BILINGUAL PUBLISHING CO.
Pioneer of Global Academics Since 1984

Research in Ecology
https://ojs.bilpublishing.com/index.php/re

REVIEW

Soils of Alpine, Subalpine Meadows and Meadow Steppes of Azerbaijan and the Peculiarities of Their Assimilation Potential in Relation to Organic Pollutants

F.Sh. Keyseruxskaya, S.I. Nadjafova*

Institute of Microbiology, National Academy of Sciences of Azerbaijan, Baku, 1004, Azerbaijan

ARTICLE INFO

Article history
Received: 9 March 2019
Accepted: 20 March 2019
Published Online: 31 March 2019

Keywords:
Soil
Landscapes
Organic pollution
Self-cleaning
Assimilation potential

ABSTRACT

Azerbaijan is a country with a huge range of different soil types, which is due to its geographical location. The country is located in two climatic thermal zones, subboreal and subtropical, characterized by a peculiar hydrothermal regime, diverse vegetation and soil fauna. For proper zoning of the soil cover of bioclimatic landscape zones and the development of effective organization of management systems, assessment of assimilation potential is of great importance, i.e. self-cleaning potential. The purpose of our research was to assess the actual assimilation capacity and self-cleaning ability of alpine and subalpine meadow soils and meadow steppes in case of their contamination with organic pollutants based on a comprehensive system analysis of biogenic and abiogenic factors. The collected material was comprehensively analyzed from the standpoint of the biogenicity and self-purification capacity of soils of various bioclimatic landscape zones from the standpoint of the danger of soil contamination with organic matter, based on the natural features of the soil and biogenic and abiogenic factors, and appropriately grouped according to the landscape feature. The analysis of the obtained data allows us to position the soils of the Alpine and subalpine meadows and meadow steppes on the growth of the assimilation potential in relation to organic pollutants in the following sequence:

Mountain-meadow chernozem-like> Mountain-forest meadow> Mountain-meadow steppe> Mountain-meadow sod

1. Introduction

Environmental problems for the territory of Azerbaijan, as well as for the whole world, associated with population growth, bio-and energy consumption, production intensification are not reduced. Already in the 80s of the last century, the Absheron industrial region ranked third in the former USSR on the module of man-made oil pressure - more than 100 tons / km^2 per year [7]. Currently, the areas of land polluted by oil and oil products exceed 12 thousand ha, chemical industry waste is more than 100 hectares [21].

In addition to oil and oil products, the country's ecosystem is polluted by other organic substances, among which foreign compounds are xenobiotics: pesticides, DDT, phenols, chlorinated benzfurans, polycyclic hydrocarbons,

**Corresponding Author:*
S.I. Nadjafova,
Institute of Microbiology, National Academy of Sciences of Azerbaijan, st. M. Mushfig, 103, Baku, 1004, Azerbaijan;
E-mail: nadjafovas@yahoo.com

 DOI: https://doi.org/10.30564/re.v1i1.602

herbicides, detergents, etc., that occupy an important place [14]. Many of the xenobiotics are difficult to decompose and accumulate in the environment - soil cover, surface and groundwater.

According to the zoning data on the distribution of toxic waste, in a number of regions of the republic, for example, on agricultural objects of Ismaili, Shamakhi, Guba, Siyazan and other regions of the republic, the amount of toxic waste is 250-1000 thousand tons., Absheron peninsula accounts for more than 1 million tons [10]. At the same time, as noted, the use and disposal of hazardous waste in the republic as a whole is practically non-existent; no more than 10% of this waste is disposed of.

In hot climates and irrigated agriculture, many organic substances that pollute the soil cover as a result of evaporation with air streams, such as petroleum hydrocarbons or pesticides, can be transferred to adjacent areas and pollute them. So, even such a low volatile pesticide, as DDT enters the air in significant quantities - more than 60% of the pesticide used [4]. This leads to the transfer of DDT over long distances and secondary pollution of environmental objects (rivers, soil, vegetation) in places remote from the areas of application.

In the end, pollution causes a violation of the natural equilibrium, a drop in soil fertility, there is a potential danger of mutagenic activity appearing near the soil as a natural substrate [20].

The territory of Azerbaijan is determined by the diversity and complexity of the combination of natural and anthropogenic-evolutionary landscapes, in which the vertical zoning of the soil cover is uniquely combined with anthropogenic soil formation.

On the one hand, they are connected with the uneven mixing of forests, the development of pasture-meadow spaces, on the other hand, the intensification of farming using water and chemical amelioration, as well as man-made disturbances of the soil cover.

Azerbaijan is a country with a huge range of different soil types, which is due to its geographical location. The country is located in two climatic thermal zones, subboreal and subtropical, characterized by a peculiar hydrothermal regime, diverse vegetation and soil fauna.

The purpose of our research was to assess the actual assimilation capacity and self-cleaning ability of alpine and subalpine meadow soils and meadow steppes in case of their contamination with organic pollutants based on a comprehensive system analysis of biogenic and abiogenic factors.

2. Material and Methods

The object of research was the soils of alpine and subalpine meadows and meadow soils. The soils of alpine, subalpine meadows and meadow steppes are confined to altitudes from 2000 to 4500m above sea level. The total area is 8200-8700 km2, which is 10.2% of the total area of the country. Soil formation takes place under the conditions of a leaching regime and with a lack of heat and high humidity. Vegetation cover is represented by alpine and subalpine meadows. This zone belongs to a moderately cold climate zone, the climate is extremely severe. The average annual temperature ranges from 4.2 to 5.1 degrees, the temperature of the hot month is 10.9-11.2 degrees, the amount of active temperatures>10 degrees ranges from 1280-1780 degrees, the average annual rainfall is 1200-1600mm., evaporation is low , the coefficient of moisture (according to Ivanov) is more than one.

Information on the physico-chemical and soil-climatic conditions of the study area was obtained in the course of field studies, as well as published and stock materials [3, 18].

Soil temperature was measured directly in the field using the SF-4 field device.

Microbiological studies were carried out according to generally accepted methods [11, 22].

Soil sampling was performed by the envelope method. In accordance with the scheme, representative soil samples of a mixed mass of 1.0 kg from a horizon of 0-20 cm were taken at key points from different soil horizons.

In the selected samples, the total number of microorganisms as well as microorganisms capable of decomposing hydrocarbon substrates, cellulose and pesticides was determined [22].

In our studies of the assimilation potential of the soil cover of Azerbaijan, we analyzed one of the most massive pollutants of the soil - hydrocarbons and pesticides within the framework of the geochemical carbon cycle. This is explained by the fact that they have a significant impact on the biogeochemical processes in the biosphere, since they directly influence due to a pronounced toxic effect on living organisms.

As an indicator of soil assimilation capacity, we use three indicators of soil biogenicity — the total number of microorganisms, the number of microorganisms capable of using petroleum hydrocarbons, cellulose, and pesticides as the sole carbon and energy source. N-hexadecane was used as the petroleum hydrocarbon, and carat as the pesticide. When choosing the type of pesticide to assess the assimilation capacity of the soil to these substances, we took into account that in adaptive farming it is necessary to use pesticides with the shortest decomposition period in the soil.

The biomass of microorganisms in the soil and their assimilation potential for hydrocarbon substrates were determined in accordance with the needs of the biomass

  DOI: https://doi.org/10.30564/re.v1i1.602

of soil microorganisms to maintain [16]. The biomass of microorganisms in the soil was determined based on the average volume of the microbial cell in the soil, equal to 0.1 µm3 ($10^{-13}cm^3$). In a natural habitat the mass of one cell is approximately equal to 10^{-13}g. This is in terms of dry matter is 0.02pg (2.10^{-14}g). and the carbon content of 0,01pg (10^{-14}g). When calculating the assimilation capacity of the soils, it was assumed that to maintain 1 kg of microbial biomass during the year, approximately 25,03 kg of organic substrate is required.

Assessment of the assimilation potential of the soil was determined by the formula:

$$B = N \times K \quad (1)$$

Where, B is the value of bacterial biodegradation of petroleum hydrocarbons (mg HC/ g x day), N is the number of hydrocarbon-oxidizing bacteria (CGU / ml), K is the amount of hydrocarbons that are oxidized by a single bacterial cell, calculated by Sobella (3.76 x 10^{-8} mg / c x day) [19].

The mineralization coefficient of KM cultures was determined by the ratio of the intensity of carbon dioxide production (A) to the intensity of oxygen absorption (B): KM = A/B. The value of this indicator shows the ability of the microorganism to carry out the process of degradation of the hydrocarbon up to the complete mineralization of the substrate and the intensity of this process [12].

In order to solve the tasks, the methods of system analysis, chemical, physicochemical, biological methods, risk theory, etc. were used. The collected material was comprehensively analyzed from the standpoint of the biogenicity and self-cleaning ability of soils of various bioclimatic landscape zones from the standpoint of the danger of soil contamination with organic substances, based on the natural features and physicochemical and biological properties of the soil, and is accordingly grouped according to the landscape feature.

Static processing of the results was carried out using Statistica V6.0 for Windows, Excel - 2003.

3. Results and Discussion

The soil cover of alpine, subalpine meadows and meadow steppes is represented by: mountain-meadow, mountain-forest-meadow and mountain meadow-steppe soils. Their area is presented in table 1.

Table 1. Highland soils

Soils	ha	%
Mountain meadow sod	301	7,0
Mountain meadow chernozem	509	1,3
Mountain meadow steppe	255	2,6
Mountain-forest meadow	653	2,7

The soils of the alpine – subalpine meadows and meadow steppes are characterized by relatively weak assimilation potential due to the fact that with increased moisture (Coefficient of moisture KM> 1) and leaching regime for forest and mountain-forest type soils, it slowly undergoes hydrolytic decomposition under conditions of weak severity of microbiological processes, at a weakly acidic and acidic reaction of the surroundings. Such ecological conditions of soil formation cause a decrease in the intensity of microbiological processes.

The main sources of pollution of these landscapes can be road transport, as well as organic pollutants - petroleum hydrocarbons, pesticides, etc. carried by atmospheric flows (air and atmospheric precipitation) from the territories of their active use in the agroecosystems of the country's foothill and arid areas.

Analysis of the physicochemical and biological indicators of alpine, subalpine meadows and meadow steppes shows that the mountain-meadow chernozem-like and mountain-forest-meadow and mountain-meadow steppe meadows are characterized by the highest potential assimilation index, which is primarily due to the high humus content, absorption capacity, pH close to neutral, most favorable for the functioning of soil microorganisms [12] (Table 2).

Table 2. Indicators of biogenicity and assimilation potential of the soils of alpine, subalpine meadows and meadow steppes

Soils / indicators	Mountain meadow sod	Mining meadow chernozem	Mountain forest meadow	Mountain meadow steppe
Humus,%	11,3-14,7	6,3-7,0	6,0-8,4	5,2-7,4
Humus, t / ha	180-380	200-260	310-320	350-450
pH-water	6,0-6,4	6,7-7,8	6,0-6,8	7,0-7,3
Absorption capacity (mEq)	45-55	37-75	40-55	39-65
Total number of microorganisms, CFU, titer	$2,5.10^4$	$2,5.10^5$	$2,2.10^5$	$2,0.10^5$
The number of CDM, titer	$3,1.10^3$	$5,5.10^3$	$5,0.10^3$	$4,7.10^3$
The number of HOM, titer	$3,4.10^2$	$3,8.10^3$	$3,2.10^3$	$3,0.10^3$
The number of PDM, titer	$2,1.10^2$	4,3.10	$3,6.10^2$	$3,1. 10^2$

Note: CDM is the number of cellulose decomposing microorganisms; HOM-number of hydrocarbon-oxidizing microorganisms; PDM-the number of pesticide decomposing microorganisms.

The higher the content of humus in the soil, the capacity of absorption, the clay fraction, with neutral pH indicators in the soil; the number of microorganisms, cellulose decomposing, destructive microorganisms of hydrocarbons and pesticides consistently grow. The biogenicity of the soil consistently grows from mountain-brown, brown, unsaturated soils towards the distribution of mountain-brown, brown residual carbonate soils. The sum of active temperatures in the range of 1730-32000, the average annual rainfall of 570-950 mm, is also relatively favorable for the high biogenicity of soils and their assimilation potential.

These areas are also characterized by fairly rapid mineralization of organic pollutants, intensive leaching from the soil, and dispersion of soluble organic pollutants in surface waters. At the same time, in the soils of mountains and foothills, along with a high level of assimilation potential, mechanical and active water migration of pollutants is of great importance against the background of diverse landscape conditions varying with the absolute height.

One of the most important factors in preserving the biosphere itself and ensuring its sustainability is the assimilation potential of natural landscapes - this is their self-healing ability in relation to the input into the natural environment of matter and energy as a result of production activities. In fact, the assimilation potential is the property of ecological systems to “resist” external influences. Assimilation potential is the buffering capacity of the components of natural landscapes (atmosphere, water sources, soil) in relation to various anthropogenic impacts at certain scales without changing their basic properties for a long period of time [2,5]. The assimilation capacity can be taken as an ecological capacity, which refers to the energy capacity of landscapes of the territory to produce oxygen and absorb carbon dioxide, which is formed in the course of economic activity [6].

Identifying the assimilation potential of a territory is necessary to determine the actual assimilation potential of landscapes as a national ecological resource in the context of continuous growth of anthropogenic impact on the environment, its rational use, development of the valuation of the ecological (assimilation) potential of the territories of restoration in case of disturbance, management, etc. at the heart of the process of self-cleaning of soil and aquatic ecosystems.

For proper zoning of the soil cover of bioclimatic landscape zones and the development of effective organization of management systems, assessment of assimilation potential, that is, self-purification potential is of great importance. The process of zoning of soil cover on their stability and ability to self-purification in general requires a scientific assessment of the resource potential of the assimilation capacity of landscapes. This problem can be solved by ecologizing the whole problem. This means that zoning should be carried out with a simultaneous systematic analysis of abiotic and biotic factors determining its assimilation capacity - the resistance and self-cleaning ability of soils in relation to this pollutant. It is important to know the environmental conditions determined by many factors - terrain, climate, hydrology, vegetation, geology, geomorphology, soil-forming rocks, etc.

On the other hand, along with biogenic factors, abiogenic factors can play a significant role in the self-purification of soil cover from polluting substances of these bioclimatic landscapes. If we take the studied landscapes as an autonomous unit of the ecoframe system of the country, there may be a discharge of pollutants with surface and groundwater runoff, which will depend on the hypsometric position and the amount of runoff. Here, along with biogenic factors, such processes as mechanical and active water migration of pollutants to accumulative zones take place against the background of diverse landscape conditions that change along with the absolute height.

The potential oxidative ability of soils, K_M, shows the activity of the hydrocarbon-oxidizing microbiocenosis of soils and, consequently, the intensity of the mineralization process of oil pollutants [12]. Indicators of assimilation potential (degree of resistance to pollution by hydrocarbon substances) correlate with indicators of the coefficient of mineralization of hydrocarbons Km, which characterizes the intensity of decomposition of hydrocarbons in the soil

Table 3. Ecological indicators, assimilation capacity and intensity of decomposition of hydrocarbons in soils of various bioclimatic landscapes of Azerbaijan

№	Soils	∑T >10^0	CM	H %	ANM, CFU	HOM, CFU/ gr soils	Assim. potential, t / year	Km Км
1	Mountain meadow sod	1000-2000	>1	15,5	2,7.10^6±0,4	244980±0,4	4.86	0,18
2	Mining meadow chernozem	2500-3000	1,2-2,0	12,7	2,0 .10^6±0,3	185940±0,3	6,7	0,22
3	Mountain forest meadow	3600-4400	0,5-0,4	7,2	3,5.10^6±0,3	280160±0,3	10,0	0,43
4	Mountain meadow steppe	3800-4500	0,6-0,7	7.3	4,1.10^6±0,4	369000±0,4	14,1	0,51

Note: CM - coefficient of moistening; H- Humus, ANM - Average number of microrganizms (colony forming units), HOM - the number of hydrocarbon-oxidizing microorganizms; Km - the coefficient of mineralization of hydrocarbons.

DOI: https://doi.org/10.30564/re.v1i1.602

in the event of their pollution by these substances.

The table 3 illustrates that the carbohydrate-absorbing microorganisms are composed of microbiocenosis and are composed of 5,0-9% by weight of cyclodextrins.

A higher ratio of hydrocarbon-oxidizing microorganizms (HOM) in the total number of saprotrophic microorganisms in mountain forest brown, mountain black soil, chestnut and mountain brown soils compared to arid zone soils - gray brown and gray soils may be associated with a higher biodiversity of phytocenoses and their high productivity.

The presence of HOM in the complex of microbiocenoses in these soils may be due to the background presence of substances of natural origin similar in composition to hydrocarbons, for example, decomposition products of plant residues.

4. Conclusion

By analyzing the results of the analysis, let's set aside the alpine, subalpine and meager levels of assimilation potential in relation to the organic pollutant in the following sequence:

Mountain-meadow chernozem > Mountain-forest-meadow> Mountain-meadow steppe> Mountain-meadow sod.

References

[1] Aliev, G.A. Soils of the Greater Caucasus (within the Azerbaijan SSR). Baku: Elm, 1994, 2: 430.

[2] Astrakhantsev GP, Menshutkin VV, Minina TR, Poloskov V.N. Assimilation potential of the natural environment and water resources // Economic growth, resource dependence and socio-economic inequality. Proceedings of the IV All-Russian Conference, 2014, 27 - 29, St. Petersburg.2014: 16-21.

[3] Babaev M., Jafarova Ch., Hasanov V. Modern soil classification of Azerbaijan. Baku: Elm, 2006: 359.

[4] Bobovnikova TS.I. et al. Experience of compiling a balance sheet in the field conditions // Migration of pollutants in soils and adjacent environments: Proceedings of the III All-Union Conference Obninsk, 1971, Leningrad. 1985: 41-47.

[5] Brezgin V.S. Assessment of the dynamics of the assimilation potential of the catchment area of the Ivano-Arakhlei lakes // Ivano-Arakhlei lakes at the turn of the century (state and dynamics) - Novosibirsk: SB RAS, 2013, 320c.

[6] Gershanok G.A. Socio-economic and ecological capacity of the territory in assessing the sustainability of its development // Economy of the Region / Institute of Economics of the Ural Branch of the Russian Academy of Sciences (Ekaterinburg), 2006, 4: 166–180.

[7] Glazovsky N.F. Technogenic flows of matter in the biosphere // Mining and geochemistry of natural ecosystems. M . Nauka, 1982: 7-28.

[8] Dobrovolsky G.V., Nikitin E.D. Ecological functions of the soil.-M: Publishing House of Moscow State University, 1986: 135.

[9] Dobrovolsky G.V., Nikitin E.D. Soil ecology. The doctrine of the ecological functions of the soil: Textbook. - M .: Publishing House of Moscow State University: 413 p.

[10] Ecological Atlas of the Republic of Azerbaijan. Baku, 2009: 112. (in Azeri language).

[11] Egorov N.S. Guide to practical classes in microbiology.M . MGU, 1995: 224.

[12] Ismailov N.M., Akhmedov A.G., Akhmedov V.A. Reclamation of oil-polluted lands of dry subtropics of Azerbaijan // Recovery of oil-polluted soil ecosystems. M.: Science, 1988: 206-221.

[13] Ismailov N.M. Global Studies and Ecology of Azerbaijan. Baku: Elm, 2006: 192.

[14] Imustafaev@iatp.az, 2006

[15] Kovda V.A. Biogeochemistry of soil cover. M .: Nauka, 1985: 264.

[16] Kogevin P.A. Microbial populations in nature. M .: Izd-vo MGU, 1989: 170s.

[17] Mishustin E.N. Association of soil microorganisms. M .: Nauka, 1975: 106.

[18] Morphogenetic soil profiles of Azerbaijan. Baku: Elm, 2004: 202.

[19] Rubtsova S.I. Evaluation of bacterial self-purification of water from petroleum hydrocarbons in the surf zone of the Sevastopol water area (Black Sea) // Ecology of the Sea. 2003, 64: P.95-98.

[20] Skvortsova I.N., Zvyagintsev D.G., Lukina N.N. Mutagenic and antimutagenic activity of soils // Microorganisms and soil protection. Moscow, Moscow State University, 1989: 193-204.

[21] State of the environment of the Republic of Azerbaijan. Baku, 1997: 95.

[22] Workshop on Microbiology / Ed. A.I. Netrusova. M .: Academy, 2005: 608.

 DOI: https://doi.org/10.30564/re.v1i1.602