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Integral Indicator of Technogenic Soil Disturbance in Absheron Peninsula

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Abstract: Integral indicator of anthropogenic disturbed soils of Absheron peninsula is calculated, which allows to evaluate the potential of self-cleaning landscape. Integral indicator is calculated by the sum of the most important points of informative indicators of biological condition of soils: the enzymatic activity, the number of saprophytic and hydrocarbon oxidizing microorganisms, the ratio of the number of hydrocarbon oxidizing microorganisms to total population, phytotoxicity (seed germination). The indicators chosen for the following reasons: catalase and dehydrogenase - redox enzymes, they are most susceptible to contamination of soil by crude oil and petroleum products. The number of microorganisms characterizes the state of microorganisms in the soil and is an indicator of soil contamination. Phytotoxicity gives information about the soil condition and the conditions of the plant germination.

Keywords: Anthropogenic disturbance of the soil, integral index, degree of anthropogenic impact, bioparameters of soils, the potential of self-purification.

1. Introduction

Mining, transportation and processing of oil inevitably leads to disruption of natural ecosystems and to replacement by technogenic disturbance. Examples are the landscapes of Absheron peninsula. Absheron peninsula - region of Azerbaijan, where more than 70% of its industrial potential is concentrated, hosts more than 300 industrial enterprises, and in relation with which there are environmental problems - significant soil degradation, surface contamination by petroleum, drilling waste dumps, etc.

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There are 6 oil producing enterprises (OPE) in the Absheron peninsula: Z.Tagiev (Khazar district), Surakhani (Surakhani district), Balakhani (Sabunchu district), Binagadi (Binagadi district), Bibi-Heybat (Sabail district), A. Amirov (Karadag district). Total area of enterprises is about 1.4% of the Absheron area. Oil producing enterprises surround the capital city of Baku from all sides, which makes the environment of the city "hostage" of these enterprises. As a result of many years of intensive and excessive pollution by oil and oil products in Absheron, depletion of the ecosystem in the form of degraded pastures, bare areas with dead shrubs and ephemeral vegetation [11] are observed. These oil-contaminated soils, as an ecosystem, passed into the class of abiogenous landscapes a long ago, among which include the oil-saturated, bituminous. Long-term soil pollution by oil and oil products and their environmental consequences suggest "excess burden" on the arid systems [6]. Processes of self-regulation has long been not providing self-healing of destroyed ecosystems, resulting in a disruption of the ecological balance in the environment in the face of increasing impact on landscapes.

In recent years, particular importance is given in research aimed at the comprehensive analysis and evaluation of anthropogenic andtechnogenic impacts on soil [7, 5]. These studies make it possible to assess the state of soil quality through an integral indicator of the biological condition of soils (IIBC). Unfortunately, in spite of the many years of intensive pollution of landscapes by oil and oil products in Absheron peninsula, research in this direction was not carried out.

The purpose of the study was to determine the integral index of the biological condition of the soil on the basis of complex parameters that determine their biological activity.

2. Material and Methods

The objects of the study were different sub-types of gray-brown soils of Absheron peninsula: gray-brown saline-alkaline; gray-brown incompletely; primitive gray-brown soils contaminated with oil that are common in the 6 administrative centers of the Absheron Peninsula. Soil samples for analytical research were collected at intervals twice a year (spring and fall) from the horizon 0-20sm, as a territory directly taken by oil producing enterprises (contaminated soils), and with the entire area by the route method [3, 7].

Method of determining the IIBC on the basis of biological parameters [8] was used to identify the integral index of the state of technogenic disturbed soils of Absheron peninsula.

In the selected soil samples, the total number of microorganisms, number of hydrocarbon oxidizing microorganisms (HOM), HOM population ratio to the total population, the activity of catalase and dehydrogenase enzymes and phytotoxicity (seed germination) were analyzedas biological indicators.

The total number and number of hydrocarbon oxidizing microorganisms were determined by conventional methods. [10] The activity of soil enzymes was determined by Khaziev [12]. Assessment of the degree of soil phytotoxicity was made by D. Grodzinskiy [4]. The content of total hydrocarbonsin the soil wasdetermined by standard gravimetric method. The extraction of hydrocarbons from soils was carried out in the Soxhlet apparatus with hexane and chloroform in a volume ratio of 1:1.

As a control, soil samples were used taken from the territory of the Central Botanical Garden (Baku), which are not subjected to technogenic impact. In operation, abiogenic factors were analyzed affecting impact on the biological properties of the soils of the study area - temperature, humidity and other indicators, published in study [1]. The statistical and correlation analysis of the results were carried out by Lakin [9].

3. Results and Discussion

Absheron is one of the most arid regions of Azerbaijan. The region is characteristic of the climate of warm temperate semi-deserts and dry steppes with dry summers. [1] The total solar radiation varies according to the area from 130 to 135 kcal / cm^2 per year. The average annual temperature in the Absheron Peninsula is 13-15 ℃. Summer runs hot, dry, lasting an average of about 150 days, while winter, its frost-free period lasts in average of 280 days, snowing lasts in average 5-7 days. The amount of rainfall for the year is 120-150 mm, nevertheless its maximum amount falls in autumn. However, a fairly high thermal tension provides evaporation with significantly more moisture than there actually is. The magnitude of the actual evaporation over a large part of the region is 1000-12000 mm / year. The average annual relative humidity is 70%. There are frequent strong winds named north Baku, Gilavar, Khazri. It is considered that the lower limit power of Xazri is 6 points, which corresponds to the speed of 10m/s [1].

The soil cover of Absheron Peninsula is represented mainly by species of gray-brown soils [2]. Gray- brown soils are characterized by low content of humus (1.2-1.8%), alkaline environment, increased accumulation of clay particles in the solonetz horizons in comparative impoverishment by these particles of the surface horizon, as well as low absorption capacity (about 20 mg-eq. in 100 gr of soil). Careful care, fertilizing and watering are required for plant growth.

Absheron Peninsula is not distinguished with richness of flora - diversity of species does not exceed 19- 20% of the floral wealth of the country. Natural complexes of ephemeral semi-desert with winter vegetation of herbs are typical for Peninsula. Most plant groups are discharged,and they do not

form a dense cover, so a lot of bare spots are in between. Only 35-40% of the entire area is covered with vegetation, and the remaining 55- 60% are deprived of vegetation.

Taking into account the area, disturbed by anthropogenic activities [11] to the total area of the districts, we have calculated an integral indicator of the degree of technogenic impact on soil cover of Absheron Peninsula in the comparative aspect (Fig. 1).

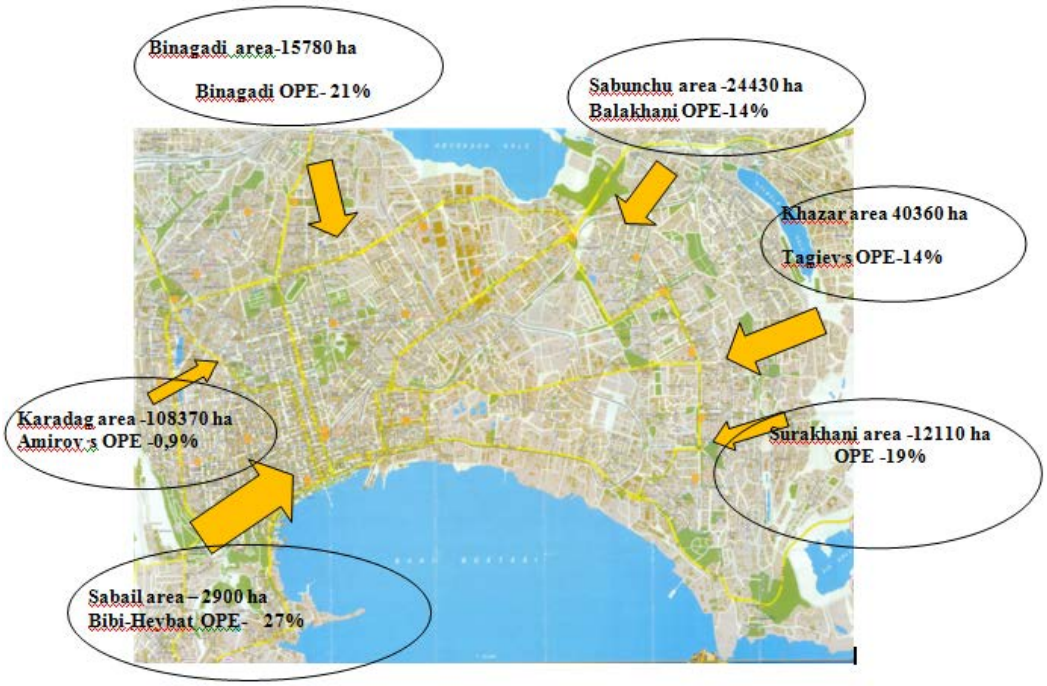

Fig. 1. Schematic map of the distribution of technogenic impact on soil cover of Absheron Peninsula

Analysis of the degree of soil cover pollution in the studied soils of Absheron peninsula showed that in all cases the degree of pollution by oil exceeded background rates adopted for the whole territory of Azerbaijan - 1.1 g / kg. The degree of contamination of soil cover of various areas of Absheron peninsula by hydrocarbons corresponded to the degree of technogenic load. Comparative analysis of the degree of anthropogenic load on soil coverand its contamination by general hydrocarbons (GH) in various parts of Absheron peninsula allowed to arrange them as follow:Sabail (GH -from 40 to 90.05 g / kg of soil)> Binagadi (GH -from 20 to 30 g / kg of soil)> Surakhani (GH -from 15 to 20 g / kg of soil)> Sabunchu (GH -from 5 to 10 g / kg of soil)> Khazar (GH-from 3 to 8 g / kg of soil)> Karadag (GH -from 0.9 to 1.1 g / kg soil).

To calculate IIBC (Table 1) of soil cover in the test areas, each value of the biological indicators in the control (in uncontaminated soil) was taken to 100% with respect thereto and expressed as a percentage value in other embodiments of the experiment (in the contaminated soils). Then, the average value of selected indicators for each variant of the experiment was taken. This procedure allows to integrate relative values of different parameters of which absolute values can not be combined into a single indicator, as they have different units.

Table. 1. - Biological indicators of soils in different areas of Absheron Peninsula

Area	HOM CFU / g soil	Ratio HOM/ saprot-roph	Catalase ml O_2/ min. per gram of soil	Dehydro-genase, TFF mg/g soil for 24 hours	Phyto-toxicity %	IIBC
Binagadi	$3,3\pm0,50x10^3$	0,26	0,45±0,01	0,13±0,01	72	43
Sabunchu	$2,4\pm0,11x10^4$	0,24	0,64±0,03	0,23±0,03	76	62
Khazar	$1,6\pm0,43x10^4$	0,31	0,62±0,03	0,51±0,03	78	63
Surakhani	$2,7\pm0,11x10^3$	0,22	0,47±0,02	0,29±0,02	74	55,6
Karadag	$5,0\pm0,2x10^3$	0,24	0,49±0,01	0,29±0,02	82	66
Sabail	$8,7\pm0,12x10^4$	0,33	0,66±0,01	0,50±0,03	70	40
AbsheronPeninsula (In average for the 6 districts)	$2,3\pm0,61x10^4$	0,27	0,56±0,01	0,33±0,03	75	54,9
Botanical garden- control	$5,1\pm0,12x10^4$	0,12	0,80±0,03	0,44± 0,03	98	100

Note: HOM - the number of hydrocarbon oxidizing microorganisms

As can be seen from table. 1, in soils of Absheron peninsula, subjected to technogenic impact the ratio HOM / saprotrophs varies compared to control soil of the Botanical Garden, which indicates the successional changes in structure of the soil microbiocenosis by increasing the number of microorganisms capable of decomposing petroleum hydrocarbons, resulting in the adaptation of the microbial cenosis to the given conditions. This shows the potential ability of these soils to self – clean itself from hydrocarbons (Fig. 1).

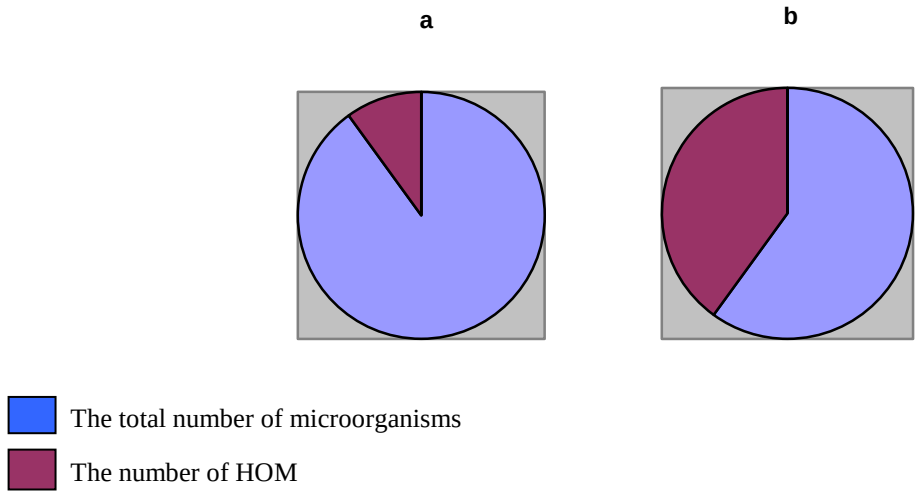

Fig.1. Ratio for HOM / saprotrophs:

a) in soils of Absheron peninsula; b) in soils of Botanical Garden.

Soil condition assessment by biological indices confirmed the decline in ecological functions of soils in areas of negative impact on soil cover in Absheron Peninsula by oil producing enterprises emissions.

The relationship between biogenic of soil and degree of technogenic load was analyzed by calculating the correlations between them. Processing the results of experiments showed that there is a positive relationship between the indicies of biogenic soil and degree of technogenic load: $r = + 0,75 \pm 0,04$.

Indicators of biological activity of soils (Table 1) and IIBC used for comparative assessment of the capacity of self-cleaning of soil cover in study areas on scale (Table. 2). Depending on the amount of points, classes of the current state of soil cover areas were specified. If the total score is 65-70, restoring of soil cover can occur relatively quick and does not require the use of any measures for remediation - soil cover in the territory of Garadagh district. If the total scoreis 55,7-65,self-healingof soil quality can be fragmented, carrying out certain low-cost remediation is necessary - Sabunchu and Khazar district. If average score is 43,7-55,7, disturbed area is recovering slowly and carrying out specific remediation measures is needed - a soil cover in the territory of Binagadi and Surakhani districts. If the total score is less than 43,7, it is necessary to conduct entire work on the technical and biological reclamation phases - soil, common in Sabail district.

Table 2. Integral evaluation of soil cover on the self-cleaning capacity

The degree of recoverability of soil cover	Total points	Recommendation
Self-healing: Karadag district	≥ 65	Carrying out additional remediation measures is not required
Partially restoring: Sabunchu and Khazar districts	55,7–65	Partial biological reclamation in some areas is required
Slowly restoring: Surakhani and Binagadi districts	43,7–55,7	Full operation of the biological stage of recultivation is required
Nonrecoverable: Sabail district	≤ 42	It is necessary to conduct whole work on the technical and biological stage

4. Conclusion

The integral analysis of biological indicators and calculated indices on their basis IIBS technogenic disturbed soils of Absheron peninsula allowed to rank them according to the degree of resistance to anthropogenic pressure and the ability of self-cleaning. In general, the investigated soil cover in 6 districts of Absheron peninsula can be characterized as slightly recovering, and requires the use of a set of measures for their cleaning.

The integral analysis of technogenic disturbed soils is important as a theoretical basis for carrying out a number of scientific and environmental activities: while the bioindication and biodiagnostics of changes in technogenic disturbed soils, while biomonitoring of soil condition as a whole, while creating environmental maps, while developing technologies for soil quality recovery, while forecasting the ecological effects of economic activity on the territory, and etc.

References

[1]. Agroclimatic atlas of Azerbaijan Republic. Baku, 1993.- 104c.

[2]. Galandarov Ch.S. Soil-ecological conditions and soil resources prediction questions Absheron Peninsula:. phD, Baku, 1989, 21c.

[3]. GOST 28168-89, 2008.

[4]. Grodzinskiy D.M. Allelopathy in plant life and pochvoutomlenie. N.Dumka, 1991, 400 p.

[5]. Devyatova T.A. Bioecological principles of monitoring and diagnostki soil. Vestnik VGU: series of chemistry, biology, the formation, 2005, №1, s.105-106

[6]. Ismailov N.M. Oil pollution and biological activity of soils // Mining and geochemistry of natural ecosystems. M .: Nauka, 1982, p.227-235.

[7]. Kazeev K.S., Kolesnikov S.I. Soil biodiagnostics: methodology and research methods. Rostov-on-Don: Publisher of the Southern Federal University, 2012, 260 p.

[8]. Kolesnikov S.I., Ponomareva S.V., Kazeev K.S., Valkov V.F. Ranking of chemical elements according to their environmental hazard to soil // Reports of the Academy of Agricultural Sciences. № 1. 2010., p. 27-29.

[9]. Lakin P.F. Biometriya., Moscow, Vol. "High School", 1990, 343p.

[10]. Methods of Soil Microbiology and Biochemistry / Ed. D.G.Zvyagintseva. M .: -MGU. 1991 304p.

[11]. Talibov A. Cartographic analysis of landscape and environmental conditions of the Absheron Peninsula. Baku: Chashyoglu, 2004, 191 p.

[12]. Khaziev F.H. Methods of soil enzymology. M .: Nauka, 2005, 250 p.