INVESTIGATION OF SAPROPEL EXTRACTION TECHNICAL TOOLS

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Abstract. A brief review of the current situation and activities in sapropel extraction, as well as equipment used for sapropel extraction in Latvia is given. Latvia has a lot of sapropel resources that are found in water reservoirs, but it is used in a very small amount. Many of the reservoirs rich in sapropel are located in agricultural areas, but extraction is not possible due to the lack of appropriate equipment for farmers. In the research the technical restrictions that hinder the development of sapropel mining are recognized.

Key words: sapropel, extraction, equipment.

Introduction

Sapropel is organic sediments that accumulate deposition and transformation of dead aquatic organisms and debris along with mineral particles. In most of the lakes in the territory of Latvia sapropel is found, it is also found in many swamps under the peat layer. Latvia has 2256 lakes with a total area of 1001 km^2, from these lakes 1323 are with an area of more than 3 ha [1; 2]. Of these, 605 lakes have been explored to a level that it is possible to determine the suitability of sapropel extraction, in 370 lakes sapropel has been researched. Total sapropel stocks in these lakes are $274 \cdot 10^6$ m^3, including organic sapropel with $57 \cdot 10^6$ m^3 of low ash content, but carbonate sapropel $40 \cdot 10^6$ m^3. For sapropel extraction silicate sapropel with the ash content more than 65 % as well as limonite sapropel with the iron oxide content greater than 10 % are useful. According to the obtained lake research results it may be concluded that the total resources of sapropel in Latvian lakes are between $700 \cdot 10^6$ and $800 \cdot 10^6$ m^3. And the maximum observed thickness of sapropel is 20 m.

Lake placement in Latvia which contain sapropel sediments is given in [2]. Of this it is evident that the main resources of sapropel are located in the central and eastern parts of republic. Research has shown that high-quality organic sapropel is mainly located in the lakes that are mainly further away from the sea and are located above the sea level. At the same time, approximately 20.4 % field soil of the republic is below the critical level – the organic matter content there is less than 1.5 %, but in the erosion endangered areas: Kraslava – 51.8 %, Daugavpils – 40.2 %, Ludza – 39.7 %, Rezekne – 30.9 %. Directly in these areas most of sapropel resources are found.

Resources of sapropel are very rich but the actually obtainable quantity of sapropel per year is only 80 000 m^3, that is average 0.03 % of the total identified resources of sapropel in Latvia. Sapropel extraction is restricted by strict rules of abstraction initiation of sapropel and expensive technological equipment costs.

Sapropel mining initiation includes both the purchase of technical equipment and watercourse development projects that are aligned with the ESB (State Environment Bureau). In order to legally be able to start sapropel extraction it is necessary to develop an opinion of the State Environmental Monitoring Bureau. The opinion confirms that sapropel extraction does not cause any damage to the environment, as well as having taken all preventive measures of sapropel mining start-ups. For environmental assessments it could be better and easier if coordination offices are available that offer ecological assessment of further harmonization with the ESB [3]. To start sapropel extraction, it is very important to get the adjacent property owner's consent. Initially, the term is aligned with the regional environmental services and the district council. In order to allow sapropel extraction it is very important to use environmentally friendly technology acquisition. Most mining equipment caused irreversible adverse effects on water reservoirs of biological balance. Such inadequate equipment is detrimental to plant, fish and birds ecosystems.

The project must include detailed information about the subscriber and preparer, information about the location of the deposit location, land holdings. In the explanatory memorandum extraction authorizations or license of subterranean depths use must be included.

In order to determine sapropel to be processed it must include information about preventive works in the mining area and location of buildings. There has to be detailed justified development system selection and its justification. Information about obtained mineral resources loading docks, temporary storage and transportation areas must be provided. These boundaries of license area only a certified person may draw for work implementation, in the presence of a mineral resources acquirer agent.

In each body of water sapropel agrochemical and quality features are determined, which determine its use in industry. It is important to clarify the geomorphological structure of deposit exploring conditions of deposit formation.

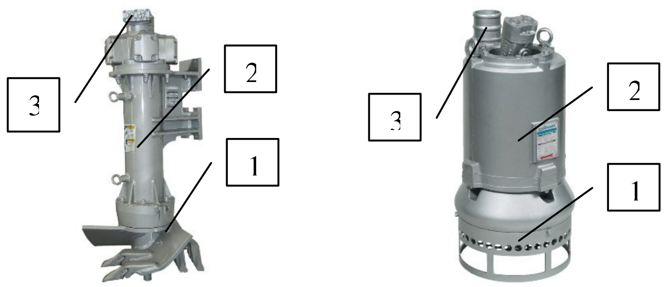
In order that Latvian farmers could start the extraction of sapropel, it is necessary to develop appropriate equipment in the holding existing water basins. As the main factor to be taken into account is the universality of the equipment, maximum use of already existing holding equipment (air compressor, transport, etc.)

Materials and Methods

Resources of sapropel that are most commonly found in Latvia can be divided: swamp sapropel and lake (river) sapropel. In the working process the author will discuss equipment of sapropel extraction for lake and river sapropel. Sapropel extraction in such water bodies must comply with all environmental ecological requirements, because incorrect conduct of extraction may harm the ecosystem of the water basin, which includes fish and other water inhabitants. In the long term it may also harm wild bird species near the water basins.

In recent years used sapropel mining technologies in Latvia and Europe are different from the so far most commonly used. Technologies are focused on an environmentally friendly extraction process, which is most harmless to the environment. The most common of these technologies is the use of dredges. Such dredges are placed on pontoons, barges, rafts. This technology is used for deepening and cleaning water bodies. Dredger is based on a pump that from the water bodies of a watercourse together with the bottom layer also is pumping water. Further injected bottom is drained to storage basins, reservoirs. For sapropel extraction dredges by different companies and mining technologies are offered:

- rotary cutter dredge (cutters help develop a layer of horizontal or vertical;
- dredge with immersed or not immersed pneumatic pump;
- dredge with immersed or not immersed centrifugal pump;
- pneumatic suction dredge pump.



a) b)

Fig. 1. **Rotary cutter dredge (a) [4]:** 1 – mill; 2 – engine; 3 – pipeline; **Centrifugal pump dredge (b) [4]:** 1 – turbine; 2 – engine; 3 – pipeline

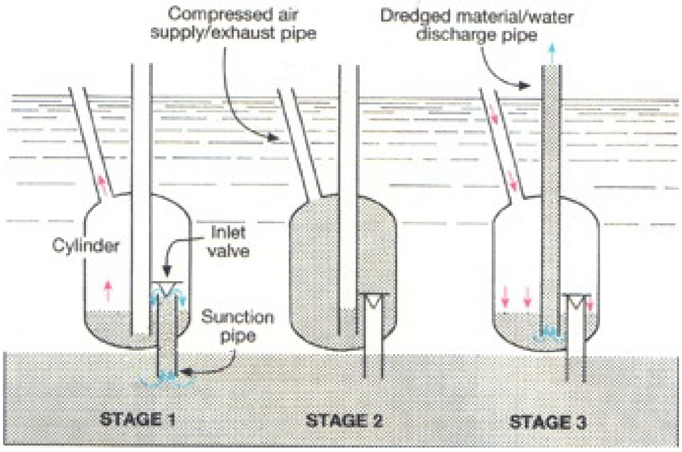
Rotary cutter dredge (Fig. 1, a) is used for extraction of solid fractions bottom at high water depth. The machine is equipped with a surface pumping node and with high engine speed for the cutter motion. The dredge with a rotating hub creates turbidity during the extraction.

Centrifugal pump dredge (Fig. 1, b) has a fixed turbine on the pump axis that turns in a closed pumping chamber. Sapropel is being pumped into the centre of the turbine chamber and then pumped through the pipelines. Centrifugal pump makes low water turbidity.

Point-vacuum method [1] is based on the vacuum pump operation principle. Sapropel extraction in the supply pipeline happens with vacuum propelled by an electric motor or internal combustion engine. Drive configuration depends on the specific areas of engineering possibilities; however, an electric motor is the most friendly version for a certain territory which does not create exhaust gases. During extraction of sapropel 2-2.5 m radius around the mining site sapropel is pumped into the pipeline using vacuum. Further the storage tanks are brought ashore. Such an extraction method is environmentally friendly, but it consumes large energy resources. The unit is equipped with automatic, which control by sensors sapropel density. Such automation is needed to get a clean and intact sapropel mud layer on top of the mining area to exclusion of density changes in the installation. This extraction method is environmentally friendly, but it consumes large energy resources. Extraction speed is an average of 3 $m^3 \cdot min^{-1}$, which is relatively small against similar equipment. With such a method of extracting sapropel is obtained in natural humidity. During the extraction process sapropel mixing with water does not happen. The machine is not equipped with rotary units, which could cause water turbidity. The only turbidity that may occur during the extraction is vacated space of sapropel filling with the sludge.

Currently available dredge pump market leader of sapropel extraction is considered a pneumatic suction dredge pump (Fig. 2, a). Such dredge suction is operated with compressed air in water pneumatic chambers being submerged. The high suction capability of this pump allows making bottom suction and feed on the surface with a very high concentration. The particulate matter concentration may be 50-70 % (90 % natural bottom density) [5] using centrifugal or bottom axis pump density from 10 to 25 %. Pneumatic chamber pump can make bottom suction without prior loosening; this is achieved through the use of external hydrostatic pressure absorption chambers. As mechanical rippers in equipment rotating cutters, auger and hydro rippers are used. With the pneumatic technology the highest environmental performance in water and on the shore is provided. The work cycle of the pneumatic suction pumps can be divided into three work cycles (Fig. 2, b) [6-8].

a)



b)

Fig. 2. **Pneumatic suction dredge pump (a) [6], work cycle of the pumps (b) [8]**

In the first cycle (Stage one) the system is filling the pump cylinders. Each cylinder is rapidly filled with mixture by the counter pressure due to the hydrostatic head, with the help of a vacuum system in case of shallow waters. As soon as one cylinder is filled, the inlet valve automatically closes by its own weight. In the second cycle (Stage two) the system is emptying the pump and reflowing. When the cylinder is filled, compressed air supplied by a compressor through the distributor and air hose acts as a piston and the mixture is thus forced out through the delivery valve. In the third cycle (Stage three) the system is discharging compressed air and preparing for Stage one. When the cylinder is almost emptied, the distributor discharges the air into the atmosphere. Once the internal pressure is released, the cylinder once again becomes filled with the mixture, as described in phase one.

Results and discussion

Comparison of sapropel extraction technology methods is summarized in Table 1.

The degree of pollution is determined by the extraction methods of mechanical parts, with rotary or linear motion node, causing water turbidity [9; 10].Taking into account the environmental requirements of the service many of the used extraction methods will not be recognized as appropriate according to the environmental requirements set by the LV and EU.

Using the pneumatic suction dredge pump technology water turbidity in the treatment zone is 2000 times lower than the operating time of the rotary cutter dredge pump. High concentration mixture of hydro obtained by the pneumatic pumps makes further transport of sapropel very simple. There is no need to obtain sapropel pumping on the shore existing basin. The sapropel mixture concentration is so high that it is ready for further transport.

Table 1

Comparison of sapropel extraction technology methods

Extraction method	Technology productivity	Level of turbidity
Pneumatic suction dredge	15-30 $t \cdot h^{-1}$	Low
Cup	30 $t \cdot h^{-1}$	High
Soft containers	1-2 $t \cdot h^{-1}$	High
Centrifugal pump dredger	10-30 $t \cdot h^{-1}$	Low
Point-vacuum	20-30 $t \cdot h^{-1}$	Low
Rotary cutter dredge	20-25 $t \cdot h^{-1}$	High
Hand bailer	0.08 $t \cdot h^{-1}$	High

In these pumps the actuator is not rotating the nodes during the operation; it makes only reciprocal motion at rate not more than 1-3 min^{-1}. Such pumps can be mounted on a variety of floating platforms (barges, pontoons, rafts). The pneumatic pump production rate is from 40- 1800 $m^3 \cdot h^{-1}$ with 50-70 % particulate concentration in hydro mixture. The main advantages of the pump are high concentrations of product extraction and low turbidity degree development of assurance zone.

Conclusions

1. In Latvia there are large sapropel resources but per year only 0.03 % are extracted, the research shows that extraction is hindered by high environmental regulatory requirements and large extraction costs of equipment.
2. Looking at the available extraction technologies for lake sapropel, it has been established that for this resource the pneumatic pump extraction method is most suitable.
3. The research shows that despite the benefits of extraction methods there are not available small in size extraction equipments for the needs of farmers.
4. In further studies it is necessary to develop the construction of equipment, which operates on the principle of operation of a pneumatic pump and which by gauges and productivity would be universal usage, in order to be used as available technique on farms (compressor, transport, etc.).

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