Using Wood Waste for Reclamation of Oil Polluted Arctic Lands

Yu V Malakhova\(^1\), E A Mazlova\(^2\), O S Ostakh\(^2\)

\(^1\)OOO «Gazprom dobycha Nadym», Nadym, RF
\(^2\)Gubkin University, Moscow, RF

E-mail: mazlovaec@gmail.com

Abstract. The paper is devoted to the study of the use of wood waste as improvers engaged in the reclamation of oil-contaminated lands using bioremediation. Wood waste can act as carriers for biological products and mulching materials that optimize the harsh climatic impact on soils cleaned from oil products. At the example of using pine sawdust of 1.0-1.5 cm fraction for biological purification from oil pollution in laboratory conditions, it is shown that the increase in oat seed germination is 6-28% compared to the introduction of a biological product by sprinkling. At the same time, it was found that fine-grained pine sawdust negatively affects bioremediation, due to accelerated decay of wood, accompanied by the release of toxic components. The use of wood waste in the reclamation of oil-contaminated Arctic lands will eliminate their expensive transportation to legal disposal or burial sites and involve them in soil restoration processes.

1. Introduction
The development of the economy and industry of the Russian Federation requires involvement of the country's territories and, in particular, those in the Arctic zone, in the active economic use. Last century operations were carried out in the circumstances of undeveloped infrastructure in remote areas, where heaps of waste (logs, barrels, pipes, scrap metal) have been accumulated by now, and many areas have been contaminated with oil products and heavy metals. Everywhere there is a thawing of soils, provoked by the movement of transport and special equipment in summer, making fires and by other violations of the code of good practice in continuous permafrost areas. This led to the irreversible destruction of the soil and vegetation layer and the disruption of the sensitive heat balance of the permafrost. To develop the resources of the Arctic, oil and gas companies are forced to deal with the elimination of objects of accumulated harm to the environment, in particular, using methods of land bioremediation.

2. Topicality, scientific merit and brief review of the literature
Remediation of oiled soils is a very slow process. With a high extent of pollution, the functional activity of flora and fauna is almost completely depressed, the vital activity of most microorganisms is inhibited \([1]\) and the self-cleaning ability of the soil is inhibited \([2]\).

The active development of biotechnology has determined the use of bioremediation as one of the most preferable approaches from an ecological and economic point of view.
However, an extremely short vegetative period in the Yamalo-Nenets Autonomous Okrug, equal to only two months with an average temperature of + 5.9 °C, cannot contribute to the effective use of bioremediation to eliminate pollution at the sites of accumulated environmental damage. Therefore, it is necessary to modify the methods of bioremediation by using ameliorants and carriers of bacteria preparations that optimize the harsh climatic effects on microorganisms. Glauconite, glass-phosphate granules and organic ameliorants - millet husks, sunflower husks, buckwheat have been used as such carriers [3-16].

However, wood waste also represents an organic part of ecosystems [16] and can probably be used as ameliorants for bioremediation of oil-contaminated areas. This approach can make it possible to involve wood waste in reuse and create optimal conditions for bioremediation of oil-contaminated Arctic territories.

3. Research objective
This study was aimed at conducting an experimental study of the possibility for using wood waste as ameliorants in order to increase the efficiency of the process of bioremediation of oil-contaminated Arctic lands.

4. Experimental procedure
A soil selected for this research consists of sand (up to 70%), clay (up to 20%), peat (up to 10%) [17]. Soil pollution with diesel fuel of the DT-L-K5 brand was carried out under model conditions with the provision of mass concentrations of oil products equal to 1%, 5% and 10%, as the most common levels of pollution in real-life situations.

Pine sawdust of three fractions was used as ameliorants: 1-1.5 cm, 0.5-1 cm, 0.2-0.5 cm. The immobilization of microorganisms on samples of pine sawdust was carried out by soaking it in an activated solution of the biological product DOP-UNI [18] during 24 hours.

Model samples of contamination in three replications were placed in plastic containers with drainage holes with a useful volume of 300 g; prepared ameliorants were introduced into them in three variations: 1%; 3%; 5%.

For the preparation of control samples, pine sawdust was not used and the introduction of the biological product was carried out directly in containers.

The registration of changes in the efficiency of bioremediation was carried out by bioindication - according to the germination of oats in control samples as compared with those studied [19] on the 8th day after planting oat seeds.

During the entire period of the experiment (108 days), the humidity was maintained by irrigation, and the pallets with the test and control samples were regularly unfolded and changed places to provide for uniform exposure of each container with soil to the light.

When setting up the experiment, the principle of a single difference was observed, that is, in its variants, the unity of all conditions was observed with the exception of one - the studied one. Thus, to study the change in the efficiency of bioremediation of oil-contaminated soils using ameliorants from pine sawdust, 30 experiments were carried out in three repetitions.

The studied variables were the following contents and values:

V - oat seed germination, %;
D - mass fraction of the initial content of diesel fuel in the samples, %;
M_{1.0-1.5} - mass fraction of ameliorant from pine sawdust of fraction 1-1.5 cm;
M_{0.5-1.0} - mass fraction of ameliorant from pine sawdust of fraction 0.5-1 cm;
M_{0.2-0.5} - mass fraction of ameliorant from pine sawdust of 0.2-0.5 cm fraction.

The results of the experimental data were verified by making regression equations. Modeling of germination values was carried out to come at conclusions about the comparative efficiency of using wood waste of various fractions in the reclamaiion of oil-contaminated Arctic territories. The results
of experiments were used on the basis of which a regression equation was estimated that describes the dependence of oat germination (dependent variable) on the parameters of the initial pollution with oil products (D) and the amount of ameliorants of various fractions \((M_{1.0-1.5}, M_{0.5-1.0}, M_{0.2-0.5})\) in equation (1) are independent variables.

\[
V = -1.18 \cdot D + 5.55 \cdot M_{1.0-1.5} + 4.28 \cdot M_{0.5-1.0} - 1.42 \cdot M_{0.2-0.5} + 57.51
\]  \(1\)

Equation (1) was worked for experimental data. The coefficient of determination - \(R^2\) of equation (1) was 0.73.

The graphs of the experimental and calculated germination values is shown in Figure 1.

![Graphs of correspondence between experimental and calculated by the regression equation values of «Oat seed germination, %»](image)

**Figure 1.** Graphs of correspondence between experimental and calculated by the regression equation values of «Oat seed germination, %».

5. **Practical relevance, proposals and results of implementation, results of experimental study**

The greatest positive coefficient of equation (1) corresponds to the variable «mass fraction of ameliorant from pine sawdust of 1-1.5 cm fraction». Therefore, other things being equal, it is this fraction that will contribute to the maximum germination of oat seeds, that is, it will have the best effect on the bioremediation of oil-contaminated areas.

Comparison of oat seed germination in control and studied samples showed that immobilization of the biological product on pine sawdust of 1-1.5 cm fraction allows to increase the germination capacity by 6-28\%\(^1\) compared to the introduction of the biological product by the sprinkling method.

\(^1\) Depending on the initial oil contamination and quantity of sawdust

For a fraction of pine sawdust of 0.5-1 cm, the increase in germination will accordingly be 4-21\%\(^1\). The fraction of pine sawdust of 0.2-0.5 cm showed the worst result - the germination rate here decreased by 1-7\%\(^1\) in comparison with the usual method of introducing a biological product. This circumstance may be a consequence of the accelerated decay of sawdust of a smaller fraction, which is accompanied by the release of toxic components such as phenol, resorcinol and catechol, as well as cresols [20].
6. Conclusions
1. The research resulted in obtaining information on the comparative efficiency of immobilization of a biological product on pine sawdust of various fractions.
2. An increase in oat seed germination by 6-28% in samples of oil-contaminated soils with the introduction of pine sawdust of 1-1.5 cm fraction was established.
3. The inhibition of oat seed germination was shown by 1-7% in samples of oil-contaminated soils, into which pine sawdust of 0.2-0.5 cm fraction was introduced, which was associated with accelerated decay of wood, accompanied by the release of toxic components.
4. Thus, the possibility of using sawdust of wood waste larger than 0.5 cm as ameliorants in order to increase the efficiency of the process of bioremediation of oil-contaminated Arctic lands has been experimentally proved.

7. References
[1] Alekhin V G, Emtev V T, Rogozina E A, Fakkhrutdiniov A I 1998 Biological activity and microbiological reclamation of soils contaminated with oil products Biol. Resursy I prirodopolzovanie Issue 2 pp 95-103
[2] Safonnikova S M 1991 Hygienic assessment of soil in the area of location of a large petrochemical complex and regulation of some toxic pollutants in it Thesis for a Candidate degree in Biology, author’s abstract (Moscow) p 166
[3] Patent 2681831 Russian Federation, MIK C12N 1/20, C02F 3/34, B09C 1/10, C12R 1/01 A preparation for biodegradation of petroleum products and a method for its production Volkov M Yu, Abdullin R M, Anikin S V, Venkov D A, Salikhov Z S Applicant and patent holder AO "Alohakhimprom" No. 2016150216; applied 20.12.2016; published 12.03.2019
[4] Khlynovsky A M, Rozanova K V 2013 New generation of biological products based on porous glass phosphate carrier for cleaning soils and water areas from anthropogenic pollution Neft. Gaz. Novatsii. 10 (177) pp 41-46
[5] Taranovskaya E A 2017 Purification of waste water from ions of heavy metals and oil products using sorption materials based on chitosan: Thesis for a Candidate degree in Engineering, author’s abstract (Saratov) 16 p
[6] Shagiev B Z, Burlaka V A, Ishchenko E P, Burlaka N V 2016 Ecological and economic efficiency of sunflower husk application in the process of biodegradation of oil hydrocarbons Niva Povolzya 1 pp 50-56
[7] Patrusheva O V 2016 Methods for cleaning marine areas from oil pollution Molodoi ucheniy Vol 29 pp 229–234
[8] Zhukalov V I 2018 Fibrous sorbents for collecting oil and oil products Pozharnaya I avariinaya bezopasnost pp 38-42
[9] Shvedchikov G V 2010 New technology for combating oil pollution based on hydrophobic and oleophilic sorbents Obshestvo. Sreda. Razvitie (Terra Humana) 3 pp 225–228
[10] Lutsenko A N 2012 On the use of innovative sorbents and devices for oil and oil product spill response Internet-jurnal «Tekhnologii tekhnosferoi bezopasnosti» 3 pp 43
[11] Povarova L V 2019 Analysis of the application of biotechnology for the purification of various environmental pollution Nauka. Tekhnika. Tekhнологii (politekhnicheskiy vestnik) 1 pp 190–206
[12] Ivanova M A, Chikina N S, Zenitova L A 2012 Oil Pollution Cleanup Butlerovskie soobscheniya Vol 29 3 pp 1-12
[13] Buluktaev A A, Sangadzhieva L Kh 2015 From the experience of using organic sorption materials for the reclamation of oil-contaminated soils Nauchnaya mysli Kavkaza 2 pp 113–118
[14] Eremin I S 2018 Development of a sorbent material based on plant roughage: Thesis for a Candidate degree in Engineering, author’s abstract (Moscow) 21 p
[15] Patrusheva O V 2016 Methods for cleaning marine areas from oil pollution Molodoi ucheniy Vol 29 pp 229–234
[16] Kolotova O V et al. 2018 Development of a biosorbent based on crop waste for wastewater treatment from oil products Vestnik Permskogo natsionalnogo issledovatelskogo politekhnichestkogo universiteta. Prikladnaya ekologiya. Urbanistika 4 pp 58-71

[17] GOST R ISO 22030-2009 2019 Soil quality Biological methods Chronic phytotoxicity to higher plants (Re-edition) (Moscow: Standartinform)

[18] Laboratory of Microbial Technologies - bacterial preparations, destructors of oil pollution URL: https://dop-uni.ru (accessed on 11.04.2020)

[19] ISO 11269-1:2012 Soil quality Determination of the effects of pollutants on soil flora Part 1: Method for the measurement of inhibition of root growth

[20] Ermolin V N 2001 Increasing the permeability of coniferous wood with liquids: Thesis for a Doktor degree in Engineering, author’s abstract (Moscow) 39 p