

# Creation of an environmental complex for the finishing of water facilities in oil fields

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**Abstract:** The aim of our study is to find solutions for reducing anthropogenic stress from oil and petroleum products pollution in oil production areas. To this end, it is proposed to establish an environmental facility for the treatment of water bodies. The climatic conditions and experience of the application of purification complexes in the conditions of the Far North should be considered. Conduct an analysis of the quality of water bodies and existing pollution at present. Based on the analysis, design an environmental complex to clean water from oil and petroleum products. The Environmental Complex will implement a phased clean-up of water bodies. The technology is based on natural mechanisms of transformation of technogenic water bodies into a natural ecosystem to improve the efficiency of industrial effluent treatment. The ecosystem will consist of gabion structures, innovative phytopulvers for optimal conditions for plant growth and development. Phyto Modules have a simple design. The proposed technology will improve water pollution and improve the ecology of our region.

## 1 Introduction

In Western Siberia, oil and gas are extracted from large deposits. The continuous development of the oil and gas complex leads to the presence of oil in water bodies. The state of the natural environment is largely dependent on the degree of pollution caused by human activities. Industrial waste, including wastewater, contributes significantly to this

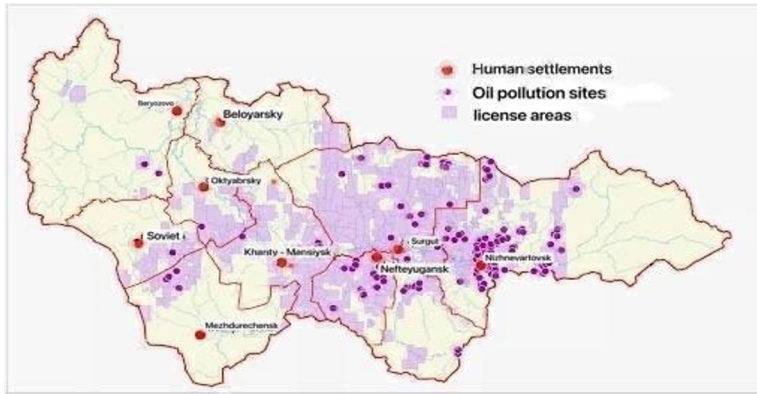
In the production of hydrocarbons, drilling wells, oil and gas extraction by well method, preparation and processing of petroleum products. All this is accompanied by the release of harmful substances into the environment, including into water bodies. Oil can film on the surface of water, is at the bottom as sediment, fish and other inhabitants of the waters may have oil smell.

The oil and gas complex pollutes the environment. It has a significant impact on the atmosphere, soil and water. The most polluted water bodies are rivers, lakes and streams. The state of small rivers has a significant impact on the state of large rivers and the overall environmental situation in the region. Conservation of the environment in mining regions is a very pressing issue. The state of the environment in Russia is monitored by a service for control and supervision in the field of environmental protection, wildlife and forest relations. The register of areas and water bodies of the Khanty-Mansiysk Autonomous Okrug - Ugra

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contaminated by oil, petroleum products, sub-commodity water is constantly maintained. Surface and groundwater can spread pollution over long distances. The oil and gas complex is currently actively working on environmental protection. To avoid pollution of water bodies by enterprises and the state, monitoring of water bodies and presence of harmful impurities in them. Observation posts are now established throughout the Khanty-Mansiysk Autonomous Okrug (figure 1.)



**Fig. 1.** Water pollution map (from open sources)

## 2 Materials and methods

The aim of our study is to find solutions for reducing anthropogenic pollution burden on water bodies by developing an ecological complex of additional treatment of water bodies. To do this, we must study the climatic conditions and experience of the application of purification complexes in the conditions of the Far North. We will conduct an analysis of the quality of water bodies and existing pollution at present. Based on the analysis, design an environmental complex to clean water from oil and petroleum products. The Environmental Complex will implement a phased clean-up of water bodies. The technology is based on natural mechanisms of transformation of technogenic water bodies into a natural ecosystem to improve the efficiency of industrial effluent treatment. The ecosystem will consist of gabion structures, innovative phytomulchers for optimal conditions for plant growth and development. Phytomodules have a simple design. The proposed technology will improve water pollution and improve the ecology of our region.

Research on the development of technologies for efficient post-quarrying water treatment in conditions of the Far North is being carried out since 2012 in the Kola Scientific Center. The Russian Institute of Technology has been working on this topic since 2010. As a result, low-cost innovative technology for creating phyto-cleaning systems using floating phytomodules was developed and a range of native plant species were selected that give high biomass in the conditions of the North. Their complex use has allowed to optimize the conditions for intensive growth and development of plants, and to form different combinations of plant blocks. We have used this experience in part for our study.

Traditional approaches to industrial effluent treatment are being continuously improved through the introduction of new technologies and modern equipment. The main criteria for selecting and evaluating their effectiveness, along with the proportion of pollutants removed, are also the amount of capital and operating costs to clean up a unit of wastewater, the complexity in service and climatic limitations of use. Therefore, the world continues to actively search for, develop and apply the most efficient, environmentally and economically

acceptable alternative methods for the treatment of industrial wastewater, reducing resource consumption and waste generation in wastewater treatment.

The first artificial sewage treatment plants based on natural mechanisms were established in Australia in the early 20th century. Research in this field began in Europe in the 1950s and in the USA in the 1970s. [1-14]. After that, the phytotechnologies for wastewater treatment began to develop massively in many countries due to the availability and relatively high efficiency of wastewater treatment, and the demand for such projects has increased sharply.

Currently recognized as a popular and cost-effective alternative to industrial wastewater treatment for various types of pollutants, phytosystems are being developed in almost all natural climate zones from Norway to Australia (mainly in North America, Europe, Southeast Asia and the Pacific) [12]. For example, in the US and the EU, artificial plant cleaning systems are considered part of a sustainable development and renewable environmental management system and used to clean industrial and municipal wastewater.

Water treatment systems built using phytotechnologies belong to the class of new water protection structures and are bog-like, similar to natural landscape systems. Phyto-systems combine the main technical elements of facilities designed for cleaning wastewater from contaminants contained therein by means of aquatic vegetation and microbial communities developing in their root zone and on other substrates in the aquatic environment. In the world, these phytosystems are called constructed wetlands, biomatops, phytosanitary systems or structures, bioengineering structures.

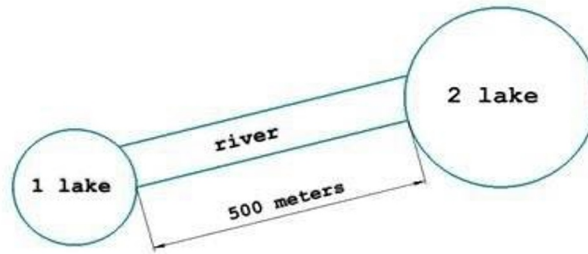
The Khanty-Mansiysk autonomous district is located in the area of the Far North. The winter period lasts for 8-9 months, the snow lies for 8 months. The earth freezes for several meters. The amount of snow reaches two meters during the winter. The snow cover on the ground and ice on the rivers is until mid-May. The summer period lasts about a month. The climate is characterized by sudden changes in temperature and pressure, lack of oxygen, ultraviolet, vitamins and minerals. The harsh winter with long frosts is replaced by warm summers. Snow melts in mid-May, and begins to fall already in September. The spring frost can be in June and autumn in early September. Therefore, the growing season is about three months. Precipitation is much in the form of snow, hail and rain due to high humidity.

Frost can reach - 50-60 0C. The average annual air temperature is minus 3.4 o C. Temperature and pressure changes can occur within a day. The climate is strongly continental. The formation of climatic features of the region forms on one side the Ural mountains, which protect from the penetration of air masses from the West, and on the other side open space from the Arctic Ocean, from where cold Arctic masses enter the district, Bringing low temperatures with you. Also affect the climate and air masses coming from the south of Kazakhstan, which bring heat.

Global experience with environmental systems in Denmark, Sweden, Norway and North America shows that artificially constructed wetlands as sewage treatment facilities are effective even at low temperatures. The winter activity decline is not significant compared to the warm season, the insulation of the marshland with snow, ice and natural vegetation allows them to remain functional even in low temperatures [4].

For the experiment in the conditions of the Khanty-Mansiysk Autonomous Region to create an environmental complex of water purification facilities, a river was selected. It naturally connects two lakes. One lake is near the oil and gas production bushes. The second lake is a source of water bodies, which flow into the huge Siberian river. It is proposed to build water treatment facilities and test near an existing oil field.

Important factor is the transport accessibility of the considered waters. Convenient location - close to the city. Small length of the river about 500 meters. These factors will reduce the cost of an experiment to create an ecological complex of water purification. When cleaning water bodies from pollution, it is possible to restore the ecological balance.



**Fig. 2.** Scheme of the ecological complex of water purification.

The environmental treatment complex of water facilities will consist of a small river located between two lakes. The first lake will be used for the discharge of waste from wells for oil extraction and initial cleaning of impurities. An ecological complex will be built on the river. In the second lake, water must meet the standards for freshwater impurities after passing 500 meters of rivers.

The entire process of cleaning up a water body in a river is divided into 3 modules. The steps will be carried out in the following sequence (figure 2):

- 1 module - filtration, sorption by installing gabion structures using phytoremediating;
- 2 module - only phytotherapy (phyto-extraction, phytodegeneration, phytostimulation, phytoevaporation, phytostabilization, rizofiltration) is used.

Phytoextraction - the ability of plants to accumulate pollutants in their tissues and thus reduce their concentration in soils.

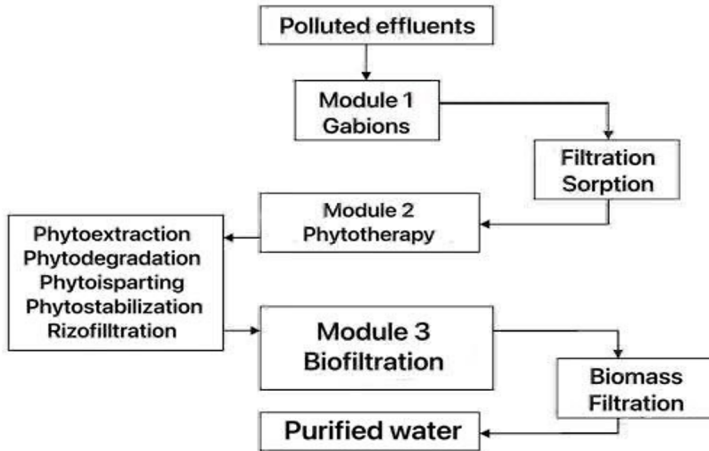
Phytodegrade - degradation of organic part of the pollution by plants and symbiotic microorganisms; phyto-stimulation - stimulation of development of symbiotic microorganisms involved in the cleaning process. The main role in degradation of pollution is played by microorganisms.

Phytostabilization (or fitorestablization) - physical and chemical immobilization of pollutants by sorption at roots and chemical fixation with various additives in the soil to stabilize toxic substances and prevent their spread through wind and water erosion; to reduce vertical migration of pollutants into groundwater.

Rizofiltration is a method of cleaning up pollution that can be carried out in situ, with plants grown directly in the polluted water or ex situ where plants are grown outside the plot and then introduced into the contaminated water.

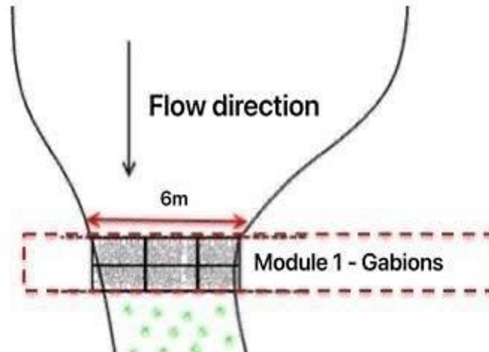
3 module - biofiltration cleaning with the use of gabion structures with biofilters. After the last module we must get water that will meet the standards of permissible concentrations of pollutants in the waters entering the plant's water disposal systems. The main one is MPC, which is the maximum permissible concentration of harmful substances in water.

Exceeding the established MPC harms the flora and fauna of the water and requires cleaning of the effluents. The MPC standards are uniform throughout Russia and their application does not depend on natural-climatic, geochemical, hydrochemical and hydrological characteristics of the waters.



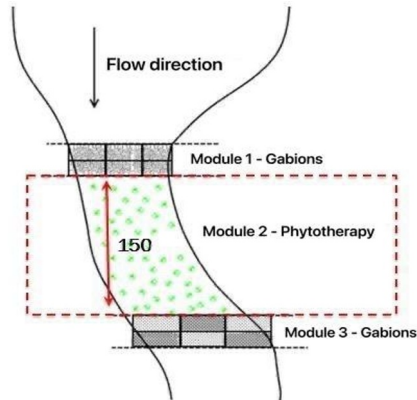
**Fig. 3.** Water treatment scheme

At the beginning, the drains are taken to the «Regulating tank». This can be any suitable water object. The contaminated water then passes through a narrow channel 6 meters wide (figure 3) and about 2 meters deep, where we will place the first cleaning module consisting of gabions with a sorbing and filtering loading based on a bioabsorber and adding gravel, gravel and stone. The total area of gabions will be about 15 m<sup>2</sup>. Sewage treatment by the following indicators: chlorides, sulphates, phosphates, nitrates, ammonium nitrogen, suspended solids, petroleum products.



**Fig. 4.** Module 1.

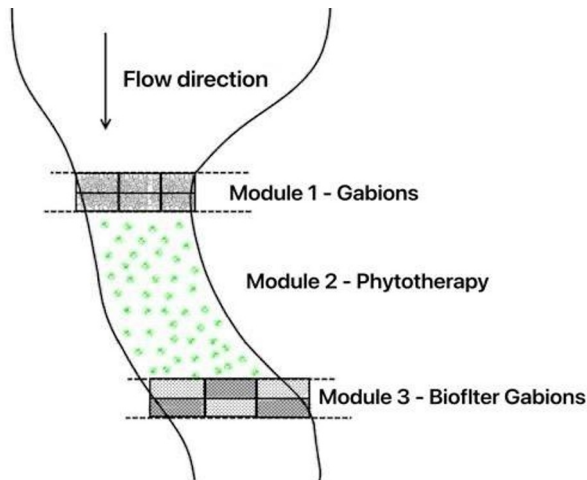
The second purification module is a phyto-remediation module, consisting in passing the effluent through communities of higher aquatic plants - macrofités (figure 4).



**Fig. 5.** Module 2.

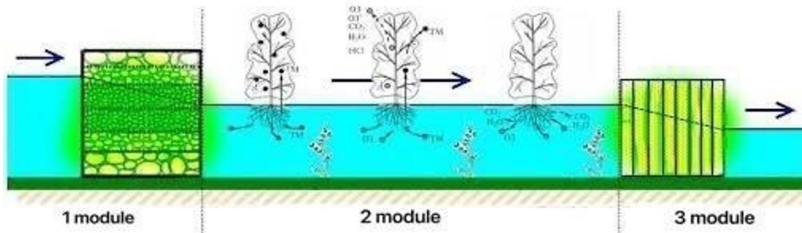
The length of 2 modules is approximately 150 m.

By introducing the macrofite communities we create a biomolecular analogue. Such a system will develop independently and support the natural water purification process. Clean the effluent of the following pollutants: suspended solids, dry residue, phosphates, nitrates, nitrites, ammonium, iron, chlorides, sulfates, petroleum products. The following plants are used: Weideland, Marsh Sabre, Creeper, Eyhornia, Pike, Willow and other plants.



**Fig. 6.** Module 3.

The final module (figure 5) uses a film filter to purify water. Its bioloading is in the form of flat sheets consisting of a set of interwoven fibers of durable polymer. Filtration should reach up to 94% and this allows maximum amount of dirt to be cleaned.



**Fig. 7.** Environmental wastewater treatment facility

Module 1 provides a combination of several technologies for the purification of water flow - mechanical, sorption. Also, if there is a biosorbent as a loading of the gabion, bio-film is formed, which provides additional water purification by bioabsorption.

Module 2 combines a large number of phytomedia water purification technologies: phyto filtration, phyto extraction, phyto evaporation, biosorption, which effectively purify the water from organic, oil traces, nitrate, nitrite-ammonium.

In module 3, the final cleaning of the effluent is achieved by loading different density and diameter biopolymer filters. Will clean up the runoff by: CHC, NH<sub>4</sub>, P, suspended particulate matter.

For the study, an environmental complex of water purification facilities in the oil field near extraction wells and tufted sites was designed. The technology of ecological cleaning is based on the use of gabion structures with biofilters and phytomodules. The experiment is planned to be conducted on a real water object on a river and two lakes. The environmental complex of water treatment facilities near the oil field will allow to clean up the water environment.

### 3 Results

The experiment will result in the construction of an ecological complex for the treatment of waste water.

It is also worth noting the features of operation of such facilities:

The most intensive cleaning processes are carried out during the warm season when the temperature is not lower than 5 °C. In the cold season, contaminated water is filtered to the required level. The biofilters must be replaced once every 5 years. The warranty period is 25 years.

The ecological complex does not require monthly costs for the operation of treatment facilities. Only periodic replacement of biofilters is required.

As a result, the application of an eco-friendly cleaning complex provides conditions:

- purification and decontamination of runoff water;
- reduction of anthropogenic load of runoff;
- restoration of water bodies and bringing the quality of water to the required standards for fisheries management waters.

### 4 Conclusion

Currently, artificially created wetlands as plant treatment facilities are recognized as promising environmentally friendly technology for cleaning and post-treatment of liquid effluents from various types of pollutants, they are created in almost all natural-Climatic zones from Norway to Australia, including cold climate zones. As the quality of functioning of the gabion structures and phytocleaning system largely depends on climatic characteristics,

volumes and composition of polluted waters, features of technological process, etc. , their creation in northern latitudes requires a case-by-case approach.

## References

1. Dong Qing Zhang [et al.] Application of constructed wetlands for wastewater treatment in developing countries A review of recent developments (2000–2013). J. Environmental Management. 2014. Vol.141. P. 116–131.
2. Constructed Wetlands Treatment of Municipal Wastewaters Manual — National Risk Management Research Laboratory; Office of Research and Development; U.S. Environmental Protection Agency. Cincinnati, Ohio 45268 EPA/625/R-99/010. 1999. September
3. Tanaka N, Gunaratne G. Design of tropical constructed wetlands. Wetlands for tropical applications: Wastewater Treatment by Constructed Wetlands. London : Imperial College Press, World Scientific Publishing Co. Pte. Ltd., 2011. P. 69–93.
4. P. Jenssen, T. Maehlum, T. Krogstad // Water Science Techniques. 1993. Vol. 28, No. 10. P. 149–157.
5. R. H. Kadlec, S. D. Wallace. 2nd ed. CRC Press, Taylor & Francis Group, Boca Raton, 2008. No. 24 (11). P. 34–38.
6. Mattila, K. Biological removal of nutrients from mine waters / K. Mattila, G. Zaitsev, J. Langwaldt // Biologinen ravinteiden poisto kaivosvedestä. Final report-loppuraportti. 2007. 99 p.
7. M. Dzakpasu, M. Scholz, V. McCarthy, S. Jordan // Water Sci. Technol. 2014. No. 70 (9). P. 1496–1502.
8. Patrick, P. Constructed wetlands. Fujita Research. Brighton, 1998. 13 p. URL: <http://www.fujitaresearch.com/reports/wetlands.html>
9. Savelyev, Ya. V. Advantages of gabions in purifying water from petroleum products. Innovative processes in science and technology of the 21st century: Materials of the XX International Scientific and Practical Conference of Students, Postgraduate Students, Scientists, Pedagogical Workers and Practitioners. In 3 volumes, Nizhnevartovsk, April 21, 2023. Volume 2. – Tyumen: Tyumen Industrial University, 2023. – P. 370-374.
10. Savelyev, Ya. V. Wastewater treatment using gabion structures. Experience, current problems and prospects for the development of the oil and gas complex: Materials of the XIII International Scientific and Practical Conference of Students, Graduate Students and Scientists, Nizhnevartovsk, April 20, 2023. - Tyumen: Tyumen Industrial University, 2023. - P. 156-160.
11. Savelyeva N.N., Saveliev, Y. V. Construction of water bodies for complex filtration gabion purification from oil products. Components of Scientific and Technological Progress. № 11(89) 2023 c. 28-31.
12. Vymazal, J. Constructed wetlands for treatment of industrial wastewaters: a review // Ecol. Eng. 2014. Vol. 73. P. 724–751.
13. J. Vymazal // Water. 2010. Vol. 2. P. 530–549.
14. P. L. Younger // J. Eng. Geol. Hydrogeol. 1995. No. 28. P. 101–113.