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Ways to Increase the Biogenicity and Fertility of the Soil Cover of Oil-Polluted Landscapes

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Abstract

The article is devoted to - studying the impact of oil pollution (Siyazanneft field) on the dynamics of microbiological processes in the soil and the identifying of the possibility of reducing amount of hydrocarbons in the soil cover using biotechnology methods, in a controlled mode.

In the series of model experiments, the effect of the various additives and the prepared bioproduct to the decomposition of hydrocarbons and the biological activity of oil-contaminated soils was studied. In a model experiment introduction of ameliorants into contaminated soil, separately and together, contributed to increasing of the general biogenecity of soils and the decreasing of the oil content in the soil by 17-62% compared to the control.

These biotechnologies can be very effective in the development of bioremediation technologies for oil-contaminated soils.

Keywords: soils, oil pollution, bioremediation, microorganisms, biotechnology

Introduction

Nowadays it is generally accepted that it is impossible to exclude anthropogenic impact on the environment. Human influence on the environment changes and transforms it.

During the long-term exploitation of oil fields in the process of extraction, transportation, processing, and consumption of oil and oil products, the degree and scale of pollution of surrounding landscapes with oil and oil products increases significantly [6].

The soil cover is most intensively exposed to pollution. The problem of land pollution with oil and oil products is especially acute on the oil production areas. The

process of accumulation of oil hydrocarbons in the soil leads to changes in their physical and chemical properties and the development of phytotoxicity of the soil cover [8]. This leads to the suppression of plant growth and development or their complete extermination. For this reason, the preparation of environmental monitoring issues, the analysis of prospects for sustainable use of natural resources and the search for possible ways to restore technogenically disturbed territories are mandatory therms for the development of humanity.

An analysis of information sources shows that among the methods of restoring contaminated areas, the most widespread are bioremediation methods, including the introduction of biopreparations, based on consortiums of microorganisms aimed at intensifying the biodegradation of oil. [2, 9, 10, 11].

The aim of the investigation is to study the possibility of degradation of hydrocarbons in the soil and restoration of the biogenecity of technogenically disturbed soils of the region.

Materials and methods

The object of the study is gray-meadow soils from the territory of the Siyazanneft oil field [1]. The sample collection was carried out according to the "envelope" principle in a sterile package [5].

The total number of microorganisms, as well as the number of microorganisms capable of decomposing hydrocarbon substrates and cellulose, were determined in the selected soil samples using the generally accepted method of limiting dilutions from soil suspensions [7]. The total number of heterotrophic microorganisms was determined on MPA. The number of hydrocarbon-oxidizing microorganisms and cellulose-decomposing microorganisms in the soil was detected on agarized mineral media with the addition of a carbon and energy source - n-hexadecane and cellulose powder, respectively.

Soil respiration was determined by the intensity of carbon dioxide production [4]. Analysis of residual oil content in the soil was carried out gravimetrically in a Soxhlet instrument after extraction with a solvent mixture of hexane: chloroform (1:1 vol.%) [3]. For a model experiment in laboratory conditions, the soil was incubated in vegetation vessels with the addition of sawdust, manure and a biopreparation in various modifications at room temperature and maintaining the humidity level within 50-60% of the total field moisture capacity.

Result and Discussion

The Siyazan region is located in the Samur-Divichi lowland in the east of Azerbaijan, on the shore of the Caspian Sea on the north-eastern slope of the Greater Caucasus. The region has a semi-desert and dry steppe climate. The average air temperature is 1.5 °C in January and 23-25 °C in July. The summer is hot and dry. Annual precipitation ranges from 200-400 mm.

Siyazan is an industrial region, where the oil and gas producing plant "Siyazanneft" is located. The content of hydrocarbons in the soil samples was 24.02 g / kg of soil, which exceeded the background indicator adopted in Azerbaijan (0.1 g / kg of soil). The total number of microorganisms (CFU) in the studied soil is presented in Table 1.

The results showed that due to technogenic pollution, compared to the control, the CFU in the studied soils decreased, which is also confirmed by the respiration intensity data. Almost complete suppression of the activity of cellulose-decomposing microorganisms in contaminated soils was observed compared to the control. The reason for the decrease in the number of this group of microorganisms, along with soil pollution with other pollutants - low content of plant residues compared to clean soil.

Table1. Number of Microorganism and CO_2 emission rate

Soils	Hummus %	Total number of microorganisms, CFU/g soil	Respiration rate mg CO_2/ 100g soil/h	Cellulose decomposing microorganisms CFU/g soil	Hydrocarbon-oxidizing microorganisms, titer
Gray-meadow	2,1	$2,2 \times 10^5$	0,7	21	$2,0 \times 10^5$
Control	2,5	$7,9 \times 10^6$	1,9	$5,8 \times 10^4$	$1,3 \times 10^4$

Along with this, in comparison with the control, in technogenically contaminated soils, the microbiocenosis shows an increase in the number of hydrocarbon-oxidizing bacteria that consumes oil hydrocarbons as a nutrient substrate. Thus, as a result of technogenic and anthropogenic impact, a restructuring of the community structure of soil microorganisms is observed in the studied soils of the Siyazan district.

Therefore, in any case, when the soil is polluted, the structure of the soil microbiota changes to one degree or another, up to its complete death, which negatively affects the functions performed by the soil. To optimize the ecological functions of the studied soil, a model experiment was conducted in 5 variants during which humidity and oxygen penetration were maintained:

1. The soil under study
2. Soil + sawdust
3. Soil +Fermistart
4. Soil + Fermistart + sawdust
5. Soil + Fermistart + manure

Wood sawdust up to 0.2-0.3 mm in size was used to improve the structure and physical and chemical properties of contaminated soil - by increasing its porosity and improving the degree of soil aeration, it is possible to positively influence the growth and development of aerobic oil-oxidizing microorganisms.

Manure is an organic material that is a source of various microorganisms capable of decomposing a wide variety of substrates. The biopreparation Fermistart belongs to the group of effective microorganisms, it includes photosynthetic, lactic acid, nitrogen-fixing bacteria, as well as a consortium of microorganisms from the group of yeast, actinomycetes, and fungi. They optimize the mineral nutrition of plants, fix atmospheric nitrogen, accumulate phosphorus, and provide catabolism of protein-nitrogen compounds.

Our goal in using various additives and biopreparation during the experiment was to study their complex effect on the decomposition of hydrocarbons and the biological activity of oil-contaminated soils. After 6 months, the content of residual hydrocarbons, the total number of microorganisms, and the number of oil-oxidizing and cellulose-decomposing microorganisms were determined in all variants. The results are presented in theTable 2.

The results showed that after 6 months, the total number of microorganisms in the soils (TNM) increases in all variants of the model experiment, which indicates an increase in the activity of microorganisms in the soil and the formation of favorable conditions for their activity.

Table 2. The number of microorganisms and the self-cleaning ability of soils before and after the experiment

Soils	Number of microorganisms, CFU/g soil			Total hydrocarbon content, g/kg soil
	Total number of microorganisms, CFU/g soil	Cellulose decomposing microorganisms CFU/g soil	Hydrocarbon-oxidizing microorganisms CFU/g soil	
Control	$7,9 \times 10^6$	$5,8 \times 10^4$	$1,3 \times 10^4$	-
Gray-meadow	$2,2 \times 10^5$	21	$2,0 \times 10^5$	24,2
Options	Number of microorganisms, CFU/g soil after 6 months			
1. Test soil	$3,4 \times 10^5$	22	$2,8 \times 10^5$	23,8
2. Soil + sawdust	$3,2 \times 10^6$	$2,2 \times 10^2$	$3,4 \times 10^6$	20,2
3. +Soil +Fermistart	$5,1 \times 10^7$	$2,5 \times 10^2$	$5,7 \times 10^6$	15,2
4. Soil + Fermistart + sawdust	$7,2 \times 10^8$	$4,7 \times 10^3$	$7,2 \times 10^8$	9,3
5. Soil + Fermistart + manure	$1,5 \times 10^8$	$4,2 \times 10^3$	$1,5 \times 10^8$	11

At the same time, starting from variant 3, the number of microorganisms exceeds the corresponding indicator. And the best result was recorded in variant 4, which can be considered the most effective, since it creates the possibility of a complex effect on the soil - decomposing hydrocarbons and increasing the biological functions of oil-polluted soils. Along with this, the introduction of the biopreparation into the soil with sawdust contributed to an increase in the number of cellulose-decomposing and hydrocarbon-oxidizing microorganisms, as a result of which the content of hydrocarbons in the soil decreased.

Conclusion

As a result of technogenic pollution, the total number of microorganisms in the studied soils compared to the control, decreases, which is also confirmed by a decrease in the intensity of respiration by more than 2 times. Almost complete suppression of the activity of cellulose-decomposing microorganisms in contaminated soils was also observed, against the background of an increase in the number of hydrocarbon-destruction microorganisms.

The introduction of ameliorants into contaminated soil: a microbial biopreparation and grower waste, separately and together in a model experiment, contributed to both an increase in the overall biogenicity of soils, with which such soil properties as fertility and self-purification are inseparably linked, and a decrease in the oil content in the soil by 17-62% compared to the control.

The developed biotechnologies should be considered as an opportunity for a complex positive influence on the soil - to increase the biological functions of oil-polluted soils and decompose hydrocarbons, and they can be used in the bioremediation of technogenically contaminated soils, which will reduce the environmental load on the soil cover of territories with an industrial orientation.

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