Finding Ways to Solve Problems of Waste Recycling: Biodegradable Hemp Materials

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Abstract. The importance of polymeric materials in modern life can hardly be overestimated. The annual growth of their production and consumption is one of the main directions of the development of the world economy. At the same time, the problem of recycling polymer waste after the end of the use of products made on their basis arises (according to various sources, only 10-15% of all produced polymers are used for the manufacture of containers). Fully biodegradable plastics are practically non-existent today. Any of the proposed solutions has its own advantages and disadvantages, which require commensuration with consumer characteristics, price, production costs. Independent examinations show that a truly complete degradation of polymers is possible only if they are made from plant materials. The article discusses the rationale for the feasibility of building a plant for the production of biodegradable materials based on plant materials in the Tyumen region.

1. Introduction
The production of products from environmentally friendly, natural raw materials has recently attracted more and more close attention of the scientific community. This direction is relevant today in connection with the constantly increasing volumes of production of polymers and polymer products. For example, from biodegradable plastic, which creates a lot of problems. Biomaterial requires special disposal conditions. May contain metal compounds that are not dangerous in themselves, but ultimately harm nature. For the decomposition of a biomaterial, certain environmental conditions are necessary, it cannot be recycled, its production leads to an increase in capital investments, methane is a by-product of its decomposition. Ultimately, it does not solve the problem of environmental pollution. According to the Association "Clean Country", in our country each inhabitant annually produces 400-500 kg of household waste, which is 2-2.5 times more than was produced in Soviet times [1]. In addition, over time, there is a decrease in oil and gas reserves, leading to a gradual increase in their cost. That is why, the need to strengthen supervision over the recycling process and the development of new methods of processing, burial and cleaning of waste is due to the possibility of preventing many environmental disasters and preserving the planet in a suitable state for posterity.
2. Literature review. Methods
The great importance of research in the field of production of products from environmentally friendly raw materials is confirmed by the global trend of transition to biodegradable materials, development and improvement of innovative materials and production technologies to solve environmental problems. At the same time, not only plastic materials can be biodegradable, but also materials based on plant raw materials, including hemp fiber. The cultivation of technical hemp can become one of the most important innovative projects for Russia. The revival of the production of this culture can provide jobs for about one million citizens, the annual turnover of the industry can reach over 100 billion rubles, as evidenced by the data of the "Committee of the Chamber of Commerce and Industry of the Russian Federation".

The state intends to expand the stimulation of the activity of agricultural producers in this sector of production, which allows in the future to count on certain benefits in the field of hemp crop processing. The program is aimed at building factories for processing agricultural raw materials everywhere. Thus, the sales problem will be solved, since many industries need a variety of hemp products. This will make the cultivation of industrial hemp virtually waste-free and highly profitable production.

In recent years, the topic under consideration has been covered in many foreign and domestic works, and is also the subject of discussions at international and regional scientific and practical conferences. Systematization and critical analysis of materials on the research topic were carried out on the basis of works of famous scientists: V.K.Astanin, V.V.Bogdanov, I.A.Valeev, V.N. Vodyakov, S.I. Wolfson, I.V. Voskoboinikov, V.V. Glukhikh, M.L. Kerber, A.A.Klesova, Yu. Longa, R.G. Melkonyan, I.N.Musina, I.V.Skopintseva, VA Ushkova, IZ Faizullin, NI Shubin and others [2, 3, 4, 5 and others]. In works [6] M.V. Shinkaruk, M.V. Shamshury, T.O. Kuzmina; [7] V.A. Serkova, A.A. Smirnova, M.R. Aleksandrova et al. Reflects the current state of the hemp industry, and also considers the activities of cannabis growers in Russia.

However, despite the large amount of research in the field of biodegradable materials, the possibilities for improving their composition and production technologies are far from exhausted.

Currently, issues related to the problems and prospects of the production and disposal of biodegradable materials are being actively considered, in particular, issues related to the justification of the production of consumables for the medical services sector from biodegradable raw materials, aimed at improving the environmental situation in Russia due to COVID-19. Among the studied types of raw materials for medical and other industries, bast crops showed good characteristics, for example, vegetable hemp raw materials, which grow in Russia and are unpretentious to weather conditions, in contrast to imported flax. The authors of the study [8] of the economic activity of the Tyumen region, the dynamics of the volume of retail trade, the activities of the agricultural sector, led to the conclusion that the development potential is being monitored in the South of the Tyumen region.

This study is aimed at confirming the feasibility of the project for the construction of a hemp processing plant in the South of the Tyumen region, emphasizes its national economic importance and is substantiated by the need for the production of medical textiles and cardboard in the Russian Federation. The successful launch should be served by a well-developed legal framework for conducting production, support for public-private partnerships, as well as the introduction of improved agricultural equipment into production to obtain products in demand in the consumer market, which will allow the industry to systematically develop and receive a stable income.

To solve the set tasks, general scientific methods of cognition (economic and mathematical modeling, elements of scenario and system approaches, experimental methods and methods of statistical processing of experimental results), methods of statistical analysis and traditional methods of assessing the effectiveness of investments were used.

3. Results
Possibilities and advantages of growing technical hemp. Hemp is one of the oldest crops grown by man and has been used extensively throughout the world. In Russia, this culture was actively
cultivated until the end of the 19th century, the products were exported to European countries and were in great demand due to their strength (canvas, ship ropes, ropes, and others). This crop gives a straw yield of 135 kg / ha, the annual yield of cellulose from one hectare from hemp is 7 times higher than from wood (Table 1).

**Table 1. Comparative analysis of straw yield and annual output cellulose among crops (from 1 hectare).**

| Culture       | Straw yield, centner / hectare | Cellulose yield Exit to % | Weight per year, ton / hectare |
|---------------|--------------------------------|---------------------------|-------------------------------|
| Flax - fiber  | 20-40                          | 54,0                      | 1,1-2,2                       |
| Rape          | 50-100                         | 42,5                      | 2,1-4,3                       |
| Hemp          | 135                            | 52,0                      | 7,0                           |

The culture gained its recognition thanks to the newly developed varieties of hemp, the content of narcotic substances in them is reduced to less than 0.1%. The advantage of this culture over others is indicated in a number of positive properties in Table 2.

**Table 2. Positive properties of technical hemp.**

| Unpretentiousness                                      | Fabric quality                                      | Low cost                                           | Environmental friendliness, bactericidal properties                  |
|--------------------------------------------------------|------------------------------------------------------|----------------------------------------------------|---------------------------------------------------------------------|
| For cultivation, several times less water is required than for the production of cotton, | As strong as linen, but softens over time.          | The production of hemp fabrics is several times cheaper than fabrics from cotton and linen. | Hemp material is 100% biodegradable in the soil, enriching it with microelements. |
| One hectare of hemp yields three times more raw material for fabric production than one hectare of cotton or flax. Does not require fertilizers or pesticides, and does not deplete the soil like cotton does (and even rather enriches it). Industrial hemp has fewer pests than other crops. | Hemp fabric “breathes” perfectly, absorbs moisture. | During growth, hemp absorbs CO2, generating oxygen for the environment. | The cannabidiol found in hemp is effective against bacteria. |

The range of use of hemp processing products in the world economy is steadily expanding, industrial technologies for the production of products are being developed for use in innovative industries. Hemp acquires the status of a strategic culture, the cultivation and processing of which are the priority directions of the economic policy of the governments of many developed countries and private business investments.

As of 2014, 78.3 thousand tons of hemp hemp and about 57 thousand tons of hemp seeds were produced in the world. At the same time, France is the leader in seed production, which accounted for
73% of the world market, and in the production of hemp, the leadership is shared by China (28%), North Korea (25%) and the Netherlands (18%). In 2015, China's share was about 55%. Canada is the second country in the world in terms of the volume of cultivation of cannabis seed - more than 25%) [9].

Currently, traditional petroleum-based commodities such as polymers are being replaced with plant-based raw materials, which are helping to move towards sustainable resource use. The above information reflects the relevance and prospects for the production of biodegradable materials based on hemp fiber. Industrial hemp in production. More than 300 types of hemp products are produced abroad, while in Russia this list has decreased, which was influenced by the ratification of the UN Convention "On Narcotic Drugs", which seriously complicated the rules of cannabis cultivation. The Soviet state followed the line of least resistance, reducing the area under crops as much as possible [10]. Today, the revived types of hemp products in the Russian Federation are: cold-pressed oil, flour, seeds, livestock feed, wall insulation, wood concrete, rope and rope products, fabrics, geotextiles. A decree was signed on the strategy of the state anti-drug policy of the Russian Federation for the period up to 2030 [11].

The possibility of selling the production of products is due to the strategy of Socio-economic development of the Tyumen region until 2030 [12].

Based on the analysis of the strengths and weaknesses, opportunities and threats to development, the following positive aspects are identified that are favorable for this project:
- favorable geographical position of the region, high level of entrepreneurial initiative,
- a developed system of state support for enterprises, population growth, due to the developed infrastructure of the city,
- provision of high-tech types of medical care, developed agriculture, construction sector.

A promising area of the city is Medical Tourism. The high level of health care and medical technology are known outside the area. The number of patients arriving at the clinics of the Tyumen region from other regions and states is increasing.

The hemp campfire, as a waste product after fiber is obtained, is used in the pulp industry. Hemp-based building materials have exceptional thermal properties that reduce energy consumption, are non-flammable, and are resistant to mold and bacteria and naturally regulate humidity. When choosing products, there is reason to believe that biodegradable products from hemp fiber will be in demand in the medical and construction industries, the cellulose industry in the Tyumen region.

The proposed product is the manufacture of medical textiles from hemp fiber, cardboard obtained from the fire. The possibility of growing and producing biodegradable materials from hemp in the Tyumen region. In the collective works "Essays on the History of the Tyumen Region" it is said that the first crops of flax appeared in the region at the end of the 17th century, and peasants cultivated flax, hemp, hops and tobacco from industrial crops. The conducted field studies showed that the soil and climatic conditions of the southern part of the Tyumen region are favorable for the cultivation of hemp and flax, it is also mentioned that hemp and linseed oil were produced in the region. In one of the appendices to the report, it was reported that in the Kurgan district, from 4 to 6 poods were sown on a tithe of land (1.09 hectares). flax seeds and 4 poods. (0.066 tons) of hemp. It was planned to increase the yield of hemp to 5-6 centners per hectare on average. The Great Patriotic War prevented the implementation of the plan [13].

In Tyumen, since 1960, the largest light industry enterprise - worsted cloth mill "Krosno" (WCM Krosno), one of the largest enterprises in the industry in the country, was engaged in the production of all types of light industry goods in a full cycle - from the receipt of raw materials (raw wool, cotton, flax and etc.) to finished fabrics and sewing products from them, with the possibility of issuing products from any stage. The raw materials were sorted, cleaned, and then, after going through all the production stages, they became fabrics. The industrial collection of KROSNO consisted of about 300 fabrics. Since 2013, the enterprise has ceased to exist. Therefore, we can conclude that the cultivation of hemp in the Tyumen region is relevant to this day. Today, it is advisable to adjust the rate of production of products from this culture, as evidenced by the data of the "Committee of the Chamber
of Commerce and Industry of the Russian Federation for the development of the agro-industrial complex." With an increase in the area under hemp crops to 1 million hectares by 2030, it can give about 3 trillion. rub. in GDP. An increase in the share of innovative products - cellulose (in the world of 450 million tons, the share of cellulose from annual plants is 19% or 85.5 million tons, in Russia about 0%), for carbon fibers, bioplastics, composites, biologically active substances and dr.

Competitive production environment. The main competitors in the market for the production of hemp products are both foreign companies and the domestic market, which is gaining momentum and expanding. The list of the main competitors is presented in Table 3.

Table 3. The main competitors in the market for the production of hemp products.

| Foreign companies | Russian companies |
|-------------------|-------------------|
| **Company** | **Products** | **Company** | **Products** |
| Hemp Canada Oil | Oil, seeds, protein | Konoplex Group | Oil, textiles |
| Lithuanian factory | Hemp fiber, yarn, | "Ecosphere" | (marketable seeds) industrial hemp |
| Natural Fiber | biofuel pellets | Nizhnekamsk | |
| Portuguese factory | Medicines | Smarthemp | Textiles, cardboard |
| Tilray | Cosmetics | Agro-Industrial | |
| Ecofibre | Natural Fiber | Cannabis Association | |
| Medical Hemp | Pharmaceuticals, cosmetics | "Konopletika" | Food raw materials |
| Hemp Works | Food products | Moscow Agricultural Academy named after K.A. Timiryazeva | |
| GenCanna | Pharmaceuticals, oils, cosmetics, food | LLC "Ecocontrol" | Scientific research in the field of technology of cultivation of industrial hemp, processing of raw materials and disposal of waste of these crops |
| South Hemp Tecno | Mulch, ZOO products | Mordovian hemp plant | Construction and automotive industry |
| Hemp Poland | Pharmaceuticals, cosmetics, oils | Agrofirm "Yuzhnaya" | Seeds |
| Plains Industrial Hemp | Insulation, absorbent, ZOO products, mulch | Irkutsk | |
| Processing, Hempco | Food, seeds, protein | "PromRussCon" | Nano and microcellulose, paper, textiles, composites, biodegradable PET containers, biofuels. |
| BAFA | Pharmaceuticals | "Nizhny Novgorod hemp fibers" | Woven and non-woven fabrics |
| Canah International | Food products | |
| Hemp Inc. | Pharmaceuticals, seeds, concrete, ZOO-products | | |
Today, in the Tyumen region, there is one main enterprise for the production of corrugated cardboard LLC Plant "Gofropak Tyumen", with a capacity of 42 million m² per year. The raw materials are purchased, ready-made rolls of cardboard paper grades T-24-T-27 and P-31-P34.

In the Kurgan region, there is a Luxokraft plant with a capacity of 54 million tons per year. Primary fibers, cellulose, recycled paper raw materials are used as raw materials. In addition, there are small enterprises that do not produce cardboard, but only sell finished products: A Megapak, Tyumen-PAK, Zima, FastMovers 72, Upakovkatorg Tyumen, Wholesale company Uralpak, Torgovaya Istra company "Protek-Tyumen packing”.

According to the results of the analysis of the competitors' market, it is possible to note the strengths and weaknesses of the project of a plant for the production of biodegradable materials, presented in the SWOT analysis (Table 4).

### Table 4. SWOT analysis of the enterprise.

| Strengths (internal, positive factors)                                                                 | Weaknesses (internal, negative factors)                                                                 |
|------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| - Lack of analogues of factories for the production of medical textiles, which will allow you to switch to natural plant material with antiseptic, bactericidal properties. | - To start production, expensive imported equipment for processing hemp is required. |
| - The raw material used for the production - hemp fire - will reduce the deforestation for the production of pulp, while competitors in Tyumen use wood pulp in production. | - In order to make products from the raw materials grown on their own, significant investments are required in improved agricultural equipment, as well as large areas of agricultural land. |
| - Possibility of increasing jobs in the Tyumen region.                                               | - Possibility of increasing jobs in the Tyumen region.                                               |
| - The processing capacity of the plant will allow farmers to sell hemp raw materials and increase the area under crops. | - Possibility of increasing jobs in the Tyumen region.                                               |
| - Increase in the production of cellulose, four times more than from trees from the same area, only trees need to grow for forty to fifty years, and hemp ripens in 110 days. | - Increase in the production of cellulose, four times more than from trees from the same area, only trees need to grow for forty to fifty years, and hemp ripens in 110 days. |
| - The process of obtaining cellulose from hemp is twice as short as from wood, without harmful emissions into the environment. | - The process of obtaining cellulose from hemp is twice as short as from wood, without harmful emissions into the environment. |
| - There is no competition with other types of crops grown in the zone of a sharply continental dry climate. | - There is no competition with other types of crops grown in the zone of a sharply continental dry climate. |

| Opportunities (external, positive factors)                                                                | Threats (external, negative factors)                                                                 |
|------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| - A young market for the production of hemp products, gaining great popularity                        | - A high degree of competition in the production of cardboard in the territory of Tyumen.            |
| - An increase in the area under hemp crops up to 1 million hectares can give about 3 trillion. Rub. in GDP. | - To start production, expensive imported equipment for processing hemp is required, due to taxation. |
| - Increasing the share of innovative products.                                                          | - Lack of domestic experience in manufacturing technologies.                                         |
| - Public-private partnership, will reduce the cost of capital investments.                             | - The Russian industry, due to the general technological lag, will not be able to work with such raw materials. |
| State programs to support agricultural producers include reimbursement of part of capital costs, per hectare support, support for elite seed production, as well as the possibility of signing concession agreements. | - To introduce a new fabric into the medical industry, it is necessary to include in GOST and other regulatory documents permission to use hemp fiber for the production of medical materials. |
| - It is supposed to take industrial hemp for processing, including third-party farms, thus forming an industrial regional cluster in Tyumen and adjacent regions. | - To introduce a new fabric into the medical industry, it is necessary to include in GOST and other regulatory documents permission to use hemp fiber for the production of medical materials. |
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Among the strengths is, first of all, a free niche in the production of medical textiles and the absence of competition with other types of crops grown in the zone of a sharply continental dry climate. The competitor in the production of cardboard is Plant "GofropakTyumen". It is considered the main competitor, but the raw materials for the production are used in the form of finished rolls of cardboard paper. The advantage over the competitor is the raw material used for the production - hemp fire, which will reduce the deforestation for the production of cellulose.

Possibility of cooperation in the form of public-private partnership. For the further implementation of the project, measures of state support were considered, subsidizing the costs of purchasing hemp seeds, mineral fertilizers, appropriate equipment, an agreement on public-private partnership. The Ministry of Industry and Trade supports the light industry within the framework of the State Program for the Development of Industry and Increasing its Competitiveness:

1. Subsidies for the cultivation of 10 thousand. rub per 1 ha.
2. Subsidizing elite seeds, 1.2 reproduction.
3. Import duty on foreign equipment, 0% VAT.

In cooperation with the state, it is permissible to sign a concession agreement. One of such projects in Russia is the Konopleks plant, which is being built in the Penza region on a concession basis. [9]

The need to amend legislation for the development of this production area. A distinctive feature of the project is the production of medical fiber used in medical institutions, as well as beauty salons and household use, from natural hemp fiber. At the moment, unlicensed cultivation and use of agricultural hemp varieties included in the State Register of Breeding Achievements approved for use in the Russian Federation is allowed. The seeds must be certified.

It is planned to cooperate with the textile enterprises of the region to work out the technology of adding hemp to cotton fabrics, which, as a result, will receive new antiseptic, bactericidal properties and become more durable. A prerequisite for the introduction of a new fabric into the medical industry is the approval of amendments to allow the inclusion of this hemp fiber in the list of approved raw materials for the production of medical supplies.

In the medical field, disposable synthetic fiber fabrics are used, in accordance with GOST R 58551-2019 national standard of the Russian Federation “Medical disposable nonwoven materials. Surgical disposable clothes and underwear made of nonwoven materials ”[14].

Regulatory document GOST R 58551-2019 does not consider hemp fiber, as well as GOST 24760-81 "Women's medical gowns": cotton fabric - fabric produced from yarn containing 100% cotton fiber or cotton fiber with an investment of no more than 10% viscose or viscose high modulus fibers; mixed fabric - a fabric made from yarn containing cotton fiber with an investment of no more than 50% of chemical fibers or threads [15].

An amendment should be made to the use of hemp fiber in GOST 7000-80 “Textile materials. Packaging, labeling, transportation and storage ”, in compliance with the requirements for medical fiber and laboratory research [16].

Feasibility study of the feasibility of launching the production of biomaterials from hemp

According to the Department of Crop Production of the Ministry of Agriculture of Russia, the increase in demand for bast crops since 2016. by 2020, amounted to 5.4%, and based on data from the Ministry of Industry and Trade of Russia, it averaged 2.2%. At the beginning of 1990. in Russia, there were 75 hemp factories; by 2016, only 6 hemp factories were operating, which indicates a regression of the acreage for hemp [17]. According to the forecast of the need for hemp fiber, taking into account the state order, the volume of required textile products for all government agencies exceeds 175 thousand tons, about 95.3 thousand tons are required for medical purposes. fiber, construction requires 70.6 thousand tons of fiber [18].

The need of the Tyumen region is 20 thousand tons of industrial hemp per year. This corresponds to a cultivated area of 1.8 hectares.

Hemp production is highly profitable, waste-free, because different components of this culture go to different types of products. For the cultivation of hemp, without agricultural land, own harvesting equipment and other things, large investments are required for the purchase of seeds, agricultural
equipment, (rent or purchase) of land, construction of greenhouses, costs of heat, water and electricity, delivery of seeds, wages of workers, laboratory research which cost more than 700 million rubles.

Hemp processing machinery and equipment. New promising technologies for the primary processing of hemp trusts, technologies for cottonization and spinning of hemp fiber appear on the market. Hemp fiber production begins with the decortication of the trusts, resulting in the formation of hemp bonfire and hemp fiber.

The process begins with a rough cleaning of stones, after which the process of decortication of the trusts begins. The technological chain is a continuation of the line for the production of fibers from straw or trusts, based on the technology of decortication, dedusting, cleaning and fiber thinning. The line consists of technological modules: fiber cutting, cleaning, fiber breaking into elementary fibers, second cleaning and boiling (Fig. 1).

![Figure 1. Technological process.](image)

To obtain quality fiber from raw materials, a correct maceration process and sufficient tensile strength of the raw material are required. In this case, the technological core of the cottonization line is a module with two drum cottonizers (Fig. 2).

![Figure 2. Cottonization technology "LAROCHE".](image)

The technology is complex and time-consuming, but it allows you to completely eliminate the chemical processing of raw materials, without requiring soaking and drying, which reduces the cost of production. In addition, this technology makes it possible to obtain blended yarn using wool and cotton technology. This is important, since hemp yarn was made on wet spinning lines, which are now gone. Flax can also be cottonized using this technology.

Advantages of the LAROCHE technological line from the considered technologies of Hammer mills and Duvex: high strength of the resulting fiber, increased fiber yield by 20-30%, energy saving; low maintenance cost, less dust [19].

4. Conclusion

Really complete degradation of polymers, according to independent experts, is possible only if they are made from plant materials, in particular, hemp fiber. In the last 8-10 years, the world economy has been experiencing a dynamic increase in the production of hemp. The versatile use of seeds, fiber, fires, the ability to get good harvests without pesticides, fully confirm its enormous national economic
importance. Hemp has a number of advantages over other crops, being waste-free. Almost any product that can be made from wood, cotton, or petroleum (including plastic) can be made from hemp. Hemp can replace all other types of fabrics without the use of chemicals. Currently, there is a steady tendency in the world to replace synthetic materials with natural ones. But there are a number of problems in the field of cannabis cultivation: outdated material and technical base (lack of modern harvesting equipment); reduction of seed enterprises and farms engaged in seed production and zoning of new varieties; poorly equipped laboratories, staff shortage.

In the field of hemp processing: depreciation of fixed assets; outdated material and technical base; violation of technology (lack of modern drying complexes and processing equipment). In the field of textile production: slow technical re-equipment of production facilities (obsolete technical and technological equipment, lack of mechanical engineering for the manufacture of spinning, weaving and finishing equipment); low level of state support. It is necessary to accelerate the initiation of a program aimed at the revival of domestic cannabis growing, as well as to establish the production of fundamentally new high-performance agricultural machinery and equipment for processing bast crops.

Today our planet is suffocating from landfills, forests are being cut down irresponsibly and massively. Air pollution, poisons and chemicals cause cancer. These problems can be solved if we grow industrial hemp, thereby preserving the environment and increasing the efficiency of our economy.

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