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POTENTIAL OF ENERGY PRODUCTION FROM BIOWASTE - SAVING NATURAL AND FINANCIAL RESOURCES

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The environmental issues of disposal waste are considered in the article. The aim of this article is to carry out the quantitative assessment and to estimate economic potential from the biodegradable waste of the enterprises of a fishery complex. The paper provides a condition of the market of agriculture products in Russia and the Republic of Karelia. Main waste recycling ways in various industries by different technologies and equipment are considered. Qualitative and quantitative indicators for growing enterprises rainbow trout in Karelia are given. The paper presented the profitability of using agriculture waste in different ways and the most effective ways of recycling by environmental aspects. Furthermore, prospects of waste recovering in the Republic of Karelia, as well as factors hindering its development are given.

Key words: Energy potential; recycling; fish waste; biowaste; biogas; bioenergy; energy efficiency; ecology
JEL Codes: J08, J21, J43.

1. Introduction

This paper focuses on the potential of biodegradable fish waste utilization. Fish-farming is a growing industry in the Republic of Karelia. Fish waste disposal is one of the most widely discussed topics related to the fish farming industry in Russia. This is important because fish processing generates side streams that are currently unutilized due to different reasons, among them are the missing waste management processes and practices. However, the utilization of side streams generates profitable business opportunities in waste management. It also creates a potential solution for

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local energy production in remote rural areas, at the same time reducing the environmental impact that dumping fish waste is causing to landfills.

From previous research we know that smaller companies in the fish industry often prefer to stay out of processing, thus reducing their waste volumes. Larger companies, which may harvest tens of tons a day, would rather utilize the resource to the full, turning wastes into income (quite substantial, in fact) instead of discarding them. One of such promising and paying approach is the conversion of fish wastes to fishmeal and feeds, as well as to biofuel.

However, we know less about the availability and optional utilization methods for fish processing side streams and other aquatic biomaterials in the Republic of Karelia, practical process and technology for managing fish processing side streams, including side stream collection, logistics, and fish oil production.

The aim of this paper is to carry out the quantitative assessment and to estimate economic potential from the biodegradable waste of the enterprises of a fishery complex. Another objective is to significantly reduce the environmental impact caused by biowastes disposal and to see the biowaste as a profitable feedstock.

2. Research and discussion

Most people perceive the “biological wastes” as something that can be of no further use. However, this is a misconception. Modern technologies, namely the biogas technology, can turn wastes into income (Achinas, 2017; Chasnyk, 2015).

In addition to the added value, this technology is the most efficient system for recycling wastes, including bio-hazardous wastes. Waste recycling in a biogas plant simultaneously yields gas, electricity, heat, fuel for vehicles, environment-friendly biofertilizer, as well as reduces the capital costs of building new agri-industrial enterprises. Thus, this technology may be a solution for most problems in the agro-industrial sector, for instance, it will make companies more competitive and energy-efficient. On the other hand, the potential of the agricultural sector cannot be utilized to the full for several reasons, such as poorly functioning market mechanisms, underdeveloped investment instruments, some firmly rooted stereotypes concerning biowaste.

Food wastes are classified as biological wastes, and their disposal is a problem of high relevance for the food industry. The national standard GOST 30772-2001 defines them as foods that have completely or partially lost their original consumer qualities through manufacturing, processing, consumption or storage. Biowaste can be conventionally grouped into two types: production wastes (the source is food industry) and consumption wastes (households and various catering facilities such as cafes, restaurants, school, or hospital canteens).

Their specific characteristic, as well as their hazard, is the high toxicity. Food wastes, per se, are not so harmful given that all kinds of organisms feed on them. However, if accumulated in great amounts, food wastes can harm the environment

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and even humans. Besides, they cannot be mixed with other sorts of wastes lest hazardous compounds (dioxides) are formed.

Fish waste recycling is a particularly pressing problem because of its immediate environmental implications. Fish wastes are an important food resource that is often underestimated. The main wastes after primary fish processing are heads, scales, skin, and viscera. These wastes are usually converted into fodder fishmeal and simultaneously, veterinary and inedible fish oil. Fishmeal is used in poultry and cattle fodders.

A major problem in the fish industry is the poor recycling of wastes from fish processing facilities. Tons of wastes remain unused daily from fish processing. A nearly only practicable way to recycle fish wastes is to produce fishmeal, but lots of recyclable material are currently landfilled. Therefore, multi-purpose and effective use of fish resources is still a topical problem.

The agricultural sector is facing the problem of enormous amounts of wastes that need to be managed. The consequences are soil acidification, withdrawal of farm land from proper use (over 2 million hectares of farmland in Russia have been turned into manure storage grounds), groundwater contamination and greenhouse (methane) emissions.

Agro-industrial sector (AIS) wastes subject to the recycling area substantial energy resource since nearly all agricultural wastes potentially carry energy (Bran, 2018; Meggyes, 2012).

Thus, the promotion of biogas-based energy production is not only a potential solution for the waste problem, but a solution for the energy problem in agriculture.

Many regions with highly developed agriculture and, hence, a high concentration of resources for biogas production (Belgorod, Krasnodar, Altai Regions, Republic of Karelia, etc.) are energy deficient. Coverage by the energy infrastructure is dramatically low in all agricultural regions, namely, only 37% of large and medium-sized agricultural producers have access to gas grids. If the biogas technology is utilized, the total energy potential of AIS biowastes in Russia will be 81 million tons of coal equivalent.

This amount is enough to cover 14% of the gas demand in rural areas. Utilization of biogas into generation plants will supply 23% of the electricity demand in rural areas, and 15% of the heat demand (Druzhinin, 2016).

Furthermore, biogas-based energy production is a source of cheap compound organic fertilizers, which are a by-product (sludge) of the biogas process. E.g., the daily organic nutrient potential of manure recycling per cow is 0.25 kg nitrogen, 0.13 kg phosphorus oxide, 0.3 kg potassium oxide, and 0.25 kg calcium oxide, which is comparable to a kilo of compound fertilizers. Such cheap and readily available fertilizers are an essential factor for intensifying agricultural production in general and making domestic products more competitive (Miskinis, 2006; BioPress, 2005).

Table 1. Biogas output from different kinds of feedstock (Tishkov, Shcherbak 2014)

FEEDSTOCK	**Output, m^3/ton**
Grease/tallow (pure, 0% moisture)	1300
Molasses	633
Grain, flour, bread	538
Technical glycerin	500
Slaughterhouse wastes (only blood, paunch manure, soft tissues)	300
Fish wastes	300
Grease trap skimmings	250
Fresh grass	200
Corn silage	180
Beet pulp (78% moisture)	119
Fruit and vegetable pulp (80% moisture)	108
Poultry manure from cages (75% moisture)	103
Root crops	100
Brewer's spend hops (82% moisture)	99
Poultry manure from litter (60% moisture)	90
Corn pomace (80% moisture)	85
Swine manure, semi-solid (85% moisture)	62
Cattle manure, semi-solid (85-88% moisture)	54
Whey	50
Molasses distillery slop (90% moisture)	50
Spent grains (93% moisture)	40
Potato pomace (91% moisture)	32
Swine manure, liquid (95% moisture)	25
Cattle manure, liquid (95% moisture)	22

For most agricultural enterprises, high fuel and electricity prices are very difficult to manage. The biogas technology is a potential solution to these problems, reducing the negative effect of high energy and fuel-and-oil rates.

Importance of fish waste utilization. The Russian market of fish and seafood shows a trend for development and arise in consumption. The sea foods segment, which used to be entirely targeted at export, is now growing more reoriented towards the Russian consumer.

Surveys have shown that fish and seafood in Russia are still in less demand than meat products. Meaning, the consumption of fish and fish products in Russia is twice lower than meat products consumption. On the other hand, fish and fish products consumption in Karelia is near twice that of Russia's average: annually, consumption of fish products in Russia is 15 kg per capita, in Karelia - 28 kg [4].

Total salmonid market capacity in Russia in 2011-2012 was around 63,000 tons, the share of imported products being around 85% (ca. 55,000 tons). At present, 70% of cage-reared trout in Russia is produced in the Republic of Karelia. The fish industry is praised as one of the most rapidly developing sectors in the Russian economy. Fish and seafood consumption volumes keep growing, the amount in 2011 nearly recovering to the USSR level.

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As of now, 63 fish farms operate in Karelia. It is a rapidly developing segment of agriculture in the region. Fish farming volumes in the republic have nearly doubled over the past five years. In terms of species, 98.8% of the fish raised was rainbow trout, and 1.2% were nelma (a subspecies of inconnu), whitefish, peled whitefish, and sturgeon (as of 2012). Total output in 2012 was ca. 13,500 ton of fish. As forecasted by the Republic of Karelia Ministry of Agriculture, Fish and commercial fish farming will grow to produce up to 35,000 tons in 2025. According to this forecast, the number of operating enterprises will increase to 75, employing up to 900 staff (Kareliastat…, 2017).

2. Materials and methods

Studying of the questions connected with the use of waste in the sphere of power and also the implemented projects show the broad prospects of use of all main types of waste in a power complex. The main difficulties in formation of uniform methodical approach are varieties of forms and methods of the research of this process.

In this regard, the general methodology of this research was formed on the system approach and use of a complex of complementary methods: the comparative analysis of power sources from waste; situation and strategic analysis of opportunities of use of waste in the sphere of power, the analysis of use in relation to northern regions; the case-study method for a research of the implemented projects in the sphere; the standard and legal analysis of the adopted acts and strategy.

The greatest contribution to commercial fish farming in 2016 was made by the following companies (Kareliasta…, 2017):

- LadozhskayaForel LLP (together with Raiguba LLP) - 2147 tons,
- Kala ja Marjapojat LLP - 1932 tons,
- RokFor LLP- 1606 tons,
- Segozerskoe LLP - 1321 tons,
- Kala-Ranta Ltd - 1122 tons.

With such fish production volumes, the problem of fish waste disposal arises for the companies that process fish. Each company deals with the problem at their own discretion, but often times the wastes are just taken to the landfill, which is certainly anything but efficient use of valuable bioresources, on top of being detrimental to the environment.

Furthermore, nearly all companies face problems with heat and power supply. Power supply to remote industrial facilities may be unreliable (sudden blackouts). As a result, nearly all companies use diesel generators as the backup power source. Current tariffs for electricity from the grid may be up to 6 RUR for kW/h (Druzhinin, 2016).

Nine companies in the Republic of Karelia process fish. They generate ca. 2 000 tons of wastes. The problem of waste disposal (fish mortalities and processing wastes) is now one of the most widely discussed topics among those involved in fish farming in Russia and Karelia. The tough and often ambiguous requirements of

Russian legislation on waste handling and disposal create problems for all trout farms. Penalties for non-compliance may reach 4000 EUR and an up to 90 days stoppage of farm operations, and if the non-compliances are not eliminated the company may be shut down altogether.

The attempt made by a Karelian firm to use special composting pits was a failure. The authorities first issued a permit for such waste processing practice, but a year later environmentalists detected some violations in this method. Eventually, the permit was terminated, a fine was imposed, and the instruction to rectify the violations was issued.

In this shaky situation, some farms would be willing to give their wastes away for free or even pay for them to be taken away just to avoid the consequences of improper disposal.

No offers to buy fish wastes are to be found within Karelia. The nearest region ready to buy is the Leningrad Region. Purchase price estimation is rather problematic as it depends on the waste, part of which can be utilized as fodder at fur farms (fresh frozen tails and heads). Furthermore, prerequisites in all tenders are the minimal threshold of batch volumes (min 5 tons), and regular deliveries. The market will now buy fish wastes for 0.05 to 0.13 EUR per kilo if delivered by the seller. Thus, Russia now has premises for fish waste recycling. The most promising recycling methods are: manufacturing of meat and bone meal and fodder, fertilizers, fish oil, as well as bioenergy applications.

3. Discussion

For the Republic of Karelia production, high - quality biodiesel with existing traditional diesel prices is low profitable. This is due to the high cost of production equipment fuel, as well as a small number of raw materials. From one kilogram of fat can produce 1.135 liters biodiesel (Tishkov, Shcherbak 2014). As of the end of 2017, the total potential for the production of biodiesel at the enterprises of the fishing industry of the Republic of Karelia can reach 300-350 tons of fuel per year.

In addition to biodiesel, fish waste can be used to produce biogas. For this fish waste must be shared with other types of waste such as: manure, grass, expired food and others. The waste disposal method can be used virtually with any type of raw materials, including susceptible to biological contamination. So thus, biogas technology can become the only way to destroy contaminated biomaterials with minimal environmental impact (Berglund, 2006; Kumar, 2012).

To set up processing of biowastes from livestock farming in the Republic of Karelia the focus should be on pig-, poultry, - and fur animal farms. Cattle manure is a valuable fertilizer utilized in fields. Russia has great potential to increase its energy efficiency in all economic sectors. This will make it possible to reach a new level of development, overcome the dependence of the economy on energy prices, improve

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the socioeconomic situation in the country and raise the welfare of the population (Druzhinin, 2018; Kotzamanis, 2001; Mbatia, 2011).

Biogas production in Karelia is feasible, and the experience from other regions of Russia is evidence for that. In 2010, the first industrial-scope biogas plant fed by animal farming wastes was built and launched in the Kaluga Region, not far from Moscow. Industrial-scope biogas plants operate also at the wastewater treatment facilities of Mosvodokanal, and at Baltica, Sun-InBev and OST breweries and distilleries. All these plants are based on European or American technologies, which will have economic effect only if companies are motivated by penalties or subsidies as high as in Europe, USA or China (Uusitalo, 2013; Deublein, 2008).

The capacity of the biogas plant's power plant depends on raw material amounts, biogas output, company's electric power demand, and investments. It ranges from 1 kW (domestic scope) to several tens of MW. The most profitable are medium- and high-capacity plants — 500 kW and more. Biogas plants with such power plants have a short payback period. The advisable option for the energy supply of an enterprise is small local-scope biogas plants with a throughput of 1-2 tons wastes a day (up to 150 kW/h).To enlarge the capacity one can additionally collect biowastes from surrounding areas (manure, silage, fresh grass, grain, vegetables, food industry wastes).Incentives for the development of the biogas industry in Karelia are growing, but they are still far beyond the European level, so in the near future one can expect cheaper biogas technologies to develop, especially where the amount of wastes is less than 10 tons a day.

Comparative assessment of the data provided by different vendors of biogas equipment shows the cost of the equipment is rather high, and substantial feedstock volumes are needed (10 tons of wastes and more). On the other hand, a biogas unit (plant) normally produces more than one company consumes, so several heat and power consumers should also be connected to it on a continuous basis.

The cost of biodiesel equipment is much lower, especially for small-scale waste processing volumes. It does not require a constant supply of feedstock or constant consumption by end users – the product can be produced in batches and warehoused.

4. Conclusion

1. The volume of fish farming in the country has almost doubled for the last 5 years. In a structure of the grown-up fish for 2018 98.8% are occupied by an iridescent trout, 1.2% is the share of a nelma, a whitefish, and sturgeon. In 2018 about 20 000 tons were produced in total. Each enterprise tries to solve this problem independently, but in general, waste is just taken out on a dump and it is impossible to call effective use of valuable bioresources in any way and, on the other hand, has a negative effect at the environment. Besides, practically all enterprises have problems with heat and power supply.

2. In order to utilize biowaste in Karelia as effectively as possible, co-operation of different actors and combination of solutions need to be considered. The investments needed for biowaste utilization processes are high and require co-operation of different stakeholders. One of the major fish processing company in Karelia (Kondopoga) has invested in fish processing plant and is currently working on to start the fish meal raw material production (fish oil, protein). This factory may become a major solution for the whole Karelia. In areas located in a long distance from Kondopoga, additionally, local solutions will be needed. One of the solutions may be to import fish waste from Sortavala area to Parikkala in Finland for further processing. Another solution is that the residue from fish oil separation will be used for biogas production in Sortavala area. However, this requires other material like manure and sewage sludge (e.g. from wastewater treatment plant in Sortavala).

3. There are several companies producing fish waste in the region that was investigated in this study. The fish waste from these companies could be used in biodiesel production by separating the fish oil and further processing it. In addition to biofuel production, fish waste can be used to obtain valuable substances. Fish waste can be used in the production of fish protein hydrolysate by enzymatic treatment. Fish waste can be used for extracting enzymes, gelatin, and proteins.

4. Now one fish processing company already has equipment for fish oil separation from fish waste. The same company is also the only one interested in producing biodiesel from fish waste. Other companies are more interested in fish-oil, fish meal production or treating the fish waste with some other means. There seems to be a demand for waste fish oil and flour produced from fish waste. Therefore, presently,-the interest in biofuel production is small.

5. From all companies processing fish only “Kala Ranta” and “Kala ja maryapojat” are ready to use fish waste for receiving fuel and even ready to invest their own money in the equipment for receiving biodiesel fuel. Both enterprises already cooperate with the same Finnish company the supplier of the equipment “PohjolanMuovituote” Oy, Suomussalmi.

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ENERGIJOS ATGAVIMO IŠ BIOLOGIŠKAI SKAIDŽIŲ ATLIEKŲ GALIMYBĖ – ENERGIJOS POTENCIALAS IR TAUPYMAS

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Santrauka

Šiame straipsnyje analizuojamos aplinkos apsaugos problemos, susijusius su išmetamomis atliekomis. Darbe pateikiama Rusijos ir Karelijos Respublikos žemės ūkio produkcijos rinkos būklė. Straipsnyje apžvelgiami pagrindiniai atliekų tvarkymo būdai, taikomi įvairiose pramonės šakose, naudojant įvairias technologijas ir įrenginius. Pateikiami kokybiniai ir kiekybiniai vaivorykštinių upėtakių auginimo įmonių Karelijoje rodikliai. Straipsnyje pristatomas žemės ūkio atliekų panaudojimo įvairiais būdais pelningumas ir veiksmingiausi atliekų perdirbimo būdai atsižvelgiant į aplinkos apsaugos aspektus. Be to, pateikiamos atliekų pakartotinio panaudojimo Karelijos Respublikoje galimybės bei veiksniai, stabdantys šios veiklos plėtrą.

Raktiniai žodžiai: energijos potencialas; atliekų perdirbimas; žuvų atliekos; biologinės atliekos; biodujos; bioenergija; energijos naudojimo efektyvumas; ekologija.

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