Naturally, this production method is harder to implement, and it requires additional devices to lower the peat humidity level. In the case of the continuous production method, the hydro transport could use the outer water and dump it after the peat is dehydrated.

The cyclic-action self-propelled amphibious harvesting vehicle consists of a floating platform – pontoon, a turntable with an installed manipulator and a quick-detachable bucket of an original design; a reloader; a bunker or cargo platform; and power equipment. In contrast to a cyclical machine, the vehicle uses a drum combined with a dredger instead of a bucket. A peat dehydration device is installed on the pontoon.

In both cases, peat is relocated from the harvesting vehicle to self-propelled amphibious pontoons for transportation to the storage area. As the harvesting machine has its own load receptor (bunker or cargo area), the loading of transport pontoons is possible irrespective of the production process.

4.5. Peat product manufacturing and heat and power generation method

The technology is covered by patent RU 2512210C2, “Peat product manufacturing and heat and power generation method,” which includes peat excavation and dehydration, addition of composites, modifying binders and mineral fertilizers, granuling or briquetting, product drying, packing or packaging, and usage of some peat products for pyrolysis and heat and power generation. A specific feature of the method is peat excavation together with wooden inclusions and their separation in the later period. Peat is mechanically dehydrated to 75-82% and mixed with drainage filler before undergoing another mechanical process of dehydration to 45-60%. The drainage filler is separated for further use. Dehydrated peat is transported to the modular processing facility, and wooden inclusions are used in pyrolysis to receive gaseous and solid fuel. Some of the solid matter is used as composite and some of the gas fuel (heat and power) is used for needs of the entire technological complex.

Yet again, the development of watered deposits must be based on the full account of positive bio-geospheric functions of bogs and minimal interference in the eco-system.

The new peat production manufacturing and heat and power generation method not just dehydrates raw materials but also adds composites and modifying binders, granulates the matter or forms extrusive briquettes, which are dried, packed or packaged, and uses some of the peat for pyrolysis and heat and power generation by means of modern bio-energy technologies.

Modern peat processing methods allow to use raw materials of a relatively high humidity level. In this case fields are not dried. Harvesting machines are amphibious, self-propelled and universal. Specialists propose using dredger for land reclamation purposes.

The proper machine is chosen by a number of factors: range of soil transportation, the geometric height of the rise, the size of the underwater and surface faces, the width of the slot, the content in the soil of coarse fractions and other inclusions, the abrasive properties of soils, the consistency of the pulp, as well as the requirements of the subsequent links of the technological chain in which the dredger operates.

It is possible to harvest peat by this technology using the Watermaster multifunctional dredger, which is a combination of a backhoe excavator and a dredge pump (Fig. 24). It replaces several vehicles and per forms all types of works in the area. This is a self-propelled vehicle that moves using stabilizers. The self-propelled speed in water is 4-5 knots

The Watermaster Classicis designed for dredging in various types of water reserves. Its use cuts investment, operational, maintenance, and transportation costs. The vehicle replaces several single-function machine, does not require use of additional vessels or cranes, and does not harm the environment.

Fig. 24. Advantages of Watermaster Classic III dredger

Importantly, the Watermaster multifunctional dredger propels itself in the water, using its own engine and the excavation mechanism. Upon reaching the designated area, Watermaster can start working right way, without undergoing costly maintenance or idle periods.

The machine is stable during dredging as its front and back stabilizers are anchored on the bottom, and there is no need for using steel cables that might hinder movement of water transport.

The Watermaster dredger is built for shallow waters, bogs or even land. The dredging is most efficient at the depth of up to five meters, and the maximum operation radius is 6 meters.

4.6. Hydro mechanized peat production method using KDS Micronex system

The peat production complex (Fig. 25) comprises the following devices and systems: pulp comes from the suction dredge into a screen for separation of large inclusions (roots, chips from stump milling, fibers of undecomposed peat-forming plants - cotton grass, sedge, reed, etc. from the peat deposit). The water removed from the peat slurry after fractionation and centrifugation of raw materials passes through a horizontal settler and returns through a pipe to the section of hydro mechanized peat extraction, thus creating a closed water cycle.

The screened pulp comes to the accumulative tank, i.e. a vertical settling tank, in which the process of primary peat dehydration through sedimentation begins. There is also a horizontal settling tank to collect peat mass floating up from the vertical settler and drained from the horizontal centrifuge. The peat settled in the horizontal tank is collected and fed back into the vertical settling tank as activated sludge and acts here as a flocculent to accelerate the peat settling process. At the outlet of the vertical settler, the peat has a moisture content of 95%.

4. Innovative peat production and processing technologies

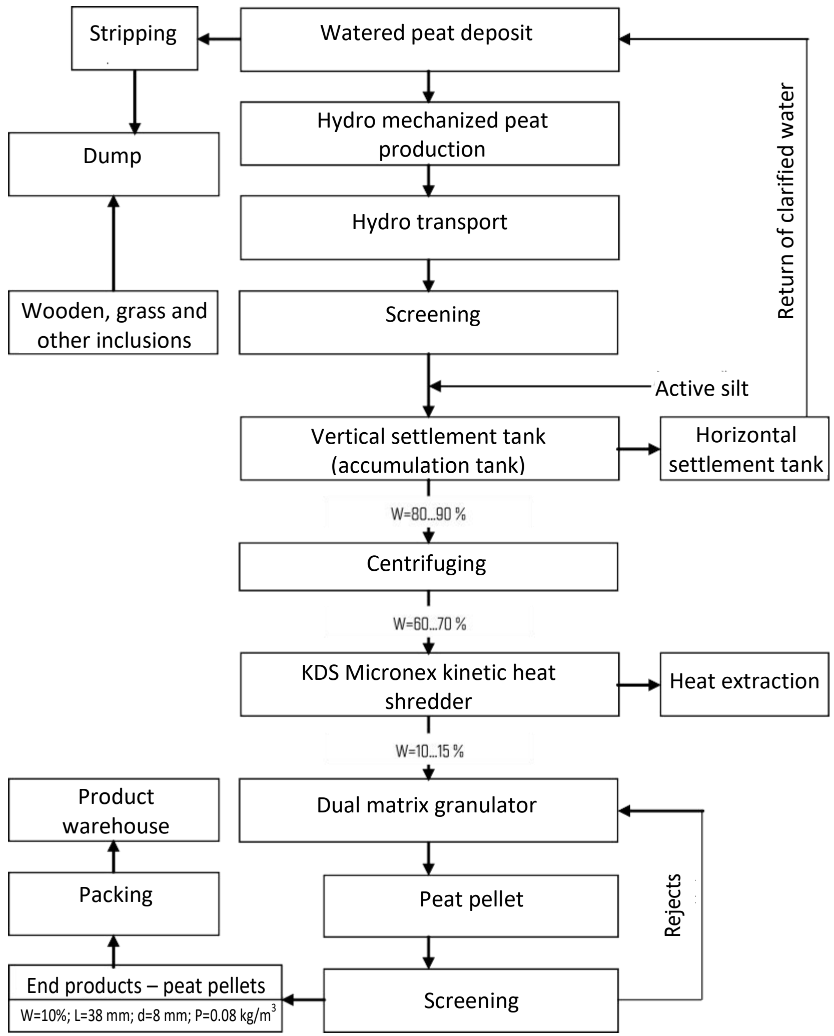


Fig. 25. Hydromechanized peat production method

Vertical settlement tanks are collected to the centrifuge rotating at the V speed by the pump and the pipe. The centrifuge reduces peat humidity to 60-70%. Then the material goes to the KDS Micronex system (Canada), which uses a new kinetic heat technology to crush and dry peat in one operation.

The equipment does not use an additional heat transfer agent for drying and combines two operations into one. The technology of crushing and drying by kinetic energy within one operation reduces humidity from 70% to 5%, crush peat to particles of up to 0.05 mm, and saves electricity.

How does that happen? KDS Micronex cyclones raw material at a speed of up to 620 km/h, particles of the raw material pass through strikers and baffle plates, grind and dry due to the released internal energy of the particles, as well as the transferred kinetic energy. The air supply is abundant throughout the process. By eliminating the need for additional energy (fuel) for drying in this way, as opposed to a drum dryer operating on biomass, natural gas or other fuels for drying materials, the KDS Micronex system can significantly reduce costs per ton of finished product. The next step is the granulation process. The operating principle of the PSI granulator is to combine two matrices. Both work simultaneously and are offset. Each pelletizing chamber is equipped with an opposing press pusher. Such a device reduces unproductive compression zones between the holes in the matrix. And double compression technology uses all pressure zones to produce pellets. The hydro mechanized peat production method was studied by A.M. Shtin, S.M. Shtin, R.T. Tukhvatulin, Ye. Yu. Khelstunova, and others.

4.7. Innovative peat processing technologies

4.7.1. Peat packaging and bailing technologies

Packing and bailing of quality peat soils, substrates, mixtures and top-layer peat is done by means of a packaging line of Premier TechChronos, an international leader in the production of peat packaging products. The equipment allows to pack peat mixtures of various compositions, including plant health additives. Innovative solutions accommodate the needs of any customer for any amount of products – retail chains, nurseries, gardening companies, and public utility services

The Canadian-made peat processing plant consists of the following production lines:

Fractioning line

Harvested peat is separated into four fractures with participles of 0-5, 0-10, 5-20, 15-40, and over 40 mm. Before fractioning, raw materials are cleaned of inclusions by a disc screen. Particles larger than 40 mm go to the hammer crusher with subsequent fractioning or removal from the production process. Fractioning into particles of 0-5, 0-10, 5-20, 15-40, and over 40 mm allows to produce peat basis for substrates with the required size of particles and the minimal amount of inclusions.

Mixing line

Seven dozers for drying radiant sand two for liquid ingredients create quality substrates with relevant pH and content of micro- and macro-elements as required by the client.

It is possible to add four solid fertilizers, perlite and vermiculite, fertilizer solutions, wetting additives, which reduces the duration of water saturation of the substrate in greenhouses. It is technologically possible to combine various types of fractions with sand or clay and to use the mixture for making substrates.

Distribution line

The line distributes products to the line making bails of 3/4.5/5.2 cubic meters, the line making packages of 5 to 100 liters, and the area where products are stored in bulk.

Packaging line

The line consists of a press for packaging products by compression with a ratio of 2.1 and sealing the upper part of the package, as well as equipment for marking, placing the received packages of 3/4.5/5.2 cubic meters on pallets and transporting them outside the production line for storage and delivery to the Customer. The press yields 20 packages per hour.

Equipment of Premier TechChronos peat processing plant

All types of substrates are made of a mix **of raised and transitional peats**, which are milled, fractured, and processed to guarantee stably high results and identity of product characteristics. The mineral addition (vermiculite, sand, agroperlite, sapropel, expanded clay) makes the substrates professional, increase their service life and buffering property, improves their structure, and guarantees the best results. Once wetted, the substrates are ready for use and contain every necessary nutrient in qualities that guarantee the normal growth and development of plants.

As a neutralizing material, peat soils mostly use organic **limestone flour or dolomite flour**.

In many types of soils, a **perlite** additive is used to increase porosity, moisture content and air permeability. In addition to good sorption properties, perlite helps preserve the main agrochemical characteristics of soils.

It is also possible to use the complex mineral fertilizer **PG-Mix**. The modern and effective fertilizer contains a balanced amount of water-soluble NPK and microelements. The micro-granular formula provides equal distribution of nutrients throughout the peat substrate. The high content of water-soluble phosphorous (95%) ensures the high degree of nutrient assimilation by plants. In addition, PG-Mix has a low content of nitrate nitrogen, which is good for crop quality. Osmocote is a long-acting fertilizer that ensures an even distribution of nutrients in an optimal proportion for plant growth.

Osmocote also nourishes plants in dry periods when they cannot be moistened (cold season, heavy rainfall). Plants grow faster, evenly, and look good as, unlike in the case of traditional fertilizers, the level of nutrients is neither very high nor very low.

The moisturing agent makes it possible to moisture a dry substrate. The moisturing agent guarantees a better moisturing speed and a high amount of absorbed water. Besides, during plants' dormant period or in the dark season, the substrate actually improves drainage and slightly decreases the amount of moisture.

The bags we use to pack our substrate are made of multi-layer polyethylene film. The inner layer of black foil protects the substrate from harmful effects of sunlight. In the absence of such protection from sunrays will lead to the rapid development of mosses and green microalgae binding nutrients and accelerating decomposition of the substrate.

Bagged substrates get heated under the summer sun. Temperatures higher than 70°C may lead to the formation of phytotoxic substances, which are particularly harmful for seedlings and young plants. During long periods of exposure, ultraviolent reduces the film thickness and discolor paints.

Holes are punched in the bags for the purpose of ventilation and prevention of film ruptures, however, they could take in water. The substrate could get wet when stored in the rain or in a heated environment for a long time. In this case, decomposition accelerates, mold develops, and the substrate sours.

The long storage periods slightly change pH as a result of reaction between humic acids and large particles of chalk or dolomite. The agrotechnical suitability period is unlimited. This means that after checking the agrotechnical characteristics, the substrate can be used as intended in 3 or even 5 years. If you are unsure of quality, use an expired substrate bag for less demanding plants.

The plant’s own laboratory regularly makes chemical, physical and biological tests of peat mixtures, which enables the plant to strictly control product quality.

4.7.2. Peat briquetting technologies

Peat briquetting is mechanothermal processing of fossil raw materials, in which low-grade peat fuel is enriched and refined.

At the same time, in comparison with the original milled peat, the fuel has higher combustion heat and thermal density and could be used by a broader range of customers. At the beginning of the 1990s, Russia had were 32 peat briquetting plants (PBP, Fig. 26) with a capacity of 950 thousand tons of peat briquettes. The unit capacity of the factories varied from 10,000 to 125,000 tons. Production of those briquettes required extraction of about 2.0 million tons of milled fuel peat.

The production method of any briquetting plant determines the composition of processing operations, the method of drying milled peat as a factor significant for production and economic parameters of the briquetting, as well as the type, layout or arrangement of technological equipment.

Fig. 26. General view of peat briquetting plant (PBP)

Note: PBB characteristics: pneumatic-water steam dryer with secondary use of the heat of juice steam, working in combination with the plant's CHP; annual productivity is 125,000 tons of briquettes.

The drier, which is installed in various systems of various designs, is the most energy-intensive element of the production process of peat briquetting plants. It is supplied by heat from fuel combustion.

Clearly, the optimal parameters of artificial peat drying should minimize financial costs, labor intensity, and heat and power consumption, and should ensure maximum preservation of product quality, such as strength, water absorption and gas absorption capacity, sieve composition, hydroscopicity, etc.

By drying method, domestic briquetting plants are divided into seven main groups. The most common group is plants with pneumatic-water steam, which are followed by plants with pneumatic gas and grinding fans, mills, steam pipes, pneumatic gas pipe dryers, and with steam-gas and pneumatic separation dryers.

The PTB efficiency can be assessed by technological fuel numbers (TFN) in artificial drying.

Comparative data of drier energy efficiency is given in Table 9.

Table 9

Comparative data of drier energy efficiency

Drier type and heat supply method	Drier TFN kgf/t	Peat specific consumption in W=50%, kg/t	Energy efficiency
Pneumatic-water steam receiving steam from heat and powerplant (closed cycle)	59.2	203.8	0.81
Pneumatic-water steam receiving steam from heat and powerplant (open cycle)	76	261.6	0.63
Pneumatic-water steam receiving steam from boiler house (closed cycle)	73.6	253.4	0.65
Pneumatic-water steam receiving steam from boilerhouse (opencycle)	98.4	338.7	0.49
Steam-pipe drum receiving steam from boiler house	106.8	367.7	0.45
Steam-gas drum receiving steam and gas from boiler house	93.8	322.9	0.51
Gas pneumatic receiving gas from process furnace	94.5	325.3	0.51
Pneumatic separation receiving gas from process furnace	81.1	279.2	0.59

As a rule, peat briquetting plants have high energy intensity and consist of big-sized multi-story stationary buildings with a high cost and long periods of construction, which fails to meet the modern economic conditions of the delivery of solid household fuel.

Effort has been taken to create new production methods and equipment for processing peat into household fuel at the production rate, which correspond to the demand for local resources while remaining competitive with fuel transported from afar.

The table indicates that the best energy efficiency is provided by pneumatic-water steam driers, which reuse joice steam and operate together with the plant heat and power plant.

A way to develop peat briquette production under the new economic condition is low-yield enterprises (Fig. 27), which due to their small size, technological completion and factory readiness require minimum construction investments, have a short period of construction, installation and development, and also have low operating costs.

Fig. 27. Briquette and pellet production complex

Another advantage of such plans is that they could be erected in the direct vicinity of peat deposits, including those with limit peat reserves, and could be dismantled and moved to new peat consumption areas.

This feature is bound to promote the implementation of regional programs of peat industry development and supply of local fuel to the population and public utility services.

LLC NESEN Engineering has developed a concept and implemented several projects converting milled peat into fuel briquettes. They are based on briquetting complexes operating on their own from acceptance of raw materials to production of peat fuel briquettes. Such complexes are rapidly built, do not require large capital investments in their buildings and structures, can be placed outdoors, and can be operated both in summer and in winter.

Giprotorfprom acting together with the Peat Industry Department of the Russian fuel company Rostorfrom and with the financial support from the Russian Fuel and Energy Ministry has developed a production process and equipment of a modular mini-plant with autonomous power supply to produce 10,000 tonnes of peat semi-briquettes and briquettes per year.

4.7.3. Extrusion briquette (brex) production method

The method of production of molded or extrusion peat briquettes uses waste of carbonaceous materials - petroleum and coal coke and semi-coke, wood, hard and brown coal, graphitization waste of coal rods and other carbon-rich materials – has fillers. The addition of carbonaceous materials to peat improves its quality and makes it possible to use extrusion briquettes as household fuel or reducing agent in metallurgical processes.

The method is based on the balanced selection of properties of original ingredients that guarantee quality through relevant processes and, what is no less important, the possibility of various processes using serial equipment.

Method of production of extrusion peat briquettes is shown in Fig 28.

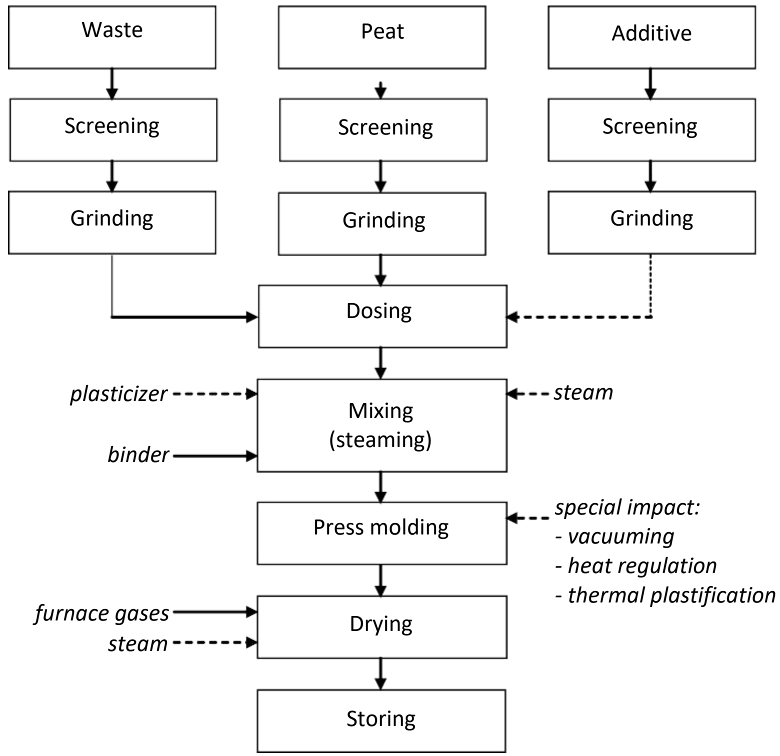


Fig. 28. Method of production of extrusion peat briquettes

The proposed production process consists of the following main elements: peat harvesting, peat and additive delivery, separation of large wooden and metallic inclusions from peat, screening and grinding of additives, batch dosing and mixing, briquetting with specified shape and size, drying, and product storing.

Large-scale production of peat extrusion briquettes could use a serial screw brick press machine.

The primary objective of this method is guaranteed properties and quality of products achieved, in particular, with steaming the batch in the course of mixing, inclusion of chemical plasticizers and binders, thermal surface regulation of molding attachments, etc.

Depending on the properties of raw materials and the used equipment, a particular method is applied to regulate qualities of the dispersed composite system during one or several stages of the production process.

As the production line becomes complex, equipment costs rise but it also become possible to manage material properties at every stage of production, the shift from one raw material to another or, if necessary, production of another kind of goods. Without profound customization, the offered production line could shift from making peat fuel extrusion briquettes to making thermal insulation products (including those granulated and shaped), building materials, fumigating peat-tobacco balls, granular fertilizers, molded peat substrates, etc. Production of fuel extrusion briquettes differs from production of peat briquettes by the significant cost of the carbonaceous reductant transportation to the place of processing, as well as the cost of transportation of finished products to the consumer. Hence, it is important to optimize logistics while optimizing the production method and planning a new technology. The optimization should be based on the best location of the production facilities and raw material suppliers rather than focusing on design of a concrete plant.

For instance, peat pellet production requires the use of equipment processing timber industry waste.

briquettes

granules

Fig. 29. Peat pellet shapes

Peat pellet characteristics are presented in Table 10.

Table 10

Characteristics of peat pellet shapes

Parameter	**Measurement unit**	**Value**
Briquette characteristics		
Diameter	mm	78
Length	mm	35-80
Humidity	%	16
Density	kg/m^3	920-1095
Compressive strength	MPa	25.7
Net calorific value	MJ/kg	17.2
Saturated density	kg/m^3	750
Energy density	MW*h/m^3	3.583
Energy density	kg f/m^3	439.8
Energy density/TFN ratio		3.07
Granule characteristics		
Length	mm	22.14
Height	mm	7.15

Table 10

Density	kg/m^3	920-1095
Saturated density	kg/m^3	790
Netcaloricvalue	MJ/kg	17.2
Energy density	$MW*h/m^3$	3.774
Energy density	$kg\ f/m^3$	463.2
Energy density/TFN ratio		3.29

The northwestern region which accommodates about 60% of all forests in European Russia is the leading domestic manufacturer of wooden pellets. The overall production capacity of pellet plants in that region exceeds 200,000 tonnes per year. Manufacturing of wooden pellet production equipment increases practically every month.

Peat pellets are much less common in Russia than the wooden one. Pellet production lines available on the market have a regular capacity of 500 kilograms to 4 tonnes per hour. Peat fuel production equipment is offered by several companies, among them LLC Pinibriket, Ecobrik, Brikprss, LLC EKKO, LLC EVRO-VOYAZH, Weima, and Salmatec.

Figs 30 and 31 present the structure of the cost price and direct costs of pellet production.

It should be noted that Russia is dragging behind the rest of the world in terms of production and consumption of bio-fuel. By using peat pellets, it could annually save 15-20% of traditional fuel.

According to SMART Business Solutions analysts, at least 80% of pellet products are exported, mostly to Western Europe.

The interest of importers is only natural. Briquetted and granulated pellets have the highest energy density (Fig. 32), which leads to steady demand in countries with high environmental culture and awareness.

4. Innovative peat production and processing technologies

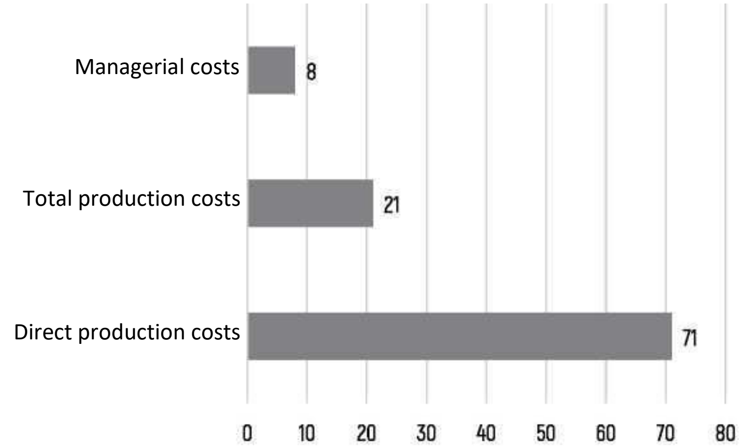


Fig. 30. Structure of cost price of peat pellet production, %

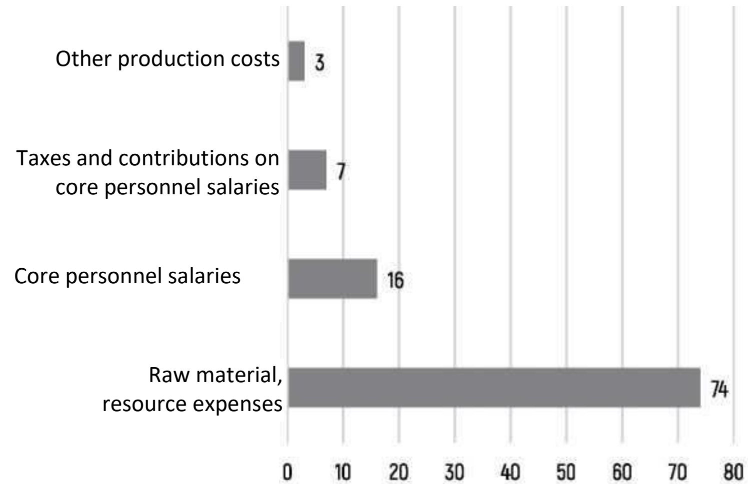


Fig. 31. Structure of direct pellet production costs, %

The leading pellet consumers are the United States, Sweden, Denmark, Germany, the UK, Austria and others.

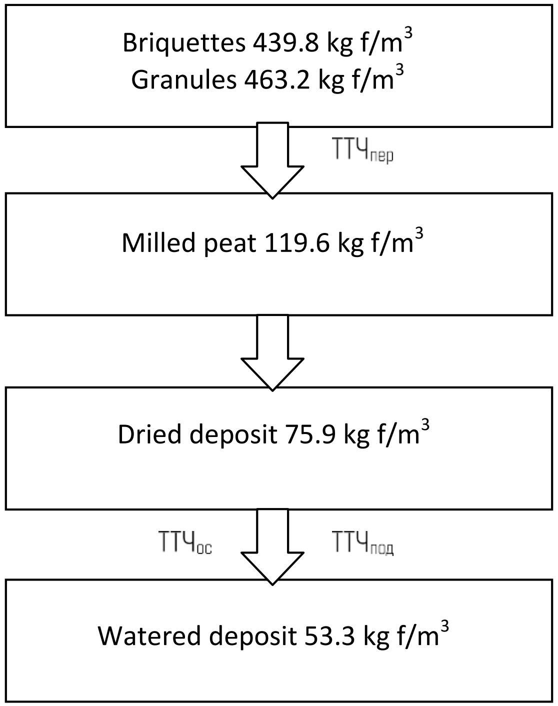
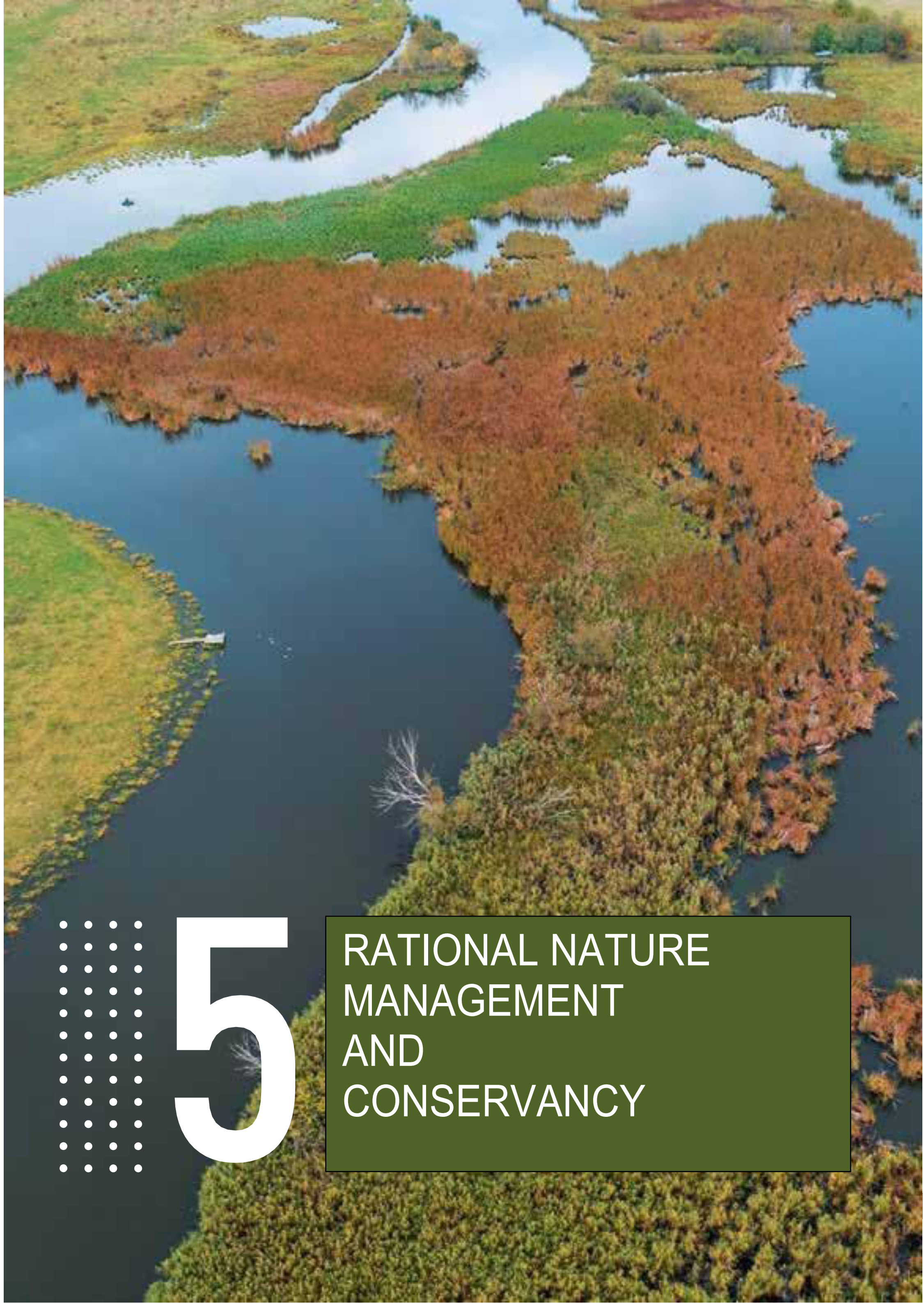


Fig. 32. Variation of peat energy density

Europe annually uses about 4 million tonnes of pellets. On the average, the EU demand grows 15% a year, and as many as 30% in Sweden.



5 RATIONAL NATURE MANAGEMENT AND CONSERVANCY

5. Rational nature management and conservancy

5.1. Peat production as natural-technological system

5.1.1. Systemic approach to evaluation of resources, production technology, and consumption of peat products

As a rule, a peat deposit is developed within 25-35 years. During such a long period of time, demand for various types of products may change, alongside changing properties of peat raw materials in the course of deposit development, the continuous improvement of technologies and equipment, and the appearance of brand new technological processes. These circumstances require resolution of a number of organizational problems, first and foremost renovation or even refocusing of enterprises.

Each enterprise operating in a market economy needs a marketing strategy based on detailed and specific market survey and changing requirements for environmental protection, resource conservation and energy efficiency. The expediency of a systemic approach to peat production derives from the possibility of static and dynamic assessment of the technological level, environmental safety, and economic efficiency of the entire process, which ranges from resource prospecting to production of the end product and its use by consumers (Fig. 33).

Stage I. Geological survey and enterprise organization. Heavy investment required. The enterprise is registered and licensed, production equipment is purposed, utilities are built, technological materials are procured, personnel are hired, and the peat deposit is prepared for development. There is no peat harvesting and revenue as of this stage.

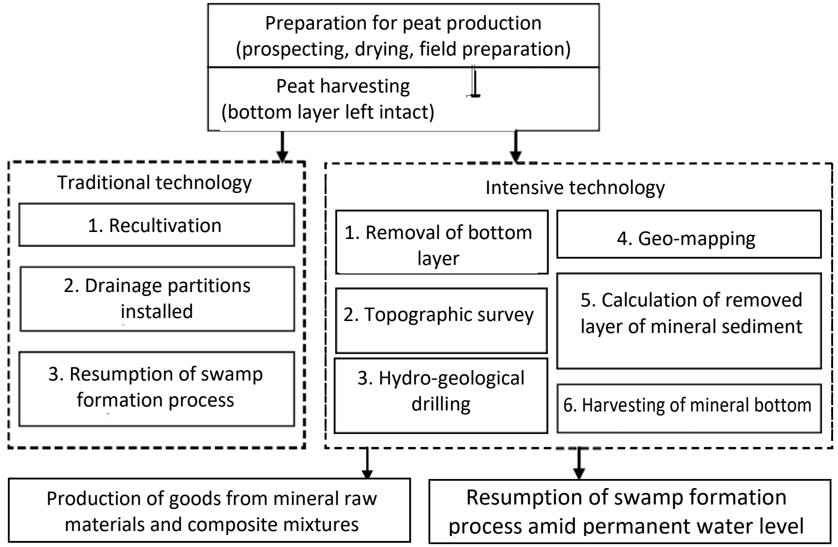


Fig. 33. Schematic diagram of integrated usage of peat resources

Stage II. Growing production. The enterprise starts harvesting peat and increases production rates, thereby receiving profit. At this stage, peat production is limited only by production resources.

Stage III. Stable production. This stage is deemed to be the peak of production: production reaches its maximum and stops growing. The growth of the peat enterprise is limited to the deposit thickness.

Stage IV. Falling production. The yield and the quality of peat products which the enterprise was established to make are on decline, same as revenue. The peat deposit is depleted to the underlying mineral soil. In order to avoid a decline in production efficiency, the enterprise may either change the pricing system or refocus on new types of peat products consistent with the changed market segments.

Consistent with the integrated peat and mineral resource production and processing technology, a crisis could be averted by manufacturing peat-mineral composites or mineral products. This approach is the anti-crisis strategy for the peat enterprise whenever traditional products have inferior quality or are highly contaminated and mineralized. An analysis of diverse peat products (Fig. 34) proves that in most cases, composite materials of at least two ingredients, one of which is peat, are produced. Peat is viewed as quasi-homogeneous material. A study of main areas of peat product manufacturing indicates the broadening use of waste of various production processes and mineral components found beneath the peat deposit. As a result, the efficiency of use of natural resources increases through the production of new organic-mineral and mineral materials, which broaden the product range, solve topical problems of environmental production and the supply of regions of fertilizers, fuel, construction and other materials, raises the cost efficiency of production by use of local resources.

The tasks solved in the course of comprehensive development of peat, man-made, and associated mineral resources could be combined into a single systemic chain: **resources – technology – consumption**, and a single natural and technological complex.

When the model is created on the basis of systemic, energy, and ecological analysis, it provides a static and dynamic picture and presents the technical level, ecological safety, and economic efficiency of every project stage, from prospecting of mineral resources to production of the end product and its use by consumer. This model is based on the systemic analysis methods. There are a hierarchy of goals, a structure, a division into various sub-systems, and criteria of single- and multi-factor optimization of the sub-systems and their inter-relation in the system as a whole.

When products are created from natural systems, specific energy costs start growing. The level of accessibility of natural resources is declining and their extraction and transportation become more labor and energy intensive. Scientific and technical progress and possession of mass energy resources lead to the substantial level of power supply per production unit in all developed countries. The limited amount of fossil energy resources and economic and ecological considerations make the energy saving policy a major factor of technical progress.

Domestic scientists are the world's leaders in terms of fundamental research of peat extraction, processing and energy usage. However, the improvement of existent technological processes and the development of new ones at the modern stage of development of science and technology require further, detailed study of energy efficiency of processes associated with peat extraction, processing and dehydration.

5.1.2. Energy and ecological efficiency of peat production

A comprehensive analysis of energy intensity of every production stage is based on technological specifics, reduction of harmful emissions, waste disposal, production of associated products and derivatives, and energy and material cost of previous production stages, which are reduced to a universal denominator of conventional fuel for comparison purposes. End-to-end energy costs are calculated on the basis of technological fuel numbers, which include all material and energy elements of production and the structure of energy and material consumption while indicating limits to maximum energy consumption. For instance, energy consumption compensating for environmental damage from harmful substances per product unit is counted using technological ecological numbers. For the purpose of convenience of calculation of fuel cost, the calculations are based on the price of natural gas, i.e. the gas equivalent. As a result, the technological ecological numbers are measured by kg f/t of products.

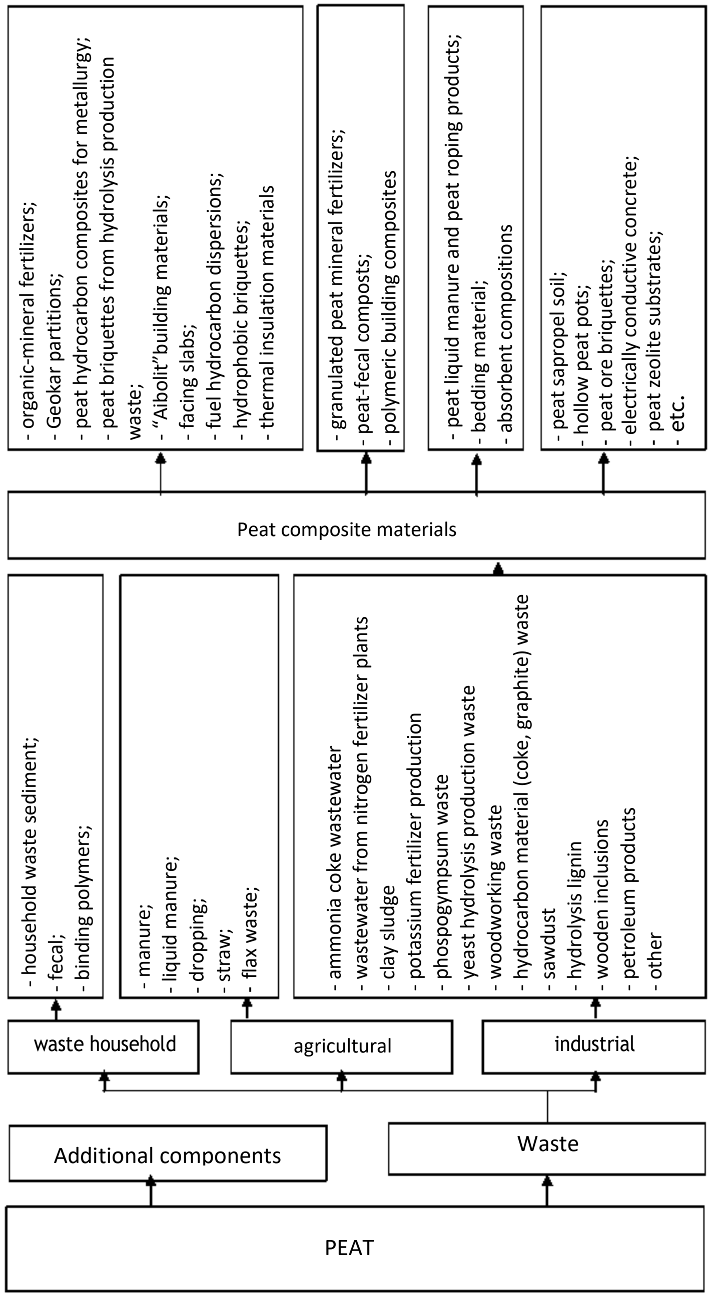


Fig. 34.Peat composite products

Due to the uniformity of values of the technological fuel number and the technological environmental number required for the comprehensive energy-ecological analysis (CEEA), there is a notion of the technological fuel-ecological number, which is equal to:

TFEN = TFN + TEN,

TFTN is the summary of energy and ecological costs of production unit per kilogram of convention fuel/production.

CEEA is a complex of software mathematical models that could be used for phased assessment of the efficiency of harvesting, processing and use of peat products.

The presentation of complex technological processes as a hierarchic bottom-up structure allows the following description of TFN and TEN: TFN and TEN of unit, subsequent processing, finishing operations, sectoral, national, global (Fig. 35).

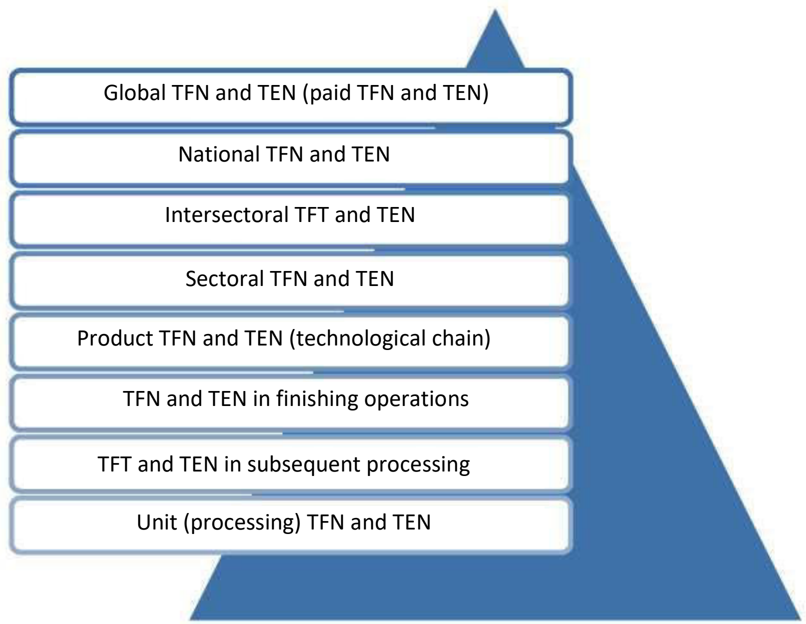


Fig. 35. Hierarchic bottom-up structure of TFN, TEN

The end-to-end hierarchy is based on the elementary technological unit.

At the same time, the peat industry has developed innovative peat harvesting and processing technologies as a result of numerous research and development projects.

The process of extraction, processing and use of peat fuel can be presented as the following scheme (Fig. 36).

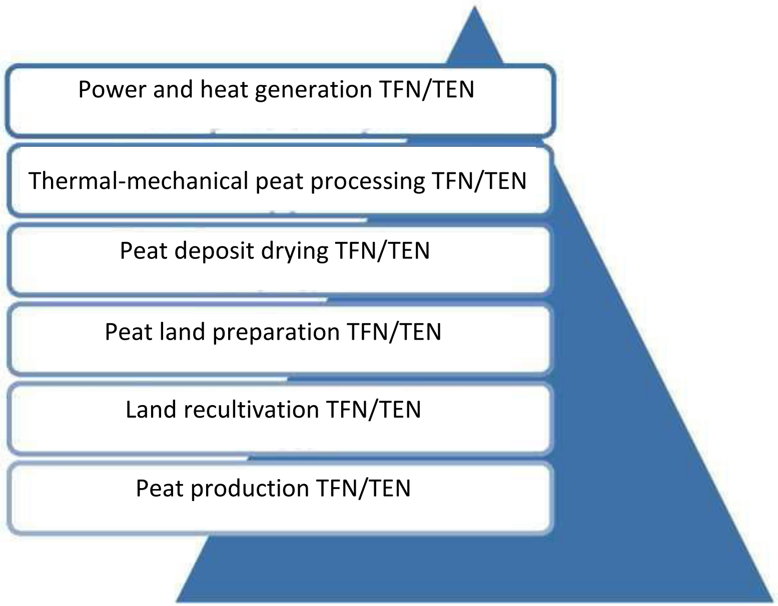


Fig. 36. Hierarchic bottom- up structure of TFN/TEN of peat fuel extraction, processing and use

In fact, peat extraction is a technological process of dehydration (drying) of peat raw materials by concentrating the active substance in a unit of volume or mass. Technologies of extraction (drying) of raw materials may vary but their final goal is to receive air-dried peat that could be efficiently used for diverse purposes.

5.1.3. Aspects of comprehensive usage of peat, man-made and associated mineral resources

In the early 1930s, Academy member A.Ye. Fersman put forward the idea of a comprehensive use of natural resources: **"The comprehensive idea is the economic idea that creates maximum value at the smallest material and energy cost, but this idea goes beyond the present day; this idea is about protecting our natural resources from predatory usage, the idea of using resources to the fullest extent, and the idea of possible preservation of our natural resources for the future."**

The idea of comprehensive usage of natural resources has acquired a number of new important aspects, alongside the national economic idea. First and foremost, these are resource, ecological, technical and some other aspects. We will analyze them in the context of rational usage of peat, derivative, and associated mineral resources.

Resource aspect. Peat is traditionally described as a local resource used to accommodate needs of a particular region. Reserves of peat fuel, which amount to 68.3 billion tonnes of conventional fuel exceed oil and gas reserves and are inferior only to coal reserves by their amount.

Given the diversity of peat use, there is a task of comprehensive assessment of peat usage areas by categories of peat reserves, with due account of their type, group, kind, degree of decomposition, and ash content. Besides, depending on the type of products, scientists indicate maximum content of various chemicals (bitumens, reducers, humic acids) and the chemical composition of ash (content of oxides of calcium, iron, aluminum, sulfur), absorption capacity, etc.

Modern technologies often geographic information system are widely used to divide peat into categories of raw materials for production of various types of products.

Fig. 37 presents across section the cross section of a peat deposit.

Each category of peat raw materials is marked with a corresponding color.

This approach made it possible to distinguish individual layers of peat in the cross section of a peat deposit according to the genetic classification for selective extraction of a particular type of peat with due account of deposit development by years.

The matrix of categories of peat raw materials by usage is presented in Table 11.

Nowadays, peat deposits are digitalized using geological profiles and quality parameters to receive frame and block models, which represent peat categories by deposit depths.

Computer technologies serve as means of comprehensive, energy-saving development of peat deposits on the example of the optimal regime of operation of one site.

The peat deposit model is created in the following steps:

Digitization of relief isolines, sampling points and contours of a peat deposit: visualization of points - peat categories; contouring - peat categories; construction of frames - peat categories; construction of a block 3D model of a peat deposit.

Using the comprehensive integrated assessment and the geological information system (GGIS) for field operation purposes, it is possible to make selection by layers (by years).

Table 11

Matrix of peat categories by types of usage

Peat usage areas	**A_C, %**	**Peat raw material categories**							
		V-0-1	**V-1-(1-2)**	**P-1-(1-2)**	**N-1-(1-2)**	**P-2-(1-2)**	**N-2-(1-2)**	**N-3-(1-2)**	**N-(2-3)-5**
		R, %							
		1–12	**13–20**	**1–20**	**1–15**	**21–34**	**16–34**	**≥35**	**>15**
Hydrolysis raw materials	0-5	+	+						
Insulation slabs		+							
Poultry bedding		+							
Humic acids and preparations	6-10						⊥	+	
Micron-greenhouses		+		⊥					
Hex peat						+	⊥	+	
Bedding Category 1		+	⊥	⊥					
Poultry bedding slabs		+	+						
Export bedding		+	⊥						
Peat for briquettes	11-15						+	+	
Semi-briquettes							+	+	
Household fuel							+	+	
Bedding Category II		+	+		+		⊥		

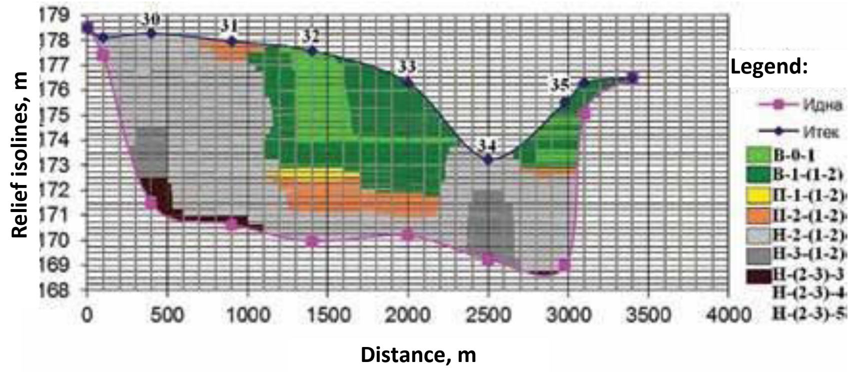


Fig. 37. Peat deposit profile

Table 11, continued

Peat pots	11-15				+		⊥		
Peat-humic fertilizer							+	+	
Concentrated peat-mineral ammonia fertilizers		+	+	+		+			
Peat-ash soil		+	+	+		⊥	+	+	
Greenhouse peat	16-23	+	⊥						
Fuel peat				⊥	⊥	+	+	+	
Peat-mineral ammonia fertilizers							+	+	
Lime peat soil		+	+	+	+	⊥	⊥		⊥
Peat compost	24-35						+	+	⊥
Greenhouse soil	36-50	+	+		+				

A_C– ash content of completely dry peat; R–peat decomposition degree; «+»–fully fit raw material, «⊥»–partially fit raw material, PMAF – peat-mineral ammonia fertilizers.

It is no less important to create a data bank of Russian peat land.

Main decisions in managing the peat land eco-system include the choice of peat production technology, peat production area layout, peat production area preparation, and peat deposit development.

The eco-system must be restored after the peat deposit is fully developed. The process aims to fix the damage sustained by the environment as a result of peat production by the chosen method and contains a plan of recultivation and amelioration of the spent deposit.

5. Rational nature management and conservancy

The peat industry is a production and processing sector with a variety of technological mechanisms aimed to deliver a broad range of multipurpose products.

Comprehensive studies carried out by domestic and foreign scientists lay a solid foundation for the comprehensive ecologically safe use of peat and peat deposits.

The peat industry is best developed in major industrial and agricultural regions. Due to the specifics of their socioeconomic development, such territories experience a substantial man-made impact, which create negative effects in all elements of the environment. Production and processing of peat and mineral raw materials, chemical and metallurgical production and a number of agricultural technologies have severe negative effects, including the accumulation of vast amounts of solid, semi-solid, and liquid waste.

At the same time, the wide geography of peat deposits and their territorial closeness to man-made areas alongside the diversity of natural qualities help solve the problem of industrial and agricultural waste management through combined recycling. Their solution of ecological problems and the provision of regions with cheap and efficient types of fuel, building materials, and other peat products requires an improvement of the existent processes of the production of peat composite materials and the development of new ones. The process can involve a broad range of waste. The comprehensive rational and resource saving technology of peat processing is the only way to achieve a steep increase in production efficiency, and to shift from large-volume production of peat raw materials to profound processing and production of a broad range of products for a variety of spheres.

Organizational aspect. Russia can successfully develop peat production by means of public-private partnership, endorsement of a strategy of comprehensive development of peat resources and restoration of the vertical management of the peat industry by setting up a holding.

The governments of peat producing regions need to address a range of organizational issues, among them:

Improvement of production and economic relations;

Development and implementation of the regional budget, credit, investment, tariff, and social policy and creation of market and other economic interests to stimulate production of local types of peat fuel and fertilizers;

Elaboration of programs to supply municipalities with local types of household fuel;

Formation of the system of public (territorial) order;

Elaboration of norms and laws;

Resolution of some other issues.

A key organizational factor is the restoration of the vertical management of the peat industry and a favorable investment policy.

The innovative development of the industry is possible if new methods based on digital technologies are used to draw investments.

A promising way to draw investments in the industry is the blockchain technology and the emission of a cryptocurrency and its trading at specialized exchanges.

The cryptocurrency can be issued in two cases, either for a particular project or for a particular brand, for instance, the Russian Peat Company.

The placement of cryptocurrency (tokens, i.e. blockchains) at e-exchanges is called the ICO (Initial Coin Offering). By its economic essence, the ICO is similar to the IPO initial public offering at the stock market. The only difference is the absence of listing (verification of securities by the exchange) and relative norms and laws.

The placement of tokens involves the preparation of a "white paper", i.e. formation of a package of materials, including information about the issuer, the project, the conditions for the payment of dividends and the redemption of tokens by issuers.

As an economic instrument, ICO is based on relations of trust. The digital blockchain technology, providing a reliable level of data reliability and security, forms a high level of generalized trust. This is achieved both by distributed data storage (without a single center) and by complex algorithms for checking the information (block) entered into the chain of initial data. Blockchain allows counterparties to trust each other, often without even having personal contact.

Market trust in ICO is also based on the image, brand, and quality of initial information. The Colion token ICO is a successful example. It was a two-stage placement, started as private and continued as public. At the first stage, colions were acquired by a limited circle of persons, which made it possible to attract initial investments and form a higher level of confidence in the cryptocurrency when it is freely placed. Today, Colions are traded on a public electronic exchange and are backed by a reserve of bitcoins (the most expensive and reputable cryptocurrency in the world), the capitalization of the economy and the brand of the leader.

ICO is also a popular way to level off banking costs and to raise funds, regardless of the geographic factor. Successful ICO projects represent the initial stage of project implementation with set goals and objectives, limited in time and resources. ICO is an alternative to negative institutional effects arising from the corruption and/or weakness of the current government. Chances for an ICO success increase with mechanisms that allow potential investors to be make sure that cryptocurrency issuers are bona fide actors. This can be achieved by giving a detailed description of the project, to use the standing or guarantees of a third party to support the project, to be open, and to clearly state the terms and deadlines.

There are over 2,000 cryptocurrencies in the world at present, and the total capitalization of that market is estimated by experts and head of specialized exchanges at over $100 billion, which is comparable to capitalization of major transnational companies. This is a proof of popularity of the instrument applied to draw investment into innovative and other projects.

One may invest in ICO via the website of the project of the crypto currency eminent or specialized platforms. The ICO infrastructure is rather well developed and includes specialized online exchanges, support services, e-wallets, an ATM network, etc.

However, the attraction of investments through ICO requires a number of steps, including the elaboration of project terms and their presentation in the white paper, the construction of the project website, the opening of the e-wallet, the issue of tokens (via specialized websites), and the placement (sale) of tokens.

Social aspect. Revival of the industry will ease social tensions and keep a live settlements in peat producing regions.

This is only natural. The implementation of new technologies and the commissioning of production facilities will create jobs and attracted skilled workers and engineers, which will lead to professional training of residents of settlements and small towns, will improve their general education level, as well as the lifestyle, and will increase the employment rates (over 600 jobs per municipality will be created on the average).

There is another issue. The cost of generation of 1 GCal of heat from burning milled peat is exceeds only the cost of burning natural gas. The shift of municipal boiler houses to local fuel is a real way to curb down the growth of heating charges. The comprehensive development of peat resources will provide quality fuel to families who live in individual homes with stove heating, while gardening communities and farmers will receive cheap and highly effective peat fertilizers. Back in the planned economy days, peat production often served as the town-forming enterprise for small settlements and ensured the development of non-manufacturing infrastructure. Nowadays, remote mining enterprises create modern shift towns. It is reasonable to build a new type of settlements outside town limits with particular comprehensive parameters in the course of peat production projects.

For instance, it could be agro-clusters comprising social, cultural consumer service and education establishments and research and production facilities (a center of innovative agricultural technologies, a training and consulting center, a design bureau, and laboratories), alongside a series of other critical infrastructure characteristic of the agro-industrial cluster. The latter is made up of three functional zones:

residential (residential areas, a community center with a kindergarten, a school, social, cultural and welfare institutions, sports and shopping malls, a canteen and a bathhouse);

production (facilities manufacturing, processing and storing agricultural products, greenhouses, workshops, machine maintenance center, gardens, a center for innovative agrarian technologies, a design bureau, laboratories, etc.)

sanitary protection zone (completely surrounds the settlement, and a forest, a park and a natural freshwater reservoir separate the production zone from the residential area). A particular interest in the cluster development of territories is the Geliopolis new-type eco-settlement. In fact, this is an autonomous civilian community. The geopolis is based as an integral living space: uniform architecture, social and cultural infrastructure, green construction and landscaping standards, a social community, and resolution of education, training, and employment issues.

The main principle soothe agro polis built on “green standards” are implemented through social aspects (self-governance, seamless “non-linear” architecture, public areas for children, sport and recreation); environmental aspects (environmental protection, recycling of heat, solid household waste and water); energy aspects (autonomous power supply, use of non-traditional and renewable energy resources);technological (comprehensive use of renewable energy resources, smart management system, innovative technologies and materials).

The new standards and technologies of construction and utility services of such settlements prescribe the use of eco-friendly, “green” standards” and the latest energy efficient technologies.

The agropolis is built with due account of new trends and construction standards, which ensure comfortable and eco-friendly living on the basis of GOST R54964-2012, that aims to cut energy consumption, to use non-traditional, renewable and recycled energy resources, to ensure rational water use, to reduce harmful effects on the environment in the course of construction and operation of buildings, including house yards, to create a comfortable residential environment and a relevant feasibility of architectural, constructive and engineering solutions.

The agropolis concept is implemented through the modular approach to the design of territories, which could be applied to micro-settlements comprising a handful of houses and vast residential areas, the developed engineering, social and cultural infrastructure (public utilities, communication, playgrounds, recreation areas, civic centers and shopping malls), a great variety of architectural styles and house construction technologies based on green standards, resource-saving construction technologies combined with every kind of ecological and technological comfort, formation of a social community with opportunities of communication, joint recreation and activity, analysis of the settlement's potential for living (consumer services, recreation, communication, transport, security, ecology, education of children, availability of social facilities).

The implementation of green standard cuts heat and power consumption by at least 50%, public utility charges by at least 15%, and water consumption by at least 40%, make sun necessary centralized supply of all kinds of energy, creates comfortable environmental conditions, reduces environmental pollution, and provides modern landscaping and architectural solutions.

Innovative technologies used in the construction of new-type settlements (green standard instruments) include traditional energy-efficient power generation, wind farms, heat pumps; solar collectors; energy efficient lighting; cleaning of drains, utilization of solid household waste; water treatment, water purification; efficient use of thermal energy (recirculation, heat insulation); technologies of "passive" house.

Ecological aspect. Besides the obvious economic advantages of peat fuel, such production facilities drastically reduce the negative ecological impact of the heat and power generation complex on the environment without using any modern protective means, i.e. it is possible to cut harmful smoke emission, to ensure complete fuel reduction with minimal emissions of carbon monoxide and nitrogen oxides; to lessen fire hazard, to reduce the risks of emergencies with catastrophic consequences, to prevent damage to the environment; to organize the processing of industrial and agricultural waste by using them as a filler for multi-purpose peat composite materials; to preserve forest resources by reducing their felling for fuel (the development of 1 ha of peat deposits for fuel allows saving more than 100 ha of forest).

Technological aspect. The development of modern peat production results from the broader usage of peat, the development of new waste-free resource-saving technologies that ensure comprehensive processing and selective extraction of materials of the required quality. Until now, peat fuel production mostly focused on sod peat, peat briquettes and semi-briquettes (mechanic and mechano-thermal peat processing). These enterprises should better be developed in municipalities of Russia's peat producing regions.

A strategic area of improving the fuel peat production technology is the shift from mechanical and mechano-thermal peat processing to a deeper stage, thermal-chemical, which yields high-quality smokeless, environmentally safe and high-calorie fuel. The combination of power engineering with advanced technology makes it possible to use the energy of chemical transformations much more fully, to save raw materials and energy resources, to improve the quality of products and to increase the productivity of units. All new equipment required for peat processing should be made at Russian machine building enterprises.

Given the steep rise of prices for raw materials and energy resources, transportation services and increased competition on the domestic market, it is expedient to consider the return to gas generators running on peat fuel. It is also possible to design mini-heat and power plants and boilers operating on local types of fuel.

Innovation aspect. The peat industry has a high innovation potential and has laid a certain scientific and practical ground work for raising the efficiency of peat usage in the fuel, energy, and agro-industrial sectors, nature conservancy, and production of new eco-friendly materials for a variety of areas.

Research and development projects have created organic energy saving technologies for the peat industry. A comparable analysis of technological processes used by those production facilities and waste recycling enterprises leads to the conclusion that they are based on similar operations performed in a particular sequence and use similar types of machines and equipment. The latter factor allows to recycle industrial and agricultural waste. The expediency of joint processing of peat and recoverable resources results from the broad availability of such resources, on one hand, and from manufacturing of household and metallurgical fuel with practically unlimited demand, on the other hand.

Economic aspect. A series of economic, legislative, information and technical measures have been planned to boost the development of Russia's peat industry. Investments in the fuel and energy complex will mostly come from the private sector. Direct government support in the form of funding from all levels of budgets will be limited to projects of a strategic or high social significance.

A feasibility study of the peat industry development demonstrates a high efficiency of products received as a result of profound peat processing. For instance, the ratio of prices on new product types to the price on peat used for the production of composts stands as follows (per product unit): molasses - 1:35; feed yeast - 1:200; biostimulants - 1:300; active coals - 1:350; wax - 1:350.

Forecasts indicate that extraction of natural resources will grow 3.8 times and processing industries will grow 5.9 times by 2030.

The volume of shipped production and distribution of electricity, gas and water will increase 3.5 times. The turnover of small and medium-sized enterprises will increase by 2.7 times. Fixed capital investments will increase 3.9 times. Average monthly monetary income per capita will rise 2.5 times.

Strategic planning, project management, and development of the cluster economy in peat production, in particular, in the Khanty-Mansi Autonomous District –Yugra, have proven to be efficient instruments and mechanisms of further sustainable development of the unique area of the Russian Federation.

The implementation of the concept of use of local fuels (brown coal and peat) developed by scientists from the Urals State Mining University and the variety of associated projects will bolster the competitive edge of particular constituent territories and broader areas.

Besides, the development of small-sized municipal energy facilities will boost the economic potential of northern parts of the country, will accelerate the GDP growth, will create new jobs in remote areas, will increase incomes and will revive the local economy, will bring additional local taxes, and will improve ecological conditions in regions.

5.2. Nature conservancy function of peat deposits

Peat bogs and peat are unique natural formations that play a key role in the ecological system of the country. Therefore, the development of peat deposits should be viewed as an impact on the ecological and economic system and interference in complex natural processes with both positive and negative consequences. Given the complexity of natural processes and their interrelation, decisions pertaining to the rational use of peat resources in a particular region should be based on systemic analysis methods, physical, mathematical and ecological-economic models, which address the dried deposits as an element of the eco-system, while decisions on the feasibility of drying and developing a peat deposit should be balanced and careful.

From the ecological point of view peat deposits are a strong factor of formation and maintenance of favorable environment, including as a way to stabilize the hydrological regime on vast territories outside deposits, to preserve water volumes and cleanness in rivers and lakes, to clean the atmosphere from excessive carbon dioxide and to enrich it with oxygen, to preserve bio-diversity, and to regulate climate.

Peat deposits are a strong environment forming factory of both global and regional scales. They serve three purposes, such as preservation of biological and landscape diversity, regulation of the water regime, improvement of the gas content of the atmosphere, and climate of vast territories.

A decision to start developing a peat deposit must be based on two main functions performed by them in nature and in society: biospheric and ecological-economic.

Biospheric group (fig. 38) has accumulative, biological, inter-circulatory, landscape, gas regulation, geochemical, hydrological and climatic functions. Ecological-economic functions (resource and raw materials, informational and recreational) allow for the practical use of peat deposits for the economic and cultural development of humanity. Due to its composition and the presence of various classes of organic compounds (humic substances, carbohydrates, bitumen), peat is of great value for the chemical and biochemical industry, agriculture, medicine, construction and a number of other sectors of the economy.

Peat deposits should be developed with due account of economic benefits, reserves, deposit depth, and quality of peat raw materials, as well as ecological consequences of the man-made impact on the environment. What is more, depending on the conditions of peat deposit formation, not just one but a variety of harvesting technologies should be applied.

The makeup and properties of peat are determined by natural and genetic conditions of its formation and change little in nature, while being highly sensitive to the man-made impact. A violation of the natural balance in the peat production process spurs on oxygenation, decomposition and mineralization processes, loss of the peat organic matter, and change of quality and quantity of its main components.

Peat land drying and peat harvesting, dehydration and storage significance change the water, air, and heat regimes of peat and speed up transformation of its makeup and properties. Peat usage as fuel had no particular quality concerns, which were limited only to the degree of decomposition, the ash content and huminity. However, quality matters for comprehensive peat processing. This means that the choice of peat deposit development technology should be based on the account of all regularities of transformation of the composition and properties of peat raw materials at various stages of extraction in order to maximally preserve its potentialities.

Given the nature conservancy function of peat and peat deposits, detailed prospecting should estimate not only the quality and quantity of peat reserves but also the role of surveyed deposits in the environment and the social sphere in order to choose the best development techniques.

While assessing the possibility of peat deposit development, it also needs to be remembered that they are an important element of the natural and geographic complex, and an important link in the chain of interrelated and interacting components of the environment. Any impact on peat deposits transforms the environment.

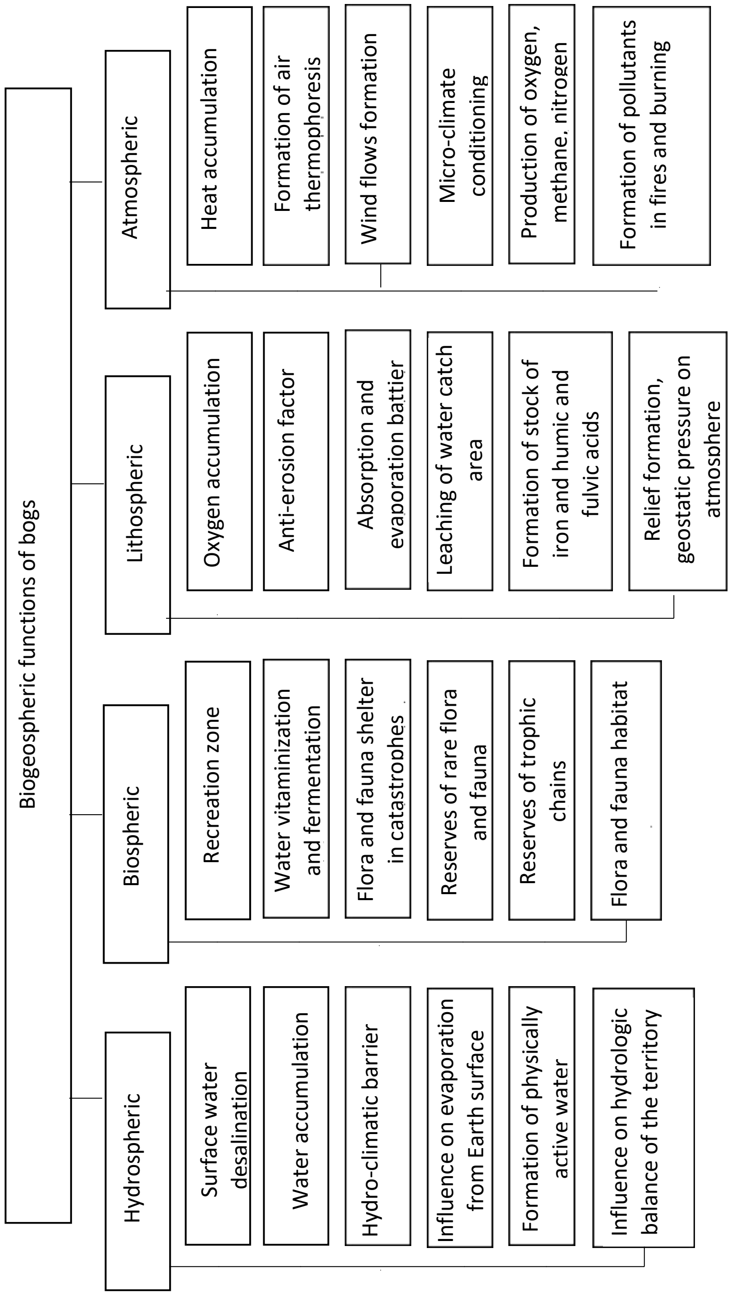


Fig.38. Biogeospheric functions of bogs

True, there is a close connection between peat deposits and the environment. And this connection goes both ways. The growing peat deposit invades mineral shores, causes certain phenomena associated with fluctuations in temperature and humidity in the areas immediately adjacent to it, i.e. is a microclimate factor, regulates river flow, etc. At the same time, from the adjacent catchment area with surface runoff, mineral particles of the soil layer are introduced into peat deposits, and seasonal river floods leave significant amounts of silty material on the surface. The products of weathering, which are suspended and dissolved in the waters, get into the peat deposit and change its initial composition with living peat-forming plants, leading in some cases to a peculiar bog mineral formation, and in others, creating new bonds that determine further stages of their migration. When assessing the hydrological role of peat deposits and the impact of their drainage and ecological development, there should be a long-term forecast of changes in water resources and the regime of peat deposits, and an assessment of the positive and possible negative impact of the large-scale development of new peat-bog regions. It is also important to consider the influence of drainage of peat deposits on the productivity of adjacent soils.

The overall impact of drainage of peat deposits on the water regime and productivity of adjacent lands is often positive and contributes to the formation of more environmentally and economically optimal landscapes in a complex peat land. They are characterized by high biological productivity, intensive biogenic circulation of substances, favorable water balance, complete elimination or minimization of manifestations of such undesirable processes as re-waterlogging, overgrowth of weeds, etc.

Peat production poses a high fire risk. The problem of forest and peat fires is increasingly topical. Such fires are difficult to extinguish; they pose a serious risk to production facilities, residential areas, and the environment. Peat fires are started by negligent fire handing or bolts of lightning. When stored in warehouse facilities, peat is also prone to self-heating and self-ignition. Although, as a rule, temperature control is carried out at peat enterprises and, if necessary, preventive measures are taken to prevent heating and spontaneous combustion of peat during storage in stacks.

As known, the successful extinguishing of forest and peat fires largely depends on their timely detection and rapid response. It is easier to prevent a fire than to put it down. Hence, peat enterprise have strict fire safety rules and units equipped with special and firefighting hardware.

5.3. Recultivation of spent peat deposits

The choice of a land recultivation way is one of the main questions, which determine its expediency and technology. The choice is based on many years of research, project solutions and recultivation works (fig. 39) at sites with similar natural and geological conditions.

Normative documents have determined primary areas of recultivation of accumulative reliefs:

➢ Agricultural for arable land, hayfields, pastures, perennial plantations in the presence of suitable (fertile) overburden in the form of a fertile soil layer or potentially fertile species with appropriate characteristics and volumes;

➢ forestry - with the creation of forest plantations for general economic and field protection purposes, tree nurseries - after their reclamation;

➢ recreational – recreational and sport grounds, hunting areas, etc;

➢ nature conservancy and sanitary-hygienic;

➢ construction.

Even after peat milling, land requires recultivation and leveling. The main stage in the planning of recultivation of spent peat deposits is the correct choice of rational areas of further usage.

The decision should be based on the following principles: operation of recultivated areas should not have a negative impact on the environment, and they should be suitable for being used as intended.

Recultivation of peat deposits is a large cycle of water reclamation and cultural and technical work carried out on spent peat deposits in order to make them suitable for further economic use. The spent peat deposits may have different economic futures. Their condition depends on the method of peat extraction (hydraulic, excavator, milling), time of production, geological and Geomorphological conditions of occurrence, stratigraphic features of the residual layer of peat deposits and underlying rocks, as well as many other factors. Mostly, open pits and hydro-peat production areas cannot be used as. Their reclamation requires significant expenses for drainage, clearing and removal of wood residues, leveling, etc. The pits should be used for fish ponds, reservoirs for breeding fish and waterfowl, etc. Milled peat deposits are most suitable for agricultural use and afforestation. These are leveled excavation areas crisscrossed by drains

There are two stages in spent peat deposit recultivation for agricultural purposes. The first stage is technical, it includes the creation of a drainage network, the removal of shrubs and underbrush, surface planning, and road construction. This stage is completed by the enterprise, which has or is developing the peat deposit.

The second stage of recultivation is biological. It includes a number of reclamation and agro-technical measures aimed to restore fertility of spent peat deposits: drainage with two-way water regime regulation, primary and pre-sowing soil cultivation, and liming. Spent peat deposits have a very low level of natural fertility. This requires the use of all types of fertilizers – organic, mineral, bacterial and micro – during the first years. Biological recultivation is performed by either the tenant or the deposit developer. Sod peat deposits are dried by creating a network of ditches, sub-surface draining or a combination of those methods. Spent peat deposits are used for growing field crops: perennial and annual grasses, as well as lawn carpets, vegetables and berry bushes.

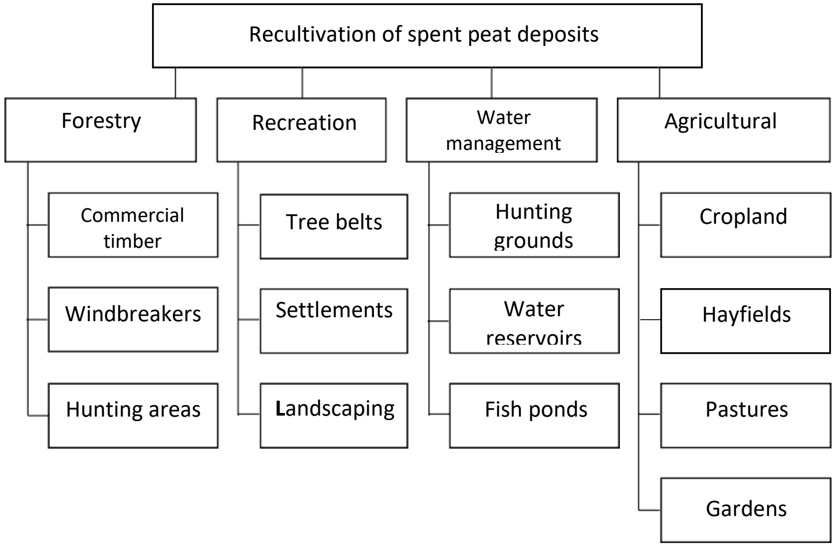


Fig. 39. Recultivation of spent peat deposits

Spent deposits with the peat layer depth of up to 30 centimeters and the untouched bog outskirts can become objects of forestry development. They are often even better suited for forest growth than deep peat deposits. Various tree species are planted after primary tillage. Speaking from experience of Belarus, the best seedlings for spent peat deposits are pine, spruce, birch, and rooted poplar cuttings. Meanwhile, Finland has proven much more efficient use of mixed pine-alder forests than pure pine.

Many spent peat deposits could be used to support production in adjacent areas: temporary roads, areas for storing end products, storage piles, etc could be located there. Depressions and quarries, flooded with water, serve as artificial reservoirs, recreation, fish farming and fishing grounds.

There are decommissioned peat deposits in most Russian regions. However, investment in their agricultural recultivation does not pay off in many cases, considering that many peat deposits cannot be used for agricultural purposes due to their natural qualities (Geomorphological, geological, Hydrogeological, agrochemical, and others). These, in particular, include zero-discharge pits, deposits located on watershed slopes, deposits underlain by sapropel, raised deposits, and others. Plenty of reclaimed areas were simply written off, taken out of use, or abandoned due to their unsuitability for agricultural production.

While considering peat extraction in general, one should proceed from the basic principle that bog ecosystems play an essential role in nature. The Biogeospheric functions of bogs are extremely diverse. Therefore, peat extraction technologies for a specific deposit should rely on the equilibrium and stability of natural ecosystems. Such technologies should be biosphere-compatible and environmentally friendly, and serve the purpose of resource conservation. Only such ecologically balanced technologies of peat extraction will enable producers to implement the concept of inexhaustible nature management (in other words, the wise use of peat deposits) the fastest of all from similarly related industries (mining of coal, shale, oil, gas). Besides, a link between the peat extraction technology and the controlled regeneration of bogs will preserve the entire balance of regional wetland ecosystems.

Conclusion: a peat development method, which ensures the maximum economic gain from natural reserves while curbing down the negative impact on other elements of the environment, is the only efficient peat development method.

5.4. Innovative usage of peat deposits

Despite the uniqueness of peat land, the swamp formation process needs continuous control, especially in the areas with a high level of swampiness.

A recultivation method that includes the repeat swamp formation has recently grown popular. It is based on watering of spent deposits. The intensive growth of hydrophilic plants is achieved by means of fertilizers and stimulants for rapid decomposition of the plant mass. The biomass grow this rapid in this case, and the residual peat layer transforms into fertile soil.

Depending on the Geomorphological position, production method, deposit type, peat kind, peat deposit location and needs of local consumers, the new usage of the peat land is chosen.

Some peat deposits are covered with water again, but most of them are used in forestry, fishery, water management, and for agricultural purposes.

The Siberian Research Institute of Rational Nature Management (SibNIPIRP) and the East European Peat Institute of the Tver State Technical University have studied main patterns of peat bogs self-recovery, the available solutions, promising areas for the use of spent peat deposits and the technology for growing and processing biomass of hydrophilic plants, low-yield peat production from spent deposits, and wastewater management in small towns using a prepared sector of the peat land.

There are two options of innovative use of peat deposits.

The first one is the establishment of agro-bio-energy clusters and cluster settlements of the 21st century.

Everything new is well forgotten old. It is worth remembering that many peat enterprises of the peat economy period had subsidiary agricultural holdings, which supplied peat harvesting personnel with agricultural products and quality food.

The proposed clusters will consist of three major centers – innovative companies using modern, best available technologies of agricultural production, power generation and biotechnological processing of natural and man-made resources. Companies of the cluster aim to use local resources, including agro-climatic, energy, land, coal, forest, peat, man-made and others available in the region. The volume, type and quality of products of these companies aim to accommodate needs of the region and are regulated by the cluster itself.

The ultimate goal of the project is to ensure transition from the traditional regional economy to the so-called efficient, innovative or green economy capable of creating the decoupling effect for the sustainable development of rural territories.

The agro-cluster is a rural settlement of an innovative type based on the principles of manor landscape architecture and prioritizing the preservation of local biocenoses;

higher social standards achieved through the development system of consumer services;

centered on the agricultural techno-park comprising scientific, educational, production, and exhibition premises.

The agro-cluster is divided into three functional areas: residential with homes and social and cultural facilities, industrial with a center of innovative technologies, and sanitary protective that separates the industrial zone from the residential one.

The Heliopolis eco-settlement. The cluster approach enables the construction of heliopolises, a new type of eco-settlements. In Greek, Helios means the Sun, and polis means an autonomous civil community, which determines principles of the Heliopolis as a common living space: unified architecture, social and cultural infrastructure, green construction and landscaping standards, a single community of residents, and resolution of education, training, and employment problems.

Please note that heliopolises (fig. 40) primarily stand for an organized community whose members share rules of the socium and bear collective responsibility for their living space. First and foremost, heliopolises stand for comfortable living, the most advanced construction technologies and alternative energy resources. These are settlements of a new type based on international green standards, particular rules of accommodation, social parameters and economic mechanisms, which make housing affordable.

Fig. 40. Modular section of 21stcentury peat workers town

Another option: the unique botanical garden, Urals Eden, similar to its British prototype, Project Eden, handmade heaven (fig. 41).

The British project was implemented near St. Austell on an abandoned territory whose landscape was changed multiple times and kaolin, a valuable type of clay, was once mined. There, a greenhouse complex was erected on a brand new principle with domes of indoor biomes. Initially, greenhouses were due to be shaped as truncated cylinders, but the project team finally opted for conjugated spheres of different sizes to fit the terrain of abandoned quarries. The greenhouse complex was built as two biomes: hemispheres of different diameters and heights that blended into the landscape. What is more, the dome shape is ideal for creating an indoor microclimate and maximizing the absorption of solar energy. The coating film weighs 100 times less than glass and is sold at half its price.

Fig. 41. Project Eden – general view

Interestingly, both domes are covered with multilayer transparent foil made of ethylene and tetrafluoroethylene copolymer (ETFE), which is an environmentally friendly material that quickly decomposes at the end of its service life and does not pollute the soil. The relief inside the domes (fig. 42) imitates the natural environment of the climatic zone.

The British Project Eden is not just a garden or a greenhouse. The biomes create natural conditions for plants from various parts of the planet, including particular temperature, humidity, light, and air composition. The microclimate is automatically maintained. A similar project can be implemented in the Russian territory, for instance, as a regional agro-bio-energy cluster.

Fig. 42. Biome relief

5.5. Agro-bio-energy cluster as foundation of sustainable development of rural territories

Criteria of the *Ecologically Sustainable Industrial Development (ESID)*, model require optimized use of natural resources. As time passes. specific energy costs of organic products continue to grow, natural resources become less and less accessible, and labor and energy costs of their extraction, transportation, and reproduction increase.

The Scientific Technical Revolution and the access of massive energy resources significantly increased energy intensity of human labor in all developed countries. However, the limited amount of fossil fuel and economic and ecological considerations made the energy saving policy a key factor of technical progress. The advanced practices of developed nations indicate that the economic potential and efficiency of industrial complex management is losing to creative management of clusters, which are more dynamic and flexible. The cluster approach as an alternative to the traditional sectoral policy is an efficient instrument for raising the competitiveness of territories.

The severe climatic conditions of Russia make heat supply the most socially significant and fuel intensive economic sector, which consumes about 40% of all energy resources in the country, half of them for public utilities. The deepening systemic crisis of the housing and public utility sector in small Russian towns is a major impediment to the economic growth. Extensive modernization of these systems is vital for the GDP growth and successful fulfillment of other national socioeconomic tasks, programs and projects, as well as the stable provision of energy security of the population and corporate consumers.

A number of clusters have been created in Russia by now, such as the industrial and transport cluster in Rostov, the pharmaceutical cluster in Irbit, etc.

The agro-bio-energy cluster is a fairly competitive regional inter-sectoral group of various types of enterprises connected by technological processes and developing within the framework of the same economic strategy, which uses the synergetic effect from integration of all available material and non-material assets. Members of the cluster share a potential for increasing their competitive edge. The proposed cluster structure will rest upon three core centers (fig. 43).

All of them are made up of innovative companies using modern and available technologies of agricultural production, energy, and bio-technological processing of natural and man-made resources. All of these companies are focused on using local resources, including agro-climatic, energy, land, human, forest, peat, man-made and others available in the particular territory. The volume, types and quality of products manufactured by these companies will accommodate local needs and will be regulated by the cluster structure.

What is the purpose of clusters? They create public goods (in a variety of real economy sectors – energy, manufacturing industries, agriculture, forestry, timber industry, transport, engineering and social infrastructure) or provide public services (in the field of science, education, culture, healthcare, social protection, etc.).

The rational use of local peat resources is one of the potentials to ensure the sustainable development of clusters and to raise the degree of economic development of the national territory. Specifics of usage of local peat resources for cluster development are presented in Table 12.

The table presents key areas of the development of competitive advantages of local peat resources and the implementation of the concept of a rational and lean use of natural resources by the municipal economy.

There are numerous examples in the world of raising the competitiveness of territories and production facilities by means of the cluster-oriented regional policy.

Cluster is a competitive inter-regional and inter-sectoral group involving various types of enterprises connected by technological processes and developing within the framework of the same economic strategy, which uses the synergetic effect from integration of all available material and non-material assets.

Clusters in the furniture, food, biotechnology, telecom and other industries are well known. The most illustrative examples of clusters is the motor cluster in North Rhine-Westphalia in Germany, the chemical cluster in Singapore, the biotechnological cluster in Sweden, the food cluster in Arizona, U.S., the telecom cluster in Italy, and the aerospace cluster in Spain.

The attempt to create the Urals peat cluster was made in the Sverdlovsk region. Yet the project existed for only a few years due to the series of technological and distribution problems. Despite the projects encountered by the cluster founders, their work yielded a positive result – the distribution process coordinated by several companies of the Urals region that produced and processed local peat resources.

Table 12

Comprehensive scientific-methodological description of usage of local peat resources for cluster development purposes

Approach	Description
Adaptive	The regional power supply system is adaptive and its capacity common dates current needs of the entire region and every populated locality and enterprise
Administrative-territorial	Power generation facilities of large unit capacity cannot solve the problem of heat and power supply in the sub-Arctic region due to the need to build expensive and long power transmission lines
Logistic	Simplicity of logistics and short distances of peat transportation
Legal	The Federal Law on Energy was adjusted in 2016 to support power generation using peat fuel, which is important for the development of small-sized power generating facilities in rural territories
Resource	Reduced consumption of non-renewable fuel and energy resources, relatively low labor and energy intensity of fuel peat production
Economic	Peat fuel prices are relatively stable in contrast to the constantly fluctuating oil and gas fuel
Ecological	Reduction of ecological impact from the fuel and energy complex, considering that peat has a low content of sulfur and ash and low harmful discharges in burning
Export	Marketing studies show the relatively large export potential of soil forming fertilizers based on deeply processed products. The main threat to land cultivation in the Middle East and North Africa is desertification of fertile lands, which grows year upon year. Besides, many countries of the region see the intensive soil erosion due to the excessive soil usage for agricultural purposes. Hence, the UN adopted a special program in the 1980s to deal with the problem. An important factor in most countries of the region is the availably of oil and gas export revenue, which the national leadership is ready to invest in the development of agricultural infrastructure and landscape architecture.
Energy	Milled peat is a local fuel. Peat briquettes and sod peat are traditionally used as a utility fuel by the population and housing and public utility enterprises. Russian scientists have developed efficient methods for broadening the area of use of peat fuel. There are years of Russian and foreign experience of power and heat generation from peat and man-made resources.

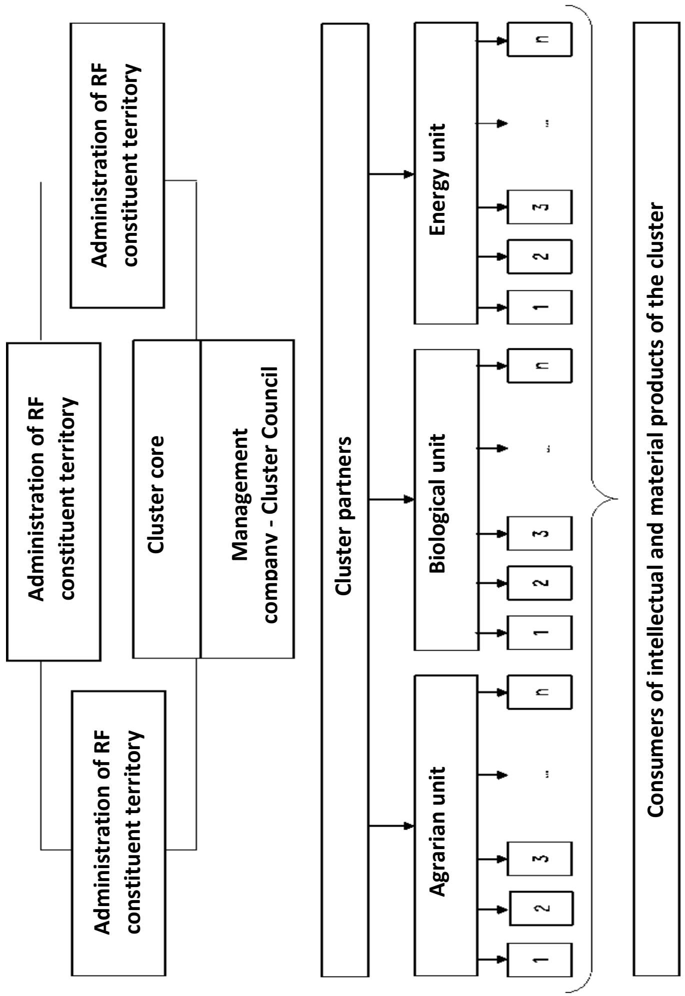


Fig. 43. Organizational chart of agro-bio-energy cluster

6. Big challenges and peat

6.1. What we describe as big challenges

The prospects of the global economy and world politics, the global agenda, and the development of particular countries and regions in the coming decades will be determined by the so-called “big challenges,” the complex of problems, risks, opportunities, significant factors, and long-term processes. These are just some of the examples:

- The man-made impact on the environment fraught with huge socioeconomic risks and risks to human life and health. The rising level of the World Ocean, pollution of the soil, water and air (that increased 8% in cities over recent years), tsunami, draughts, earthquakes, and other natural calamities are the reality we have to deal with here and now.
- The new demographic and epidemiological factors – ageing of the population in developed countries and advanced emerging markets, the associated social problems, the increased rate of chronic diseases, and risks of pandemics.
- Social stratification both in particular countries and on the global scale, which acquires a distinct regional nature and provokes mass migration and fierce regional conflicts.
- Lowering efficiency and manageability of comprehensive socio-technical systems, primarily key infrastructure (financial, transport, energy, etc.,)

Their scale, complexity and impact on the ecology create substantial risks. Besides, technical infrastructures are nearing the limit beyond which their modernization and optimization will no longer be efficient because of the exhausted potential for developing basic technologies.

Due to their universality, the concept of “big challenges” has become common in all key world powers and was included in one way or another in long-term development strategies and policies of the EU, the U.S., China, India and Brazil.

The global challenges are supplemented with a complex range of national problems. In the case of Russia, there is the spatial factor that determines specific features of the logistic systems, the interconnection of regions, distribution of resources, and the size of population.

There is no way to find an optimal solution within the framework of the existent paradigm due to the shortage of natural, financial and manpower resources. The “unsolvable” contradiction can be overcome only by means of science, new technologies and innovations that could offer new solutions, which often have no direct connection to the known challenges.

6.2. Russia’s scientific and technological development strategy as the answer to “big challenges”

From the angle of scientific and technological development of the Russian Federation, the big challenges are:

- The exhausted opportunity of Russia’s economic growth based on the extensive extraction of resources: focus on using renewable resources;
- The need to ensure food security and independence of Russia, competitiveness of domestic products on the global market, the reduction of technological risks in the agro-industrial complex;
- The quality change of global and local energy systems, the increased significance of power supply capacity, the increased amounts of power generation, conservation, transfer and use;
- The need for efficient development and use of territories, including the elimination of socioeconomic development disproportions in the national territory.

Researchers and the business community are well aware of the initiatives of the Russian president and government aimed at the national economic development. A priority area is the implementation of the Russian scientific and technological development strategy for the period until 2025.

The strategy has seven key priorities, including three mentioned below:

- 20b.Transition to the ecologically clean and energy saving power industry, higher efficiency of production and profound processing of hydrocarbon raw materials, and creation of new sources and methods of energy transportation and conservation;
- 20d. Transition to highly productive and ecologically clean agriculture and aquaculture, implementation of systems for rational chemical and biological protection of crops and farm animals, storage and efficient processing of agricultural products, safe and quality food;
- 20g.Effiective response of Russian society to big challenges in the context of interaction between the man and nature, the man and technology, as well as social institutions at the modern stage of global development, which is based, in particular, on methods of humanitarian and social sciences.

Seeking to solve the problem of Big Challenges, the Engineering Economics Faculty of the Urals State Mining University annually holds as part of the Urals Mining and Industrial Ten Days the international scientific and technical virtual conference “Project Management of Natural and Man-Made Complexes amid New Challenges” and the national contest “Urals Youth to the Innovative Economy of Russia.” The contest has seven nominations associated with the priority areas of Russia’s scientific and technological development.

The contest aims to identify and support active and talented youngsters, to integrate the creative potential and industrial needs of enterprises and companies against the backdrop of international economic sanctions and substitution of imports, to develop entrepreneurial competences in the next generation, and to create conditions for the youth business initiative.

The annual event undergoes multi-stage preparations and helps create a pool of creative, innovative and economically-minded youngsters capable of developing and implementing innovative and business projects in a competitive environment and amid the systemic crisis, as well as raise the economic and business awareness of young residents of the Sverdlovsk region.

A successful combination of scientific and technological achievements and the use of leadership factors trigger an innovative growth and bring strong socioeconomic effects. Importantly, breakthroughs sometimes happen outside the area of high technologies or services. It is quite often that formally conservative economic sectors get revolutionized under the influence of advanced technologies and innovations.

6.3. Pilot projects in priority areas of Russia’s scientific and technological development

Pilot Project 1 regarding 20b priority of Russia’s scientific and technological development. The development of an ecologically safe and energy saving technology of peat production and processing to supply heat and power to the municipal power sector (Industrial partner YUTEK-Regional Networks).

Many northern territories of Russia face the challenges of Northern Supply Haul due to their severe climate and the lack of transport and energy infrastructure. These territories can engage in economic activity only if they are supplied with energy resources, food, and other goods.

Such constituencies have a huge territory and low density of the population, which is mostly concentrated in towns with several thousand residents. The constituencies boast unique but extremely fragile eco-system created by special natural and climatic conditions. At the same time, they possess vast reserves of local energy resources, such as peat and wood. The fairly equal distribution of local fuel resources throughout the region allows their efficient use in case of optimized transportation costs (within several dozen kilometers). The construction of energy facilities with a large unit capacity cannot solve the problem of heat and power supply for the simple reason that power supply to consumers requires the construction of expensive and long power transmission lines. In those circumstances, the regional power supply system should be adaptive and its capacity should meet current needs of the region as a whole and every populated locality or enterprise consistent with the regional development program, while minimizing the harmful impact on the local eco-system.

This target is achieved through:

- Orientation at local energy resources (peat, wooden waste);
- Abandonment of the unconditional priority of building large power plants;
- Construction of relatively small modern autonomous power plants: modular mini-heat and power plants of the cogeneration type working on local fuel and having the capacity, which varies from several dozens of kilowatts to several dozens of megawatts;
- Autonomous mini-heat and power plants are combined into one or several local energy systems with the possibility of their future connection to the unified energy system;

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- The use of innovative technologies of solid fuel burning in the construction of mini-heat and power plants for cutting operational costs with reliable equipment and drastically reducing the emission of harmful substances.

This approach will help create energy infrastructure based on the principles of the small-sized municipal power sector, which has a number of obvious advantages over the traditional big-sized power sector under these circumstances. The relatively small mini-heat and power plants located close to consumers use the economic advantage of co-generation and have nearly twice bigger efficiency than a big power plant, which only generates power.

The development of the small-sized municipal energy sector will bolster the economic potential of northern territories of the country, while providing:

- Additional and accelerated GDP growth;
- New jobs in remote areas;
- Higher incomes and revival of the local economy;
- Additional local taxes;
- Improvement of ecological situation in regions.

Pilot Project 2 regarding 20d priority of Russia’s scientific and technological development. **Elaboration of the technology of highly productive and ecologically clean agriculture and aquaculture based on the comprehensive use of peat resources.** (Foreign partner: Institute of Soil Science, Fertilization and Environmental Resources, Heilongjiang Academy of Agricultural Sciences, industrial partner LLC Ecoprom).

As we have said before, peat has high agro-physical qualities and contains bio-active substances, which enable its successful use in crop production, veterinary, pharmacology, balneology, and various modern nature conservancy bio-technologies. The national food security is directly related to the restoration of farmland fertility. The earlier intensification and chemicalization of land cultivation and irrational land cultivation methods reduced the amount of humus and caused depletion of water and physical qualities of soils.

In contrast to the famed Russian Black Earth zone, soils in the central economic region of Russia contain a relatively small amount of humus. It is practically impossible to solve the problem without using organic fertilizers. In the early 1990s, the cropland need for organic fertilizers was met at only 50%. The situation is even worse nowadays. Russian agricultural enterprises apply organic fertilizers in an amount of about 420 ... 450 million tonnes per year (3.6 ... 4.0 tonnes per hectare of arable land), which is 30 ... 35 percent of the scientifically grounded norm. In many regions of our country, there is a sharp decrease in the content of humus in the soil, which is the main indicator of its fertility.

Scientists assign a huge role to organic fertilizers based on peat and sapropel in regulating topsoil energy and the humus balance, improving the physical and chemical properties of the earth, increasing the efficiency of mineral fertilizers, as well as regulating the condition of the soil biocenosis. The correct and timely use of these biogenic materials for the preparation of fertilizers and the regular application of organic compost can significantly increase the yield of many crops. One of the most promising ways of using peat and sapropel is the preparation of various types of products on their basis - both for agriculture in general and for smaller consumers: greenhouses, dacha cooperatives, garden plots, etc.

In this case, a topical area is export-oriented facilities for deep peat processing. Here is an illustrative example. The main threat to agriculture in the PRC and the countries of the Middle East and North Africa is the growing desertification of fertile lands and soil erosion that is happening every year due to over-exploitation as a result of intensive agriculture. Yet the problem can be solved, since most countries of these regions have enough free oil and gas revenue. The leaderships of these countries are ready to invest in the development of agricultural and landscape architecture. For example, the governments of Saudi Arabia and the United Arab Emirates have adopted special government programs to eliminate deserts in their countries, to turn them into a “blooming land”. The task is not only to create territories suitable for agriculture, but also to cover the deserts with forests and grass.

Therefore, the use of soil-forming fertilizers in these regions acquires vital importance, because the soil is in constant and stable demand, and creates a prospect of exporting new types of peat fertilizers. In 2018, 90 million m^3 of peat were produced for being sold on the global market; of that amount, 46 million were used as fuel, and the rest was used in agriculture. The demand for agricultural peat is truly colossal.

In October 2019, an international forum on the use of peat in the PRC was held in Qingdao, China. All leading peat manufacturers - Canada, Finland, the Baltic countries, and Russia – attended the forum. The Chinese leadership reported the annual consumption of 50 million m^3 of peat per year for the rehabilitation of disturbed lands. They estimated the required volume of peat to restore soil fertility at 1 billion tons.

A new promising enterprise, LLC Ecoprom, is extracting and processing peat in the Urals using innovative technologies. Nowadays, Ecoprom is a leader amongst Urals peat processing enterprises. The use of innovative technologies and the digital economy in the context of the developing world integration processes make it possible for Russian society to effectively respond to major challenges, taking into account the interaction between the man and nature, the man and technology, social institutions at the present stage of global development, including by use of methods of the humanities and social sciences.

Pilot Project 3 regarding 20g priority of Russia’s scientific and technological development. **Construction of a unique scientific research natural and man-made complex at the Chistoye peat deposit in the Sverdlovsk region to ensure inter-disciplinary studies of interaction between the man and nature, the man and technologies in the development and use of local resources in rural territories.**

The natural and man-made complex of the Chistoye peat deposit in the Sverdlovsk region is unique as the new development of this deposit has started just recently, in 2013. This allows to detect new regularities and to specify and improve the best models of interaction between the man and nature and the man and technology. The complex is using the newest technologies to extract and process peat consistent with the global technological development level.

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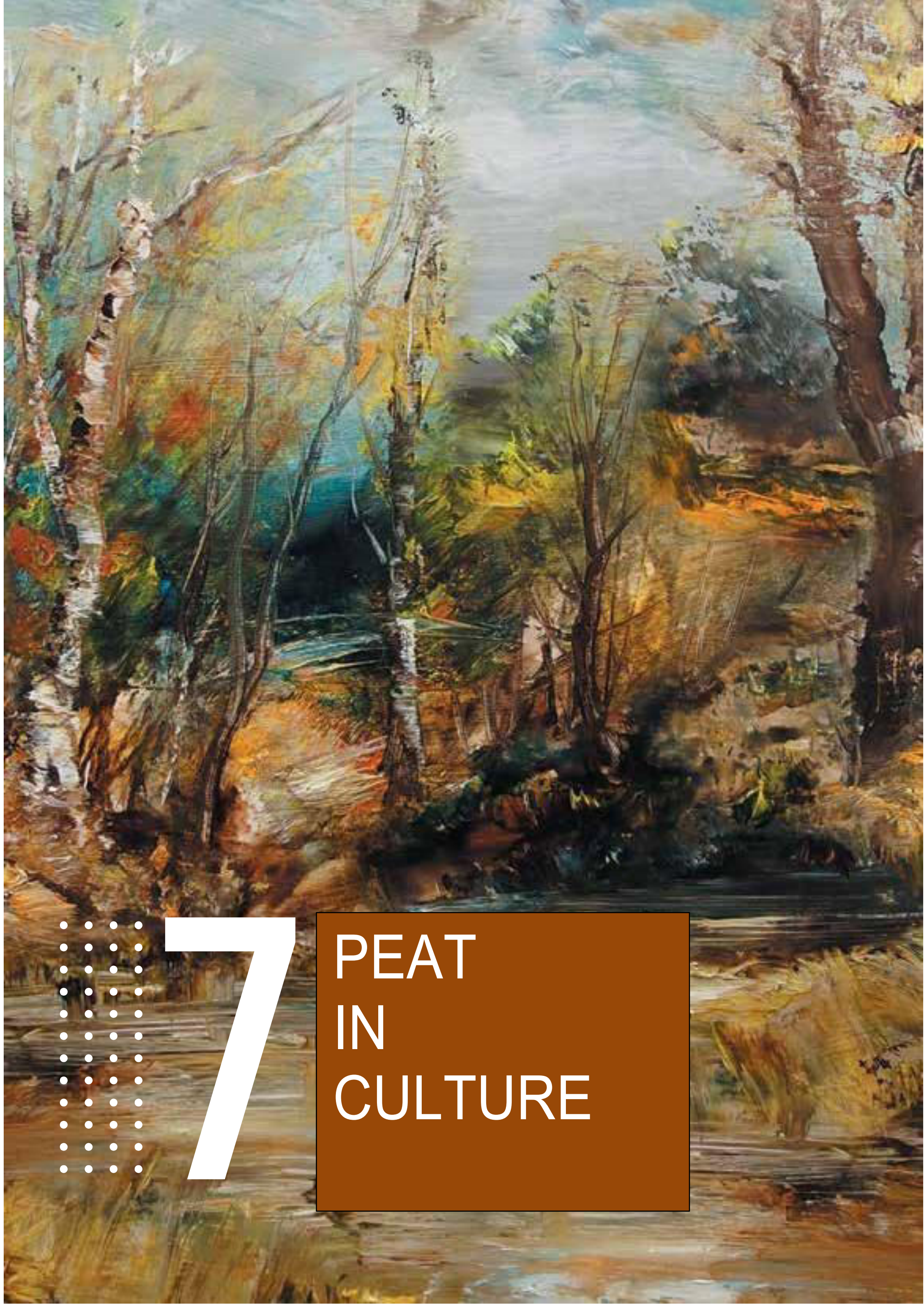
The inter-disciplinary research yields new scientific results and requirements for innovative technologies and technological equipment, which surpass global analogies, and a mechanism of rational use and reproduction of peat resources, and helps substantiate the principles of public-private partnership in using local bio-energy and agrarian resources and choose efficient ways of socioeconomic development of Russia’s peat producing regions.



7 PEAT IN CULTURE

7. Peat in culture

7.1. In the world of bog and peat books

Dozens of books, including fiction, have been written about the mysterious peat land. The literary works of A. Kuprin, V. Bykov, P. Melnikov-Pechersky, I. Shmelyov, M. Prishvin, V. Shalamov, S. Dovlatov and many others dedicated to the remote and mystical bogs and, of course, to peat are well known.

Alexander Kuprin, an officer, a hunter and an adventurer, was charmed by bogs and wrote about them in his books on multiple occasions. There is, for instance, the Olesya story depicting the remarkable old forest and bog full legends and peculiar entities. The forest surrounds the hut on chicken legs where “witch” Olesya lives. The girl, same as the bog are wrapped up in an aura of mystery.

Bogs described by writer Vasil Bykov neither lure nor intoxicate the reader. In contrast to Kuprin, the Bog story is about the possibility of death. As Bykov wrote, “the bog that lied ahead looked completely impassable, the bog was covered in sedge and calamus and spots of black water were visible here and there ... ". The story is about soldiers abandoned in an unfamiliar area, who wearily wander through forests and swamps.

No less horrid bog descriptions can be found in books of Pavel Melnikov-Pechersky (bottomless bog peat), Ivan Shmelyov (liquid death covered with green hillocks) and Varlam Shalamov (blind all-consuming force).

Mikhail Prishvin is the only one who writes in his story “The Sun’s Storage” that Bludovo bog accumulates peat resources useful to people and serves as the Sun’s storage. “We see it this way: the whole Bludovo bog and its huge reserves of peat fuel are the Sun’s storage. This is really so: the hot Sun is the mother of every blade of grass, every flower, every marsh bush and berry. The Sun gave them its warmth, and they, dying, decaying in fertilizer, share this inheritance with other plants, bushes, berries, flowers and blades of grass. The bog water prevents parent plants from sharing these treasures with their children. It is stored under water for thousands of years, the bog becomes the Sun’s storage, and this Sun’s storage, the peat, is the Sun’s heritage eventually passed to people.”

Authors of popular science and scientific books feel much more optimistic about bogs.

Excellent works on peat bogs were published by B.S. Maslov, L.I. Inisheva, A.A. Zemtsov, M.S. Gostishcheva, Ye.V. Porokhina, M.A. Sergeeva, I. V. Fedko, V.Yu. Vinogradov, O.A. Golubina, G.V. Larina, Ye.V. Porokhina, N.A. Shinkeeva, M.V. Shurova and others.

For instance, acclaimed researchers L.I. Inisheva and B.S. Maslov wrote in their book “The Mysterious World of Bogs” about bogs, their formation and development, vegetation and fauna; about peats that accumulated in the postglacial period and continued to grow, about their stratigraphy and properties; and about overgrowing and silting of lakes.

The textbook by B.S. Maslov “Melioration of peat bogs” reveals the technicalities of drainage, primary development, domestication and agricultural use of peat soils. In an accessible form, the author tells about the drainage of bogs done before peat extraction, and about swampy forests and parks. It also tells about specifics of surveys, as well as design and construction of drainage and drainage and humidification systems in swamps in compliance with all agronomic, socio-economic and environmental requirements.

“The Mysterious Swamp” book published by Prof. L.I. Inisheva in 2016 is intended for curious young people and a wide range of readers interested in nature and its life to describe the role of bogs and peat in the biosphere, agriculture, animal husbandry, energy, and medicine, and their economic use.

A group of scientists from the Tomsk State Pedagogical University (L.I. Inisheva, V.Yu. Vinogradov, O.A. Golubina, G.V. Larina, Ye.V. Porokhina, N.A. Shinkeeva, M.V. Shurov) published in 2010 a special edition “Swamp Stations of the Tomsk State Pedagogical University” within the framework of the program of scientific excursions of the All-Russian Scientific School of Young Scientists “Swamps and Biosphere” to provide basic information about bog stations, and to describe properties and peat bog regimes. The authors say that scientific stations should be viewed as national wealth.

The book “Plants in Swamps” (authored by L.I.Inisheva and B.S. Maslov), which tells about bog plants of Russia, is of particular interest. It tells original poems and stories and focuses on the use of bog plants for medicinal purposes. The publication is intended for the general public.

Of course, the list of these books could still be continued, but it is already sufficient to emphasize that fiction and popular scientific books, or rather, their authors did not overlook this unique natural resource - peat, specifics of its formation, properties, extraction and processing, and economic and social applications.

7.2. Peat extraction and use in world of philately

Thanks to its unique properties and mysteries, peat has also become a subject of philately. The latter paid attention to the amazing natural product and made it appear on postage stamps, envelopes, cards and postcards are dedicated to him (peat).

Please note that postage stamps, post cards and envelopes carrying postage stamps are not just financial evidence (means of payment), but also documents of state origin. Philatelic materials are both a hobby and a collection of business and career instruments contributing to professional capitalization.

Who needs philatelic capital and professional portfolio? Speaking from experience, it could be politicians, political experts, businessmen, scientists, industry amateurs and enthusiasts (mining industry, agriculture, energy sector, etc), artists and designers, art critics, experts on various subjects, historians, diplomats, pedagogues, lawyers, rarity collectors, and other categories of people.

As Albert Einstein once said, "collecting is especially useful for those who are engaged in mental work." Ernest Rutherford argued that “all sciences are divided into physics and stamp collecting”. "Philately is the hobby of kings and the king of all hobbies!" - this expression is used by many philatelists of the world, and it is not by chance, since many “movers and shakers” love collecting philatelic materials. These include British king George V, the last king of Egypt Farouk, and U.S. President Franklin Delano Roosevelt.

A postage stamp, an envelope, postcard is a wonderful and valuable material for studying history, economics, art, for developing concentration of attention.

The significance of a postage stamp begins with proving its value, or the amount of information it contains. This means that a postage stamp is valuable by its expert content, which presents it as an act of the state. Everything matters, from the scale of circulation to cancellation. This information tells more about a document than the document itself. Also, one should not forget that a postage stamp could be used as a document and globally recognized proof. It is not accidental that the postage stamp is sometimes described as the country's business card.

The Falkland Islands. A postage stamp from the “Peat transport” series (issued on August 1, 1995). Michel Catalogue code FK 650. Comb perforation 14. Offset print. Nominal value: 35 p– Falkland Islands penny

There could be different depths of stamp analysis. As a rule, the analysis begins with a commentary on the stamp appearance and its political role: the stamp starts with politics, considering that it is issued by a political entity, a state.

The value of stamps and other philatelic materials also depends on their function. Everything started with the need for indicia, which originated as micro vignettes and later developed into images printed on stamps. The goal was simple: the stamp moved freely around the world and represented the issuer country abroad. In fact, it was the first legal agent of a state in foreign countries. It appeared that the “agent” could pursue a particular policy, for instance, promote the development of the peat industry.

The Falkland Islands. A postage stamp from the “Peat transport” series (issued on August 1, 1995). Michel Catalogue code FK 651. Comb perforation 14. Offset print. Nominal value: 40 p – Falkland Islands penny

Interestingly, the stamp is the only fact of history that is hard to oppress. One may burn books by odious leaders but it is not customary to destroy stamps. So, one can still stamps depicting the most odious personalities.

Secondly, stamps, envelopes, and postcards play the role of a propagandist, which is not limited by time and is protected by the collecting logic. This means that philatelic materials have always been a form, at least, of political and economic positioning.

The Falkland Islands. A postage stamp from the “Peat transport” series (issued on August 1, 1995). Michel Catalogue code FK 652. Comb perforation 14. Offset print. Nominal value: 65 p – Falkland Islands penny

The state policy as “the economy epitome” could be easily tracked down by stamps. Importantly, one could embed plenty of economic, political and social hints in stamps without giving detailed explanations. The stamps semiotics and international distribution allows ending a variety of messages (economic, political, and social) to those who can read them without any political or geographic limitations.

Thirdly, many philatelic materials are attractive by their artistic properties. Stamp designs or miniatures have been brought to perfection and acquired a major function of aesthetic education. The style itself becomes a state brand and wins appreciation along with their content. For example, the amazing delicate style of Czechoslovak artists and designers made Czechoslovak stamps very popular.

Fourthly, philatelic materials are historical records. A person who collects stamps, envelopes and postcards records the historical process. A professional can learn much more from such materials than from current history books.

Fifthly, philatelic materials keep memory of entire mankind. They have depicted practically all legends and values. Some experts believe that stamps could be used to refresh the memory of the next generation! Stamps are guaranteed to become rarities and artifacts practically at the moment of their issuance. It’s true that the older the rarity is the higher its value. Stamps increase the value of the entire country. In this case, the rarity creation formula has a special significance, as the degree of rarity is controllable. The rarity acquires a hidden meaning. The stamp nominal value is a political operation aimed to increase the weight of the symbol.

Sixthly, one should always remember about the educational role of philatelic materials.

Seventhly, these materials (especially stamps) are sort of a code storing the genetic memory of the country and the entire people. It is practically impossible to destroy what is depicted by philatelic materials. What is more, the bigger repressions against them are the higher their value and the more are described in catalogues as unique and priceless!

We have presented postage stamps from the Falkland Islands, which describe the technology of peat loading and transportation by various types of transport, from animals to tractors and trucks. Soviet philately did not overlook the economic significance of peat, either.

The advertising and propaganda postcard “Fertilize your fields with peat and increase your harvest” arouses genuine interest. This red-brown card was put into circulation in 1930 and had a nominal value of 5 kopecks. One million copies of the postcard were issued by the Soviet People's Commissariat of Posts and Telegraphs (PCPT) of the USSR.

A strip divides the postcard into two equal halves. On the right, there is place for the addressee information (“where”, “to whom”), and on the left, there is an image describing the usefulness of peat. The left half of the postcard depicts a state farm worker holding high-yielding rye ears in her left hand. The thumb of her right hand is directed towards a large propaganda sign, "Fertilize your fields with peat." The postcard contains several numbers, including the yield of rye grain per hectare, which amounts to 14.1 centers without fertilizers and to 21.0 centers with peat and manure fertilization. The postcard even contains the address where one can apply for information (30A, Trubnikovskiy Lane Moscow).

Soviet postcard “Fertilize your fields with peat and increase your harvest” Autotype print. Issued by PCPT. Mosoblit No. 1823. Moscow, 1930, GOZNAK. Circulation 1 mln

As known, peat and peat products are widely used for medical purpose. The German postal agency did not overlook this area and issued postcards under the title *Gruss aus dem Moorbad.*

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German postcard. A lady taking a therapeutic peat bath Gruss aus dem Moorbad.

Both post cards depict ladies taking the rapeutic peat baths, a mixture of peat and peat water. The bath widens skin capillaries, intensifies pulse, respiration and metabolism, accelerates resolution of chronic inflammatory processes and formation of callus in poorly healing fractures, and rises body temperature. This bath is also good for treating nerve damage and stiff joints resulting from certain diseases. Peat baths are mainly used in the treatment of rheumatic diseases and sports injuries, and are also very useful for people suffering from obesity, overweight, stress, low immunity, and androgenic and gynecological disorders.

A lady takingeir a therapeutic peat bath Gruss aus dem Moorbad– Greetings from mud bath

The numerous therapeutic effects of peat batches include: treatment of locomotive system disorders, diseases of the genital organs, and chronic prostatitis; post-traumatic rehabilitation; beneficial effect on the nervous system and the skin, and anti-ageing effect.

Speaking of philatelic materials dedicated to peat, we have to mention the postcard depicting the “Peat digger” canvass by German genre and portrait painter Walter Firle (1859-1929), a member of the Munich Artists' Association. His works are known for their profound realism. This painting also gives a realistic depiction of a tired man wiping sweat from his forehead, and digging peat with shovel with great difficulty.

Postcard “Peat digger” Illustration from a painting of German artist Walter Firle (1859-1929)

Not just postage stamps and postcards have been dedicated to peat harvesting. Artistic stamp envelopes as an illustrative example of the keen interest of scientists in peat production and use in a variety of social and economic areas.

Artistic stamped envelope. Catalogue No. 2694. Leningrad. International Peat Congress. First Five-Year Plan Palace of Culture. Date of Issuance 31.07.1963. Nominal value 4 kopecks

In 1963, the Soviet Communications Ministry released two artistic stamped envelopes dedicated to the International Peat Congress.

The envelope released on July 31, 1963, depicted the First Five-Year Plan Palace of Culture designed by architect N.A. Miturich and built by the Russian-German Construction Association on the former place of the Lithuanian market. The palace was opened in 1939. The constructive-style building is an asymmetric combination of simple geometric forms. Interestingly, the stairs are located in full-glaze cages. The palace hosted main meetings of the International Peat Congress. The international event was accompanied with exhibitions of peat machines and equipment and tours to industrial enterprises and research centers of the national peat industry, the congress organizer. The congress was attended by 700 delegates from 26 countries. The motto of the congress, “International Practices of Use of Peat and Peat Deposits.”

Artistic stamped envelope 63-348. International Peat Congress, Leningrad, 1963 Artist V.V. Alexeyev

The congress had an active sections dedicated to the agricultural use of peat and peat deposits. The section attracted 124 representatives of 13 countries who agreed that diverse uses of peat and peat deposits in agriculture, especially organic and peat stimulants had a big future in many countries and contributes to the prosperity of people of the world.

There is yet another interesting philatelic material indicating the importance of this natural resource: the postcard, Peat Pavilion, based on the photo by V. Kovrigin issued in 1956.

The pavilion was designed by architect V.V. Zharov in 1949-1954 and initially called Peat. Its wooden predecessor was built in 1939 and deconstructed in the post-war years. The pavilion contained a pool with bog plants to demonstrate the peat formation process.

The new pavilion was built in the Stalin Empire style. The facade is decorated with a four-column portico and a composition depicting the Soviet coat of arms where wheat ears were replaced with two sickles against the background of the globe. There was a red star in the place of Polaris, and the map of the USSR was painted marsh green. The composition survived, for the map of the USSR was painted white for some reason. The wooden doors and window frames are decorated with floral designs, and the back facade is decorated with sculptures of peat-forming plants.

Postcard
Peat pavilion. All-Union Industrial Exhibition
Published by IZOGIZ
1956 Circulation 100,000

The entire pavilion was dedicated to peat, an important natural resource and its production and processing technologies. The exposition presented harvesting equipment and artistic works commending Soviet successes in this area. In 1959, the theme of the pavilion was drastically changed and it was called “Young Naturalists and Technicians”. And in 1964, all the old materials were included in the new exhibition "Agriculture."

In conclusion of the section dedicated to peat-related philatelic materials, we should say that the amount of such collection materials will grow alongside an increase in the investment appeal of the peat industry and will reflect, in particular, the stages of its revival in the Russian Federation.

Glossary

Agglomerate - collection of particles that are firmly held together.

Adsorbent - highly dispersed natural or artificial materials with a large specific surface where substances from contacting gases or liquids are absorbing

Anaerobic - not requiring free molecular oxygen for energy synthesis processes.

Asphaltenes - a class of high molecular weight components of hydrocarbons.

Aerobic - requiring free molecular oxygen for energy synthesis processes.

Biota - a historically formed community of species of living organisms sharing one habitat.

Bitumen - a solid or resinous product, which is a mixture of hydrocarbons and their nitrogenous, oxygenated, sulfurous and metal-containing derivatives.

A **swamp** - a plot of land that is constantly or for a long time abundantly moistened, covered with specific vegetation and characterized by a soil-forming process, which results in the accumulation of undecomposed organic matter, which then turns into peat.

Hemicellulose - a group of wood carbohydrate substances, which, unlike cellulose, are more susceptive to dilute solutions of mineral acids and alkalis.

Hydrophilic - a substance that can absorb water well, as well as has a high wettability of surfaces.

Hydrophobic - a substance in which the surface has the physical property of avoiding contact with water, i.e. not wettable.

Humates - salts of humic acids.

Humic substances - systems of organic molecules of high molecular weight, formed, transformed and decomposed at intermediate stages of the process of mineralization of organic matter in dying organisms.

Humus - the main organic matter of the soil, containing nutrients needed by higher plants.

Deposition - a process of organized storage or accumulation.

Isolines - a level line (function) or a contour line - a symbol on a map, drawing, diagram or graph, which is a line, at each point of which the measured value retains the same value.

Innovation - an innovation that has been or is being implemented to increase the efficiency of processes and/or to improve product quality

Cluster - a combination of several homogeneous elements, which serves as an independent unit with certain characteristic properties.

Consumers - organisms that consume ready-made organic substances created by producers.

Xeromorphism - morphological and anatomical features inherent in xerophytic plants - inhabitants of arid places: a decrease in the leaf surface, small cells, a large number of small stomata, a dense network of veins, the presence of hairs on the leaves, wax plaque, submerged stomata - all this helps to reduce water consumption for evaporation.

Mesotrophy - medium nutrition.

Micromycete hyphae/micromycetes - fungi and fungi-like organisms with microscopic spores; hyphae - a filamentous formation in fungi, consisting of many cells or containing multiple nuclei.

Microorganisms or microbes - the collective name for living organisms that are so small that they can only be seen through a microscope. The characteristic size of microorganisms is less than 0.1 mm. These include both non-nuclear - prokaryotes: bacteria, archaea, and eukaryotes: some fungi, protists (but not viruses that are isolated into a separate group). Most microorganisms are single cell, but there are also multicellular microorganisms.

Mycelium – the fruit body of fungi, consisting of thin branched filaments called hyphae.

Monosaccharides - organic compounds, one of the main groups of carbohydrates; the simplest form of sugar.

Inorganic substances - simple substances and compounds that are not organic, i.e. do not contain carbon, as well as some carbon-containing compounds. Inorganic substances do not have a carbon skeleton characteristic of organic substances.

Oligotrophy - low diet.

Organic compounds - substances with a complex molecular structure of the carbon skeleton related to hydrocarbons or their derivatives. Organic matter is rare in the Earth's crust, but all known life forms are based on organic compounds. The main classes of organic substances of biological origin are proteins, lipids, carbohydrates, and nucleic acids. In addition to carbon, they mainly contain hydrogen, nitrogen, oxygen, sulfur and phosphorus.

Polysaccharides - high molecular weight carbohydrates, polymers of monosaccharides (glycans).

Producers - organisms capable of producing organic substances from inorganic ones. These are green plants and some types of chemotrophic bacteria.

Reducers - organisms (bacteria and fungi) that destroy the remains of living things, turning them into inorganic and simplest organic compounds.

Residential - a plot of land intended for the construction of residential and public buildings, roads, streets, squares within cities and urban-type settlements.

Synthesis - the process of combining or combining disparate elements into a single whole.

Caking – a property of a substance that characterizes its ability to compact by gravity, resulting in a loss of flowability.

Sorbent - an absorbing solid or liquid.

Sorption - absorption of various substances from the environment by a solid or liquid.

Substrate - soil mixture of different composition for sowing, cuttings, planting and growing plants.

Fermentation - chemical reactions involving protein catalysts - enzymes.

Milling - crumbling and mixing the soil with a cutter.

Eutrophy - good nutrition.

Edifier - an organism whose activity creates or seriously changes the environment.

Ecomorphs - oppressed forms of trees, shrubs, and some shrubs.

Extrusion - obtained by extrusion, produced by extruding material through the extruder head.

Eukaryotic - containing a nucleus.

Definitions and abbreviations

BGC – biogeocenosis
GDP – gross domestic product
VNIITP – All-Union Research Institute of the Peat Industry
GIS – geographic information system
MGIS – mining- geological information system
HA – humic acids
HMS – hydro-meteo-station
GOELRO – State Commission for Electrification
GRES – state district power plant
HTC – hydro-thermal coefficient
EH – easily hydrolyzed
NHR – non-hydrolysable residue
OS – organic substance
ROP – reducing-oxidizing potential
ROC – reducing-oxidizing conditions
S – settlement
dc – district center
SEC – static exchange capacity
dp – dry peat
CEEA – comprehensive energy-ecological analysis
PES – peat land eco-system
DP – difficult to hydrolyze
PL – peat land
PD – peat deposit
TEF – ton of equivalent fuel
FES – fuel and energy sector
CHPP – combined heat and power plant
SWL – swamp water level

Contents