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«ХАЛЫҚ» ЖҚ

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»
ЧФ «Халық»

N E W S

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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАНПК сообщает, что научный журнал «Известия НАНПК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАНПК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.



ЧФ «ХАЛЫҚ»

В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект *Ozgeris powered by Halyk Fund* – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz».

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится

работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

**С уважением,
Благотворительный Фонд «Халык»!**

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COMPARATIVE ECOLOGICAL ASSESSMENT OF SOIL CONDITION IN THE TERRITORY OF OIL FIELDS OF ATYRAU REGION

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Abstract. For many decades, the main sources of pollution in the Atyrau region have been hydrocarbon deposits. Currently, the oil and gas industry is widespread and has a significant impact on the environment. The development and development of mineral deposits has a negative impact on all components of the natural environment, including soil. In this study, oil fields located in the Makat and Zhylyoi districts of the Atyrau region were selected as the object of study to assess the ecological condition of the soil. The results of the study make it possible to reliably determine the rate and degree of soil contamination. When conducting observations, generally accepted techniques and methods were used. The soils of the study area are represented by sandy, sandy loam and light loamy varieties. In general, excess of the maximum permissible concentration for heavy metals is observed only in lead and zinc in the Tengiz deposits, which can be explained by the presence of an acidic reduction barrier in the taiga peaty-gley soil. The content of cadmium, lead, and zinc in the soils of the deposit in some places was found to be below the established maximum permissible standards.

Keywords: pollution index, soil, ecological state, heavy metals, Zhylyoi, Makat, oil fields

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АТЫРАУ ОБЛЫСЫ МҰНАЙ КЕН ОРЫНДАРЫ АУМАҒЫНДАҒЫ ТОПЫРАҚТЫҢ КҮЙІН САЛЫСТЫРМАЛЫ ЭКОЛОГИЯЛЫҚ БАҒАЛАУ

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Аннотация. Көптеген ондаған жылдар бойы Атырау облысының негізгі ластаушы көздері көмірсутегі кен орындары болды. Қазіргі уақытта мұнай-газ өнеркәсібі кең таралған және қоршаған ортаға айтарлықтай әсер етеді. Пайдалы қазбалар кен орындарын игеру және игеру табиғи ортаның барлық компоненттеріне, соның ішінде топыраққа кері әсерін тигізеді. Бұл зерттеуде топырақтың экологиялық жағдайын бағалау үшін зерттеу нысаны ретінде Атырау облысының Мақат және Жылыой аудандарында орналасқан мұнай кен орындары таңдалды. Зерттеу нәтижелері топырақтың ластану жылдамдығы мен дәрежесін сенімді анықтауға мүмкіндік береді. Бақылауларды жүргізу кезінде жалпы қабылданған әдістер мен әдістер қолданылды. Зерттелетін аумақтың топырақтары құмды, құмды сазды және жеңіл сазды сорттармен ұсынылған. Жалпы ауыр металдар бойынша шекті рұқсат етілген концентрациядан асып кету Теңіз кен орындарында қорғасын мен мырышты ғана байқалады, мұны тайганың шымтезек топырағында қышқылды қалпына келтіру тосқауылының болуымен түсіндіруге болады. Кен орнының топырағындағы кадмий, қорғасын, мырыш мөлшері кейбір жерлерде белгіленген шекті рұқсат етілген нормалардан төмен екені анықталды.

Түйін сөздер: ластану көрсеткіші, топырақ, экологиялық жағдай, ауыр металдар, Жылыой, Мақат, мұнай кен орындары

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СРАВНИТЕЛЬНАЯ ЭКОЛОГИЧЕСКАЯ ОЦЕНКА СОСТОЯНИЯ ПОЧВ НА ТЕРРИТОРИИ НЕФТЯНЫХ МЕСТОРОЖДЕНИЙ АТЫРАУСКОЙ ОБЛАСТИ

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Аннотация. На протяжении многих десятилетий основными источниками загрязнений на территории Атырауской области являются месторождения углеводородного сырья. В настоящее время нефтегазовая промышленность имеет широкое повсеместное распространение и в значительной мере влияет на окружающую среду. Освоение и разработка месторождений полезных ископаемых оказывает негативное влияние на все компоненты природной среды, в том числе и почвы. В этом исследовании в качестве объекта исследования были выбраны нефтяные месторождения, расположенные в Магатском и Жылыойском районах Атырауской области для оценки экологического состояния почвы. Результаты исследования позволяют достоверно определить темпы и степень загрязнения почв. При проведении наблюдений были использованы общепринятые методики и методы. Почвы исследуемой территории представлены песчаными, супесчаными и легкосуглинистыми разновидностями. В целом превышение ПДК у тяжелых металлов наблюдается только у свинца и цинка в месторождении Тенгиз, что может объясняться наличием кислого восстановительного барьера в таежной торфянисто-глеевой почве. Содержание в почвах месторождения кадмия, свинца, цинка в некоторых точках обнаружено ниже установленных предельно допустимых норм.

Ключевые слова: индекс загрязненности, почва, экологическое состояние, тяжелые металлы, Жылыой, Магат, нефтяные месторождения

Introduction

The soil always reacts to changes in environmental factors, and also responds to the influence of humans and land use, and agricultural processes occurring on it. Some changes in the soil will be short-lived and reversible, others will radically change its condition and become a permanent feature of the soil (Kolesnikov, 2010; Kubrina, 2012).

With the acquisition of independence, the Republic of Kazakhstan, in order to improve the economic well-being of both the population and the Republic as a whole, began to increase the rate of extraction of natural resources, incl. and petroleum hydrocarbons (oil and gas). Of these oils, less than 25 % is processed on the domestic market, and the rest is transported to near and far abroad. Transportation routes are different: railway, sea, and the main share belongs to pipeline transport. The latter is more economical and also environmentally friendly. It is worth considering the environmental situation of the Atyrau region, since a large share of oil production falls on it. Atyrau region is one of the most environmentally polluted regions of Kazakhstan. The aggressive growth rate of oil and gas production is having a negative impact on the local environment. Such anthropogenic factors in the processes of the oil industry as drilling oil wells, laying oil pipelines, transport highways and construction work cause disruption of the natural landscape, resulting in its degradation.

Soil cover is the most important component of the biosphere. All processes occurring in the biosphere are determined by the soil cover. Therefore, the study of its current state of soil cover and changes under the influence of anthropogenic activity is extremely important. Hydrocarbon deposits of Atyrau region are the main sources of pollution in the territory for many decades.

In this region, due to the complex geological structure of oil and gas-bearing fluids and the high pressure of the oil formations in these fields, there is a risk of soil contamination during oil extraction. Environmental pollution may also occur during processing and transportation (Diarov, 2003).

The oil and gas industry is now widespread and has a significant impact on the environment. All components of the natural environment, including soil, are negatively affected by the development and exploitation of mineral deposits. Moreover, the nature of soil degradation is different and depends on various factors (Turebekova et al., 2016). Thus, the soils of the Atyrau region contain such heavy metals as lead, copper, cobalt, antimony, zinc, but in the fields their MAC does not exceed the norms, except for some areas of the Tengiz field, where the oil extraction works are carried out particularly intensively. In these areas, lead exceeds the MAC standard by a factor of 2, zinc by a factor of 18–29, and arsenic by a factor of 15–30. Not only soil, but also plants contain heavy metals in their composition.

Study area

Makat district is located in the south-eastern part of the Atyrau region, its territory has a length from north to south of 58 km and from west to east 124 km. In the north, the district borders with the Kyzylkoginsky district, in the southeast with the Zhylyoi district, in the southwest with the suburban areas of Atyrau and in the west with the Makhambet district. The area of the district within the administrative boundaries is 487.8 thousand hectares, which is 4.2 % of the territory of the Atyrau region.

The administrative center of the district is the urban-type settlement of Makat, located 130 km from the regional center — the city of Atyrau. The basis of the region's economy is the oil and gas production industries, which are represented by NGDU «Makatneft», NGDU

«Dossorneft», LPU «MakatZhaiktransgaz», and there is also the Dossor auto repair plant. The Makat region is industrial. The development of its economy is associated with the development and exploitation of oil fields. The territory of the Makat region, geomorphologically, belongs to the Caspian accumulative Upper Quaternary marine, in places alluvial lowland of the marginal trough of the platform with preserved marine salinization and with partial aeolian modeling. By the nature of the relief, it is an extremely flat plain, composed mainly of sandy and partly loamy Upper Khvalynian deposits (Diarov, 2003).

Zhylyoi district is located in the south-eastern part of Atyrau region. It is bordered to the north by Kzylykoginsky, to the north-west by Makat districts of Atyrau region, to the west by the Caspian Sea and to the south by Aktobe region. The area of the district is 29352.2 km². The Zhylyoi region is characterized by a rather monotonous topography. It is located in two geomorphological regions - the Caspian lowland and the Podural chalk plateau. Most of the region's territory lies within the first of them. The basis of the region's economy is the oil industry, which is represented by NGDU «Kulsaryneft», «Prorvaneft» and «Tengizchevroil» JV, the largest Tengiz field, oil fields and corresponding linear transport and related enterprises.

Materials and research methods

Oilfields in Makat and Zhylyoi districts of the Atyrau region were selected as study objects for a comparative assessment of the current state of soil cover. Large oil fields are located in these study areas.

The main purpose of the surveys was to identify anthropogenically disturbed (degraded) and contaminated lands as a result of previous oil production activities. During the analysis, samples were taken from 2 deposits in each region of the region. A total of 4 points were considered in the oil fields of Tengiz (coordinates 46°09'10" 53°23'00"), Koschagyl (coordinates 46°49' 53°46'), Iskine (coordinates 47°24' 52°42'), Koshkar Yuzhny (coordinates 47°44' 53°45') (Figure 1). The sample was taken at distances of 1, 5, 10 km from each point of the studied deposits.

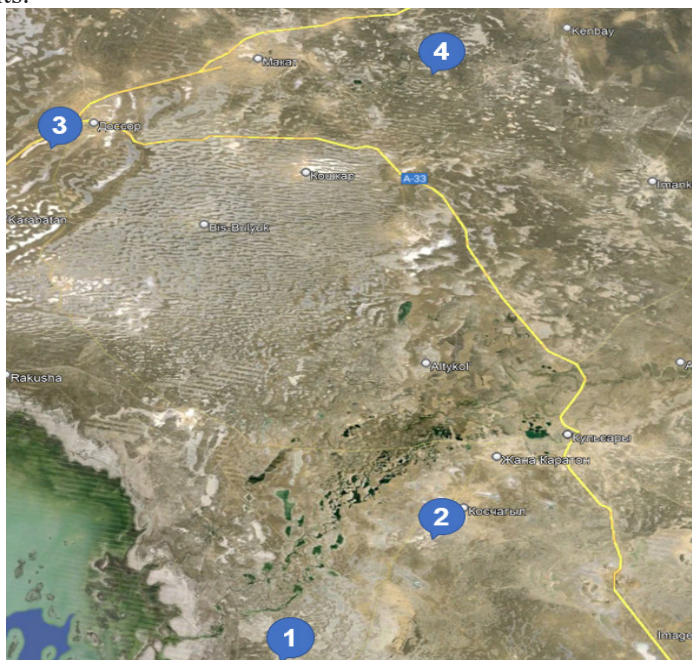


Figure 1 – Schematic map of soil sampling sites in oil fields of the Zhylyoi region and Makat region.

Oil fields: 1 – Tengiz, 2 – Koschagyl, 3 – Iskine, 4 – Koshkar Yuzhny

Soil samples were taken from the main soil varieties and near the studied oil fields of the Makat and Zhylyoi districts of the Atyrau region in the upper horizon at a depth of 0–25 cm. To conduct a study of soil contamination in the studied region, classical methods of analysis were used. Sampling, preservation, and analysis of the first day were carried out in strict accordance with regulatory documents and in accordance with GOST 17.4.4.02–84. Soils. Selection methods and sample preparation for chemical, bacteriological and helminthological analysis in accordance with GOST 17.4.3.01–83. Soils. Requirements for sampling. All analyzes were performed in a specialized chemical laboratory, and the acidity of the medium (pH) was determined. The content of heavy metals in soil samples was determined by atomic absorption spectroscopy using a spectrophotometer.

In many modern and foreign studies, the Single Pollution Index formula is used to identify the presence of contamination by a single pollutant metal (Single Pollution Index):

$$PI=Ci/GB \quad (1)$$

This formula is used to determine the presence of contamination by a particular metal pollutant. If the value of $PI < 1$ indicates the absence of pollution, $1 < PI < 2$ - about weak pollution, $2 < PI < 3$ - about average, $3 < PI < 5$ - about strong, $PI > 5$ - about very strong pollution. The index is the basis for the calculation of comprehensive pollution indicators.

Currently, the Nemerow Pollution Index (NPI) is widely used to assess soil quality. The Nemerow Pollution Index (NPI) takes into account not only the contribution of each pollutant, but also the potential hazard of the metal pollutant with the highest content.

The formula for the Nemerow Pollution Index (NPI) is given below:

$$NPI = \sqrt{\frac{PI_{1max}^2 + PI_{1ave}^2}{2}} \quad (2)$$

where PI_{1max} is the maximum PI value among n metals, and PI_{1ave} is the average PI value. NPI ranks five classes of soil pollution: $NPI < 0.7$ – clean soil, $0.7 \leq NPI < 1.0$ – borderline level, $1.0 \leq NPI < 2.0$ – weak pollution, $2.0 \leq NPI < 3$, 0 – average, $NPI > 3$ – severe pollution (Kowalska, ect., 2018; Tong, ect., 2020).

PLI – Pollution Load Index, calculated as the geometric mean of PI.

$$PLI=(PI_1 \times PI_2 \times \dots \times PI_n)^{1/n} \quad (3)$$

The coefficient indicates the cumulative accumulation of heavy metals. A PLI value below 1.0 indicates no contamination (Muller, 1969; Tomlinson et al., 1980).

Results and its discussion

In 2022–2023, a study of soil contamination by oil was conducted at oil fields located in the Zhylyoi and Makat districts of the Atyrau region. To determine the level of soil contamination at the oil fields, environmental monitoring was carried out, including selection of sampling sites, collection of soil samples, processing and interpretation of the data obtained.

These fields are characterised by the development of salt domes with numerous

industrial oil and gas reservoirs. The Zhylyoi district is the most heavily industrialised. There are over 40 oil fields with total reserves of 2.5 billion tonnes. The next most vulnerable to industrial pollution is Makat district. Within the boundaries of Makat district there are Koshkar, Karsak, Komsomolskoye, Iskine oil fields, NGDU «Makatneft», NGDU «Dossorneft», LPU «MakatZhaiktransgaz» and there is also the Dossor car repair plant.

Tengiz is an oil and gas field located in the Atyrau region of Kazakhstan, 160 kilometres south-east of the city of Atyrau. It is part of the Caspian Sea oil and gas province. Tengiz is the second largest oil field in Kazakhstan in terms of oil reserves (after the Kashagan field). The Kosshagil oil field is located in the Zhylyoi district of the Atyrau region, 270 km south-east of the city of Atyrau. The geological reserves of oil in this field are estimated at 95 thousand tonnes. Eskine is an oil field located in Makat district of Atyrau region. The field is limited to a four-wing salt dome structure. The oil bearing capacity is associated with Cretaceous, Jurassic and Permo-Triassic sediments (Ishhanova et al., 2001; Abirov et al., 2022: 159–173).

The South Koshkar field is located in the Makat district of the Atyrau region, 17 km from the Sagiz field and 35 km from the Makat field. Deep exploration drilling has been started in the South Koshkar dome. As a result, commercial oil bearing capacity has been established in the south-western and north-western wings of the dome.

The increase in the content of oil and oil products in the soil of oil fields depends on many factors, especially the time and intensity of field use, the nature of oil and oil product emissions to the environment, and the physical and chemical composition of oil (Zhang et al., 2018; Imashev et al., 2014: 286–289). The acidity of the soil environment in the studied oil fields of the study areas was different. Tengiz Point had a pH of 7.7, Koschagyl had a pH of 8.0, Isken had a pH of 7.9 and South Koshkar had a pH of 8.1. Active alkalisation of soil solutions is observed in the soils of the study areas. The results of our own research and literature data show that the soils in the oil field areas are intensively polluted by oil and oil products, resulting in the destruction of the soil cover and the destruction of the geochemical structure of the soil.

The heavy metals zinc, copper, lead and cadmium were detected in soil samples collected from the oil fields studied. The samples were collected and prepared for analysis in accordance with the current regulatory requirements for the control of general and local soil contamination in the Company’s area of influence. Table 1 shows the results of the determination of heavy metals in the soils of the fields studied.

Table 1. Content of heavy metals in soils of oil fields of Zhylyoi and Makat districts of Atyrau region

Sampling points	pH	Cu	Cd	Pb	Zh
MPC, mg/kg		3,0	0,5	32,0	23,0
Tengiz	7,7	2,878	0,087	33,112	23,472
Koschagyl	8,0	2,481	0,027	31,231	20,182
Iskine	7,9	2,387	0,042	30,112	22,793

South Koshkar	8,1	2,538	0,075	31,735	21,931
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Norms for MPC of heavy metals in soils in accordance with the joint Order of the Minister of Health of the Republic of Kazakhstan dated 30 January 2004 № 99 and the Minister of Environmental Protection of the Republic of Kazakhstan dated 27 January 2004 № 21-p “On approval of norms of maximum permissible concentrations of harmful substances, harmful microorganisms and other biological substances polluting the soil” for copper (Cu) 3.0 mg/kg, lead (Pb) 32.0 mg/kg, zinc (Zn) 23.0 mg/kg.

The analyses carried out in sampling at different points of the oil fields showed that the content of copper in soils ranges from 2.387 to 2.878 mg/kg at MAC - 3.0 mg/kg. At MPC of 0.5 mg/kg, the cadmium content in the soils of the sampled areas ranged from 0.027 to 0.087 mg/kg. At a MAC of 32.0 mg/kg, the analysis of soil samples from the sampling sites ranged from 30.112 to 33.112 mg/kg of lead in soil. The amount of lead observed in the soils of the oil fields of the Zhylyoi and Makat districts, which corresponds to optimal conditions for human and animal life, only slightly exceeds the MPC at the Tengiz oil field. The amount of zinc observed in the soil varies from 20,182 to 23,472 mg/kg with MAC - 23.0 mg/kg. These analyzes showed a slight excess of the maximum permissible concentration of zinc in the Tengiz oil field of the Zhylyoi region. For other deposits, the zinc content in soils corresponds to optimal living conditions for people and animals. All results of studies of soil samples showed that the content of heavy metals at the points of soil sampling does not exceed the maximum permissible concentration, except for a slight excess in the Tengiz fields (Figure 2).

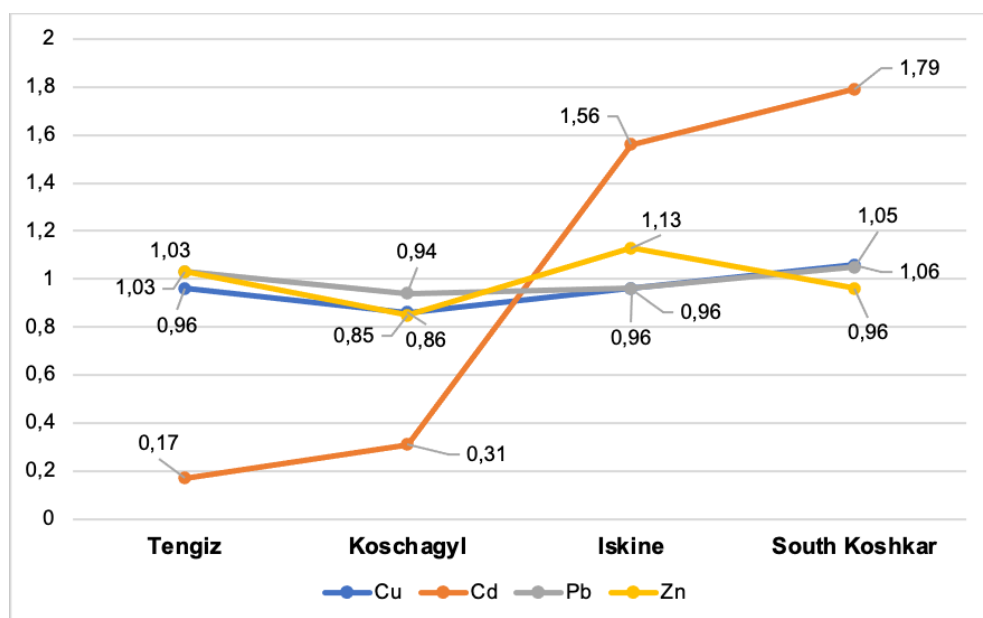


Figure 2. Dynamics of heavy metals in soils of oil fields of Atyrau region

Using formula (1) of the Single Pollution Index, we calculate the presence of pollution with individual pollutant metals. The pollution index results of selected heavy metal pollutants

in the oil fields of the study areas are shown in Table 2.

Table 2. Values of individual indices of soil pollutants in the studied deposits

Heavy metals	MPC, mg/kg	Tengiz	Koschagyl	Iskine	South Koshkar
Cu	3	0,96	0,86	0,96	1,06
Cd	0,5	0,17	0,31	1,56	1,79
Pb	32	1,03	0,94	0,96	1,05
Zn	23	1,03	0,85	1,13	0,96

The calculations carried out at the studied points of the oil fields showed the values of $1 < PI < 2$ in the South Koshkar oil field for three heavy metals (Cu - 1.06; Cd - 1.79; Pb - 1.05), which corresponds to the weak pollution index. For the Iskene deposit, the pollution index corresponds to the value of weak pollution $1 < PI < 2$ for two heavy metals (Cd – 1.56; Zn – 1.13). In the Tengiz fields, the state of the soil cover corresponds to the pollution index $1 < PI < 2$ for two heavy metals (Pb - 1.03; Zn - 1.03), which indicates weak pollution of this field. Only in the Koschagyl oil field, the pollution index for all heavy metals showed a value of $PI < 1$, which indicates the absence of contamination of this field with these metals.

The ecological assessment of the soils of the oil fields of the Zhylyoi and Makat districts of the Atyrau region was carried out using the Nemerov Pollution Index (NPI), which is widely used to assess the quality of soils, as it takes into account not only the contribution of each pollutant, but also the potential danger of the metal pollutant with the highest content. According to formula (2), the indicators obtained are ranked by Nemerov Pollution Index classes, the data of which are given for each oil field in Table 3.

Table 3. NPI statistical indicators for the studied oil fields of the Atyrau region

Oilfield	Value	Pollution status
Tengiz	0,92	border level
Koschagyl	0,85	border level
Iskine	1,37	Slight
South Koshkar	1,53	Slight

The values of complex pollution coefficients PLI, both average and maximum, indicate degradation of the surface layer of soils and a high degree of pollution with heavy metals. Using formula (3), we calculated the pollution coefficient (Pollution Load Index) (Table 4).

Table 4. Statistical indicators of PLI for the studied oil fields of the Atyrau region

Oilfield	Value	Pollution status
Tengiz	0,80	No metal contamination
Koschagyl	0,74	No metal contamination

Iskine	1,15	Deterioration of soil quality
South Koshkar	1,22	Deterioration of soil quality

Judging by the values of the complex pollution index (Nemerow NPI), the degree of soil pollution in oil fields increases in the following order: Koschagyl (0.74–0.85, no pollution) < Tengiz (0.80–0.92, weak pollution) < Iskine (1.15–1.37, light pollution) < South Koshkar (1.22–1.53, light pollution) (Figure 3).

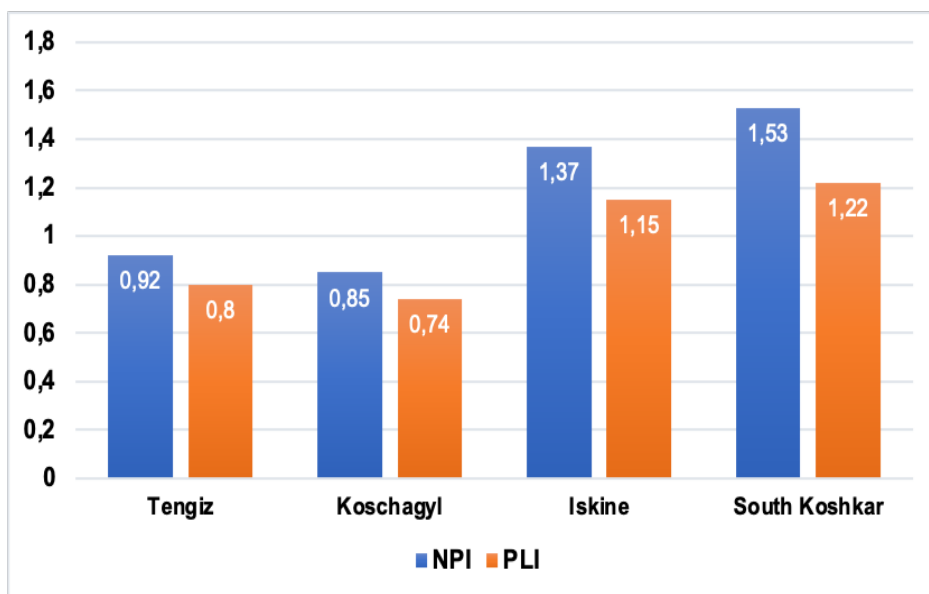


Figure 3. Mean values of the Nemerov Pollution Index NPI (A) and Pollution Coefficient PLI (B) in the soils of the investigated oil fields of the Atyrau region.

The results of soil analysis for heavy metal content in the studied oil fields of Zhylyoi and Makat districts of Atyrau region showed that the ecological state of the soil cover was not strongly disturbed during the study period in 2022–2023. According to the results of soil analysis in the Tengiz, Koschagil, Eskene and South Koshkar oil fields, it can be said that the chemical composition of the soil has the same heavy metal content.

Conclusion

In conclusion, it should be noted that the formation of the oil and gas complex in the studied areas of the Atyrau region has significantly increased the anthropogenic load on the land cover. The main causes of ecological disturbance of the soil cover of the region are: technogenic disturbances, petrochemical and industrial effluents, drilling muds, toxic chemical elements, etc.

High levels of lead and zinc have been found in soil samples. Soil pollution sets off a chain reaction. It affects soil biodiversity, reduces soil organic matter reserves and its filtering capacity. Soil pollution leads to contamination of soil moisture and groundwater, and the balance of nutrients in the soil is disturbed.

In the course of the work, the ecological condition of the soil was therefore assessed on the basis of the composition of a number of pollutants. It was found that the amount of heavy metals in the samples analysed fluctuated within the norm, indicating the absence of oil pollution in the area. The only heavy metals exceeding the MAC were lead and zinc in

the Tengiz oil field, which can be explained by the presence of an acid-reducing barrier in the taiga peat soils. It was found that the levels of cadmium, lead and zinc in the soil of the field are below the permissible norms in some places. This allows us to conclude that the soil component in the study area is in a satisfactory ecological condition, based on the presence of polluting chemical elements and substances.

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