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# THE PROSPECTS OF PHYTOINDICATION OF THE BYTKIV-BABCHENSKYI OIL AND GAS DEPOSIT TERRITORY

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The expediency of biomonitoring studies conducting on the Bytkiv-Babchenskyi oil and gas deposit territory, which is the largest and one of the oldest in the Western region of Ukraine, is substantiated. The geological structure, physical, geographical and natural-climatic conditions of the territory, mineral oil and gas condensate deposits' regimes are described. The structural and tectonic characteristics of oil wells and features of their operations are given. Functioning peculiarities and technical suitability of wells on the oil deposit territory are characterized. The history of the study of the territory of Bytkiv-Babchenskys oil and gas condensate deposit and the possible anthropogenic impact of pollutants entering the environment during the operation of wells are highlighted. It is found that the field is at the last stage of development and needs a number of reclamation measures. Prospects for conducting biomonitoring studies of oil production areas with the help of representatives of various groups of living organisms – lower and higher invertebrates and plants – are considered. The most informative physiological, cytogenetic, cumulative, phenological and morphological reactions of plant organisms in response to oil pollution are analyzed. It is established that in the conditions of oil products pollution by a complex of vegetative objects signs it is possible to judge an ecological condition of environment. The advantage of dendrological objects as biological indicators of the quality of the oil-contaminated environment is substantiated. Sensitive and unstable to stressful growth conditions plant species are promising indicators of the level of ecological danger of the territory, while resistant species have valuable remediation properties. The prospects of phytoindication methods of biomonitoring of the oil deposit area are described, as well as the need for phytorecultivation measures within this ecosystem. *Key words:* bioindication, oil deposit, natural conditions, oil wells, anthropogenic impact.

**Перспективи фітоіндикації території Битків-Бабченського нафтогазоконденсатного родовища. Глібовицька Н.І., Караванович Х.Б.**
Обгрунтовано доцільність проведення біомоніторингових досліджень території Битків-Бабченського нафтогазоконденсатного родовища, яке є найбільшим та одним із найстарших у Західному регіоні України. Описано геологічну структуру, фізико-географічні та природно-кліматичні мови території, режими покладів корисних копалин – нафти і газоконденсатних покладів. Надано структурно-тектонічну характеристику об'єктів розроблення та особливості їх експлуатації. Охарактеризовано особливості функціонування та технічну придатність свердловин на території родовища. Висвітлено історію дослідження території Битків-Бабченського нафтогазоконденсатного родовища та можливий антропогенний вплив забруднювачів, що надходять у довкілля під час експлуатації свердловин. Виявлено, що родовище розташоване на останній стадії розроблення та потребує низки рекультиваційних заходів. Розглянуто перспективи проведення біомоніторингових досліджень територій нафтовидобутку за допомогою представників різноманітних груп живих організмів – нижчих і вищих безхребетних і рослин. Проаналізовано найбільш інформативні фізіологічні, цитогенетичні, кумулятивні, фенологічні та морфологічні реакції рослинних організмів у відповідь на нафтове забруднення довкілля. Встановлено, що в умовах впливу забруднення нафтопродуктами за комплексом ознак рослинних об'єктів можна судити про екологічний стан навколишнього середовища. Обгрунтовано перевагу дендрооб'єктів як біологічних індикаторів якості нафтозабрудненого середовища. Чутливі та нестійкі до стресових умов росту види рослин є перспективними індикаторами рівня екологічної небезпеки території, тоді як стійкі види володіють цінними ремедіаційними властивостями. Описано перспективність фітоіндикаційних методів біомоніторингу території родовища, а також необхідність проведення фіторекультиваційних заходів у межах цієї екосистеми. *Ключові слова:* біоіндикація, нафтове родовище, природні умови, нафтові свердловини, антропогенний вплив.

**Formulation of the problem.** Bytkiv-Babchenskyi oil and gas condensate deposit, which contains large amounts of oil and gas condensate, is located in Nadvirna district of Ivano-Frankivsk region at a distance of 7 km from Nadvirna and 45 km from Ivano-Frankivsk. The deposit belongs to the Western oil and gas region of Ukraine [2]. The field is in the last stage of operation, the development of hydrocarbon deposits is carried out in the mode of depletion, except for only one oil well, where a number of technological procedures are carried out. There is instability in the operation of fountain wells, due to their low productivity [1].

As a result of the deposit development, emissions of pollutants into the environment amount to 7456.48 t/year, of which greenhouse gases − 6915.89 t/year. The main air pollutants entering environment during the wells operations are methane, ethane, propane, butane, pentane, hexane, oxides of nitrogen, carbon, suspended particles, ethyl mercaptan, mercury and its compounds, xylene, toluene, compounds of iron, manganese, soluble hydrogen [1]. Therefore, monitoring the ecological condition of the territory of Bytkiv-Babchenskyi oil and gas condensate deposit is a necessary prerequisite for the preservation of this anthropogenically altered ecosystem.

**Relevance of research.** Significant anthropogenic impact caused by the operation of the deposit necessitates the constant monitoring of the ecological state of the given and adjacent territories. In this aspect, a promising method of monitoring the ecosituation of the region is phytoindication, which involves the use of plant organisms as possible indicators of the level of environmental pollution. Therefore, the identification of plant species with phytoindication and phytorecultivation capabilities is an important way to preserve the natural environment of Bytkiv-Babchenskys oil and gas condensate deposit.

The connection of the author's work with important scientific and practical tasks. Phytoindication of anthropogenically transformed areas today is a common biological method of environmental quality control. However, studies of the ecological status of oil-contaminated areas have been carried out in fragments with the participation of herbaceous plants, and tree species have hardly been used. Since tree species have powerful phytorecultivation features, it is advisable to study them as ecological monitors of oil-producing areas.

**Analysis of recent research and publications.** Exploration of the area adjacent to the deposit began in the 1860s. The study of the deposit was carried out with the help of wells, from which oil was extracted from the sandstones of the Cretaceous period [6]. In 1889, the first industrial influx of oil was obtained from menilitic formations [2].

Of all the field's deposits, the total oil production is 8722 million tons, which is 69.8 % of the initial reserves of dissolved gas production containing 7413 millions/m$^3$.

In 1958 an Eocene gas condensate deposit was discovered, in 1962 it was put into operation. In 1962 the Babchenskyi deposit was discovered, in 1966 it was put into development [6]. The total fund of oil wells is 240, of which − 168 productive, 58 piezometric, 14 degassing wells [1]. Thirteen wells were drilled in the menilitic deposits of the Babchenskyi oil and gas condensate deposit. Four wells fell into the unproductive part of the Babchenskyi deposit and were liquidated for geological and technical reasons, six wells are in the oil fund (one of them is in conservation), three operating wells producing gas [6].

During the period from 2016 to 2020, 1178.24 thousand tons of oil, 2022.49 thousand tons of liquid, 683.005 million m$^3$ of dissolved gas were extracted from the Bytkiv-Babchenskyi oil and gas condensate deposit [1].

In the process of Bytkiv-Babchenskyi oil and gas condensate deposit development within the productive horizons 9 gas condensate and 3 oil production facilities were formed [6].

According to the structural and tectonic characteristics of the deposit, there are ten deposits, each of which is the object of development, except for three [1].

The closest settlements to the deposit are the following: Markovo, Babche, Bytkiv, Pasichna, Delyatyn. Orographically, the Bytkiv-Babchenskyi oil and gas condensate deposit is located on the south-eastern slope of the Ukrainian Carpathians, which is a mountainous area intersected by numerous valleys of the Manyavka, Bystrytsia, Nadvirnyanska, and Lyubytnya rivers. These rivers are accessible for wading traffic. The linear elongation of mountain ranges is a characteristic feature of the terrain [6].

**Highlighting previously unsolved parts of the general problem to which this article is devoted.** In order to control the ecological state of oil-contaminated ecosystems, analytical methods are used to study the level of environmental pollution by petroleum products. However, these methods are time consuming, environmentally and economically unprofitable. The purpose of this work is to analyze the anthropogenic impact of Bytkiv-Babchenskyi oil and gas condensate deposit due to the technical features of well operations, to search for biological methods of environmental control and restoration of man-made environment. In this sense, the phytoindication direction is considered as the most promising, cost-effective and environmentally friendly.

**Novelty.** Plants are the most convenient objects for biomonitoring of oil-contaminated areas, as they are the primary links in the food chain and absorbers of pollutants of anthropogenic origin. Herbaceous plants are used in the practice of biomonitoring studies of oil-contaminated ecosystems, but there is very little literature on the use of woody plants as indicators of the ecosystem of oil-producing areas [10; 16; 18]. Oil-resistant tree species are able not only to serve as environmental monitors of the environment, but also to play a phyto-reclamation role.

**Methodological or general scientific significance.** The study of plant organisms reactions at different levels of biosystem organization in response to oil pollution will reveal species resistant to contaminants, and species that have reclamation properties. Thus, using plants, we will be able to monitor the level of ecological danger of oil-contaminated ecosystems and carry out ecologically safe reclamation of these areas.

**Presentation of the main material.** The area of Bytkiv-Babchenskyi oil and gas condensate deposit is 176.5 km$^2$. The area on which all the wells of the deposit are located is 134.5748 ha [1].

The Bytkiv-Babchenskyi oil and gas condensate deposit is characterized by a cover-scaly tectonic style [2]. Hydrocarbon deposits are stratified, vaulted, tectonic shielded, lithologically limited, confined to the Coastal Slice of the Carpathians and the first and second tiers of the folds of the central part of the Boryslav-Pokutska zone. The deposits modes are the follows: gas, elastic, dissolved gas, elastic-water pressure.

The climate of the district is transitional from Western European to continental Eastern European. The average January temperature ranges from −4.30 ºC to −7.60 ºC. The period with air temperature above +10 ºC is 83–160 days. Most precipitation falls on June-July, the total rainfall is 879 mm per year. The average height of snow cover is 24 cm.

Geologically, the field is located in the Paleogene deposits of the Bytkiv Anticline of the south-eastern part of the Inner Zone of the Pre-Carpathian region and combines oil deposits in Oligocene and gas condensate in Paleocene-Eocene deposits [6].

Flysch formations of the Upper Cretaceous, Paleocene, Oligocene, and Miocene molasses deposits form the geological structure of the deposit. Rakovetskyi, Babchenskyi and Bytkivskyi blocks are included in the first tier, Rakovetskyi, Babchenskyi, Bytkivskyi, Pasichnyanskyi, Lyubizhnyanskyi and Dilyatynskyi blocks are included in the second tier. The main oil deposits are caused by Oligocene formations [2]. Transverse landslides break the folds of both structural tiers with an amplitude of 300–1000 m. Within the deppsit folds of the first tier up to 7 m wide extend by 14 m, the second tier up to 6 m wide extend by 30 m. The density of degassed oil is 768–865 kg/m$^3$ [2]. The concentration of sulfur in the oil is 0.24–0.70 %, paraffins − 5.9–12.5 %, resins − 3.1–18.8 %, asphaltenes − 1.1–2.0 %. The specific weight of oil ranges from 810 to 864 kg/m$^3$. Gas mixtures contain 87.3–94.3 % methane, 0.27–6.54 % carbon dioxide, 0.35–0.78 % nitrogen [1].

The largest in terms of gas and condensate reserves in the Western oil and gas condensate region is the Eocene gas condensate deposit of the Bytkiv-Babchenskyi oil and gas condensate deposit. The initial gas reserves are 45.522 billion m$^3$, the initial condensate reserves are 2822 thousand tons. Gas accumulations are confined to the Paleocene-Eocene deposits. The average value of the depth of deposits is 2320 m. Inhomogeneous structure, fractures and low reservoir properties are marked by productive deposits [6].

In order to conduct ecological monitoring of oil-contaminated areas in assessing the toxicity of oil-contaminated soils, the following test objects are used: bacteria, earthworms, millipedes, mollusks, insects, legumes *Folsomia candida* and *Onychiurus stachianus* and higher herbaceous plants − *Daucus carota* L., *Lepidium sativum* L., *Raphanus sativus var. radicula* Pers., *Sorghum bicolor* L., *Phaseolus vul*garis L., *Panicum miliaceum* L., *Sinapis alba* L., *Carex hirta* L., *Linum usitatissimum* L., *Helianthus annuus* L., *Brassica napus* L., *Cucumis sativus* L., *Panicum mili*aceum L., *Anethum graveolens* L., *Trifolium pratense* L., *Avena sativa* L., *Fagopyrum vulgare* St. [3; 7; 12; 13; 18; 22].

Hydrocarbon oils affect microorganisms through the transformation of physicochemical properties of the soil: reducing the availability of mineral nutrients, deterioration of water and air conditions, changes in acidity and soil structure. Oil pollution inhibits the growth of actinomycetes, nitrifying and cellulose-destroying microorganisms and stimulates an increase in the number of oil-oxidizing microorganisms and micromycetes that use hydrocarbon oils as a nutrient medium. In the conditions of oil pollution of the environment, an increase in the number of potentially dangerous and allergenic soil fungi for humans has been recorded [22; 26]. Low oil concentrations (0.01 %) stimulate the growth of green algae *Chlorella homosphaera* and *Chlorella vulgaris*, while higher oil concentrations cause a significant reduction (15 and 20 %) in the number of these organisms. The most resistant to oil pollution are blue-green algae: *Nostoc punctiforte, Nostoc linckia, Anabaena oscillarioides, Phormidium autumnale* and *Plectonema gracillimum*, which are able to absorb hydrocarbon oils [5; 8].

Plants increase germination, biomass, length of aboveground and underground parts, chlorophyll content in leaves at low concentrations of oil in the environment. The increase in the content of petroleum products in the environment leads to the inhibition of growth processes and plant death. The consequence of oil pollution is a reduction in plant diversity, their projective cover and phytomass [9–11].

To diagnose and assess the level of oil pollution of soils, it is advisable to use the following indicators of woody plants:

– accumulative − accumulation of plant contaminants present in oil, in particular, heavy metals, aromatic, aliphatic hydrocarbons, acidic compounds [20; 23];

– morphometric − plant height, number, length and width of leaves, length of petioles, number and length of shoots, number of flowers, size of perianth, number of fruits and seeds in the fruit, total plant weight and weight of its parts, asymmetry factor, tissue thickness, necrotic plant damage, diseases and pests [14; 25];

− cytogenetic − damage to the genetic material of cells, chromosomal aberrations, disturbances during mitotic, meiotic division, pollen germination, its viability [21; 24];

− physiological and biochemical − activity of enzymes, concentration of chlorophylls and carotenoids, activity of photosynthesis, gas exchange, respiration, content of organic and mineral components in the cell, acidity of the intracellular environment and the state of the buffer system of cells [15; 19; 27];

− phenological − features of the ontogenetic periods and phenological phases of the organism [21].

Woody plants growing on the territory of Bytkiv-Babchenskyi oil and gas condensate deposit should be used as phytoindicators and phytoremediaries of the ecological state of the oil-contaminated environment.

**The main conclusions.** The Bytkiv-Babchenskyi oil and gas condensate deposit, which has been the object of oil production and constant operation for decades, is at the last stage of development and is in a state of depletion. In the conditions of Bytkiv-Babchenskyi oil and gas condensate deposit it is expedient to carry out biological monitoring with the help of plant organisms, which simultaneously perform two functions – phytomeliorative and phytoindicative. Simplicity of accounting for effects and interpretation of results, economic feasibility and environmental efficiency make it appropriate to use plant test systems to diagnose and assess the toxicity of oil-contaminated soils.

**Prospects for the use of research results.** The analysis of plant organisms' features complex at different levels of the biosystem organization will allow to carry the selected objects to this or that group of plants possessing valuable indicator, accumulator or elimination properties. The use of plant test systems in monitoring studies of oil-contaminated ecosystems will make it possible to timely analyze the level of man-made hazards and prevent destructive changes in the area in the future.

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