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THE RESULTS OF STUDYING THE PETRO-DESTRUCTIVE FEATURES OF THE M–1 BIOPREPARATION

Research article

Abstract

The article provides information on the results of the study of the oil-destructive ability of the drug M-1. Currently, methods of biological purification (bioremediation) are used to clean oil-contaminated lands. Bioremediation provides almost complete decomposition of the pollutant to the state of water or carbon dioxide. The proposed preparation is effective for cleaning oil-contaminated soils with an average level of pollution. It is shown that the drug significantly reduces the concentration of petroleum products in all variants. At the studied levels of soil pollution, a high and rather rapid (in 30 days) decrease in the concentration of petroleum products is observed – up to 36,2–44,9% of the initial one. During 12 months of bioremediation under the action of the biodestructor M-1, there has been a significant decrease in the amount of petroleum products. At the studied levels of soil pollution, the residual pollution ranges from 13-16% of the initial pollution.

Keywords: oil-contaminated soils, oil sludge, bioremediation, purification from oil pollution, biological purification.

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РЕЗУЛЬТАТЫ ИЗУЧЕНИЯ НЕФТЕДЕСТРУКТИВНЫХ ОСОБЕННОСТЕЙ БИОПРЕПАРАТА М–1

Научная статья

Аннотация

В статье приводится информация об итогах изучения нефтедеструктивной способности препарата М-1. В настоящее время, для очистки нефтезагрязненных земель используются методы биологической очистки (биоремедиация). Биоремедиация обеспечивает почти полное разложение загрязнителя до состояния воды или диоксида углерода. Предложенный нами препарат является эффективным для очистки нефтезагрязненных почв со средним уровнем загрязнения. Показано, что препарат значительно снижает концентрацию нефтепродуктов во всех вариантах. При исследуемых уровнях загрязнения почвы наблюдается высокое и достаточно быстрое (за 30 суток) снижение концентрации нефтепродуктов – до 36,2–44,9% от исходной. За 12 месяцев биоремедиации при действии биодеструктора М-1 отмечается значительное снижение количества нефтепродуктов. При исследуемых уровнях загрязнения почвы остаточное загрязнение колеблется в пределах 13–16 % от исходного загрязнения.

Ключевые слова: нефтезагрязенные почвы, нефтешлам, биоремедиация, очистка от нефтезагрязнений, биологическая очистка.

1. Introduction

Oil and its derivatives are natural chemicals that are used by humans every second all over the world. Since this resource is often and widely used for various purposes, and its extraction and processing are carried out quite intensively, it is the main pollutant of the environment [1]. In industrially and economically developed countries, soil contamination with oil or its

products is a huge and serious problem. Every year around the world, about 50 million people enter the environment. tons of oil and petroleum products, as for Russia, this is 1,2% of the total volume of oil production (more than 3 million tons) [2].

When recultivating soils contaminated with oil and its products, physical, chemical, and biological methods of purification are used [3]. Physical methods of purification are more crude methods in relation to the state of the soil, they include methods such as burial of oil or soil contaminated with it, conventional pressure water washing, heat treatment, etc. In such ways, it is possible to worsen the ability of soils to recover, that is, to further worsen the condition of soil ecosystems. Chemical treatment of soils with various solutions and oxidants also changes the agrochemical parameters of not only soils, but also groundwater. Burning of polluted soils is also a method that has a negative effect on the environment [4].

Currently, methods of biological purification (bioremediation) are used to clean oil-contaminated lands. Bioremediation provides almost complete decomposition of the pollutant to the state of water or carbon dioxide [5]. The method of biological purification is based on the use of microorganisms capable of living in a polluted environment, but the use of such microorganisms for higher purification efficiency requires some improvements in such technologies [6], [7]. Quite often, recultivation with the use of biodestructors is combined with the use of mineral fertilizers [8], [9].

The purpose of our work is to study the sources of environmental pollution by oil and its products, as well as the features of bioremediation of oil-contaminated soils of moderate pollution using the M-1 biopreparation.

2. Methods

Experimental work was carried out during 2019–2021 in laboratory and stationary conditions of the Birsky branch of Bashkir State University. The experience of identifying the oil-destructive properties of the biodestructor M-1 was carried out in the laboratory of environmental monitoring of physical and chemical pollution of the environment.

To identify the composition of the organic part of the oil sludge, chromatography was performed using a GCMS-QP2010S gas chromatomass spectrometer. Chromatographic identification of the organic part, namely hydrocarbons, alcohols and esters are presented on the chromatogram, the most significant peaks are considered with retention time in the range from 2 to 11 minutes.

The method for determining petroleum products in soils is based on the extraction of petroleum products with tetrachloroethylene (C_2Cl_2) or carbon tetrachloride (C_2Cl_4) in special desiccators, filtration of the resulting extract, separation of polar compounds on a chromatographic column filled with aluminum oxide, and measurement of the content of petroleum products by IR spectometry on an AN-2 analyzer [10].

A 50 g soil sample was placed in a Petri dish and 5 ml of M-1 biopreparation was added. Then oil sludge was added in concentrations from 4 to 6% of the soil mass. The studies were carried out in 3 variants, the 4th option was the control, which was represented by the same soil, without the introduction of oil sludge.

Biodesructor was added to all variants 3 times by 1% for every third day of testing with careful mixing of the soil. Samples for the analysis of the content of petroleum products in the soil were selected for every 5 days. After 30 days of research, the soil was left in Petri dishes in the air. During the summer period, the soil naturally dried up to an absolutely dry state, and then was moistened with tap drinking water. Soil moistening was carried out 10 times. Soil samples for the analysis of the content of petroleum products were also taken after 12 months.

3. Results

We have studied the M-1 biopreparation, which is a consortium of microorganisms isolated from oil-contaminated soils. This consortium has passed laboratory tests on soils artificially contaminated with oil sludge.

The components of the biological product were grown in sterile conditions on special selective media in Petri dishes.

The selective medium was heated in a water bath and stirred until all the components dissolved. Then diesel fuel was introduced, closed with a cotton-gauze plug and placed in an autoclave for sterilization.

The sterile medium in hot form was poured under aseptic conditions into Petri dishes (approximately 20 ml per standard cup). After the agarized medium cooled, microbial cells were applied to the surface with a microbiological loop. After 3 days, the grown colonies were noted, from which the seed material was obtained: homogeneous colonies from the surface of agarized media were transferred under aseptic conditions with a bacterial loop into a vessel with a growth medium, closed with a cotton-gauze stopper and placed on a mixing device.

A liquid growth medium was prepared. At room temperature, the production of seed material was carried out with constant stirring and growth control on a Den-1 densitometer for 7–10 days. The minimum concentration of cells in the resulting mother liquor should be 4–6 $x10^6$/ml.

In order to adapt the cells to the utilization of petroleum hydrocarbons, cultivation was carried out with intensive aeration by microcompressors (air consumption of at least 2 liters/ min).

To study the activity of the drug M-1, oil sludge was used, which was analyzed at the beginning.

In laboratory conditions, we studied oil sludge, which is a multicomponent mixture of substances of different nature.

The results of the experiment on the quantitative analysis of oil sludge showed us that this product consists of 96,27% organic substances, among which resins (72,49%) and asphaltenes (21,15%) are the most represented, and paraffin, naphthenic hydrocarbons, alcohols, esters – dioctyl phthalates are also present in a small amount (2,63%). Mechanical impurities are present 1,28%. The composition of oil sludge also includes metals, among which the largest amount is characteristic of Fe (2055 mg/kg) and Al (1736 mg/kg), Pb (7.9 mg/kg), Mn (86 mg/kg), Cr (3.1 mg/kg), Cu (5.3 mg/kg), V (2.9 mg/kg) [11].

The experience of identifying the petro-destructive properties of the biodestructor M-1 was carried out in the laboratory of environmental monitoring of physical and chemical pollution of the environment. At the first stage, we delivered 10 variants of

the experiment and a control sample with oil-free soil. The experiment was conducted according to the methodology described above.

The results of the concentration of oil sludge in the substrate samples were checked twice: at the end of the first month and twelve months after the start of the experiment on the introduction of biodestructor. The data after 30 days and after 12 months are shown in Table 1.

Table 1 – Change in the concentration of petroleum products when exposed to biodestructor M-1

Experience option	Initial concentration of oil sludge, g/kg	Concentration of petroleum products, g/kg						
		Day 5	Day 10	Day 15	Day 20	Day 25	Day 30	Day 365
1	40	32,54	30,79	26,84	20,55	18,47	14,46	6,08
2	50	41,67	38,89	35,32	33,74	31,81	24,16	8,06
3	60	57,19	48,93	45,09	40,82	37,64	31,29	13,22

With 4% contamination of the soil with oil sludge during the first five days, an intensive decrease in pollution is observed – by 18,6% for 5 days, in subsequent observation periods, the amount of petroleum products decreases by an average of 10–15% for every five days. On the thirtieth day, the concentration of petroleum products is 36,2% of the original, after 12 months 15,20% of the original.

With 5% contamination of the soil with oil sludge during the first five days, an intensive decrease in pollution is observed – by 16,7% for 5 days, in subsequent observation periods, the amount of petroleum products decreases by an average of 3–7% for every five days. On the thirtieth day, the concentration of petroleum products is 48,3% of the original, after 12 months 22,03% of the original, i.e., about a fifth of the total pollution remains.

With 6% contamination of the soil with oil sludge during the first five days, there is a decrease in pollution by an average of 1% per day, in the next twenty-five days there is a more intensive decrease – up to 3% per day. On the thirtieth day, the concentration of petroleum products is 52,2% of the original, after 12 months 27,47% of the original.

4. Conclusion

In all variants of the experiment, a significant decrease in the concentration of petroleum products in all variants was noted during the first 30 days of the action of the biodestructor M-1. At the studied levels of soil pollution, a high decrease in the concentration of petroleum products is observed – up to 36,2–44,9% of the initial one.

During 12 months of bioremediation under the action of the biodestructor M-1, there has been a significant decrease in the amount of petroleum products. At the studied levels of soil pollution, the residual pollution ranges from 13–16% of the initial pollution.

Conflict of Interest

None declared.

Конфликт интересов

Не указан.

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