Трансформация экосистем
Ecosystem Transformation

ISSN 2619-0931 Online
www.ecosysttrans.com

DOI: https://doi.org/10.23859/estr-240419
EDN: https://elibrary.ru/moszys
UDC 6504.06

Review

The problems of reclamation of lands disturbed as a result of the construction and operation of linear facilities (using pipeline transport as an example)

A.A. Amosova[1], D.I. Vasilieva[2], O.A. Samarina[1], Yu.A. Kholopov[3]*

[1] *Samara State Technical University, Molodogvardeyskaya St. 244, Samara, 443100 Russia*
[2] *Samara State University of Economics, Sovetskoi Armii St. 141, Samara, 443090 Russia*
[3] *Volga State University of Railway, Svobody St. 2B, Samara, 443066 Russia*

**kholopov@bk.ru*

Abstract. This paper examines the key stages of the land restoration process, when land productivity declines during the construction or reconstruction of linear facilities (using pipeline transport infrastructure as an example), as well as emergency situations, such as oil pipeline ruptures. Based on the example of Samara oblast, statistical data on disturbed lands of the region are analyzed, of which 37 thousand ha (about 0.6%) are occupied by pipeline transport. The choice of technology for the restoration of disturbed lands should be based on their intended use. In particular, for Samara oblast, it is recommended to use agricultural techniques for restoring damaged properties of degraded soils: activation of native soil microflora, soil treatment with sorbents and biological products, bioremediation.

Keywords: oil fertility restoration, promising methods for activating soil biocenosis, environmental impact

ORCID:
A.A. Amosova, https://orcid.org/0000-0003-1163-0908
D.I. Vasilieva, https://orcid.org/0000-0002-0808-8364
O.A. Samarina, https://orcid.org/0009-0007-3935-6329
Yu.A. Kholopov, https://orcid.org/0000-0002-2442-7186

To cite this article: Amosova, A.A. et al., 2025. The problems of reclamation of lands disturbed as a result of the construction and operation of linear facilities (using pipeline transport as an example). *Ecosystem Transformation* **8** (3), 224–234. https://doi.org/10.23859/estr-240419

Received: 19.04.2024
Accepted: 01.09.2024
Published online: 29.08.2025

DOI: https://doi.org/10.23859/estr-240419
EDN: https://elibrary.ru/moszys
УДК 6504.06

Научный обзор

Проблемы рекультивации земель, нарушенных в результате строительства и эксплуатации линейных сооружений (на примере трубопроводного транспорта)

А.А. Амосова[1], Д.И. Васильева[2], О.А. Самарина[1], Ю.А. Холопов[3]*

[1] *Самарский государственный технический университет, 443100, Россия, г. Самара, ул. Молодогвардейская, д. 244*

[2] *Самарский государственный экономический университет, 443090, Россия, г. Самара, ул. Советской Армии, д. 141*

[3] *Приволжский государственный университет путей сообщения, 443066, Россия, г. Самара, ул. Свободы, д. 2В*

**kholopov@bk.ru*

Аннотация. Рассмотрены ключевые этапы процесса восстановления земель, снижение продуктивности которых возникло при строительстве или реконструкции линейных объектов (на примере объектов инфраструктуры трубопроводного транспорта), а также из-за аварийных ситуаций, например, после разрыва нефтепровода. На примере Самарской области проанализированы статистические данные о нарушенных землях региона, из которых 37 тыс. га (около 0.6%) заняты трубопроводным транспортом. Выбор технологии для рекультивации нарушенных земель должен опираться на их предполагаемое назначение. В частности, для Самарской области рекомендовано использование сельскохозяйственных методов восстановления нарушенных свойств деградировавших почв: активизация аборигенной микрофлоры почвы, обработка почвы сорбентами и биопрепаратами, биоремедиация.

Ключевые слова: восстановление плодородных свойств почвы, перспективные методы активизации почвенного биоценоза, воздействие на окружающую среду

ORCID:
А.А. Амосова, https://orcid.org/0000-0003-1163-0908
Д.И. Васильева, https://orcid.org/0000-0002-0808-8364
О.А. Самарина, https://orcid.org/0009-0007-3935-6329
Ю.А. Холопов, https://orcid.org/0000-0002-2442-7186

Для цитирования: Амосова, А.А. и др., 2025. Проблемы рекультивации земель, нарушенных в результате строительства и эксплуатации линейных сооружений (на примере трубопроводного транспорта). *Трансформация экосистем* **8** (3), 224–234. https://doi.org/10.23859/estr-240419

Поступила в редакцию: 19.04.2024
Принята к печати: 01.09.2024
Опубликована онлайн: 29.08.2025

Introduction

Human economic activity is the most common cause of disturbed land, which has completely or partially lost its valuable properties. It can lead to negative changes in the geomorphological structure of the area and its hydrological regime, the destruction of soil and vegetation cover, etc. The adverse effects on soil can be categorized into two main groups: landscape and ecological alterations. The first group includes fundamental disturbances of the landscape and land surface components (biotope); the second - reduced species composition of biocenoses, decreased bioproductivity, loss of vegetation cover, and decline in the numbers of fauna representatives (Ola et al., 2024; Yang et al., 2024). As a result of pollution (for example, by petroleum products), especially valuable and highly fertile chernozems become unsuitable for agricultural production and require long-term natural restoration (Ruseva et al., 2024).

The above factors can serve as catalysts for the process of landscape degradation in the surrounding area: in particular, significant changes in the microrelief can be initiated, expressed in erosion, the formation of gullies, and karst sinkholes. Waterlogging processes are activated in surface water bodies and the hydrological regime of small rivers is disrupted; for groundwater, adverse effects are mainly manifested in changes in their feeding and chemical composition. Large and medium-dispersed suspended particles begin to accumulate in the atmospheric near-ground layers and their gas composition changes (Smetanin, 2004; Vasilieva, 2020).

To avoid any negative impacts on the landscape and natural objects during the construction or reconstruction of linear facilities, it is essential to provide for reclamation measures aimed at restoring the properties of disturbed land (Ponomarev, 2014). The removal of topsoil should be considered in the course of engineering and environmental surveys. During excavation work, the removal and prudent use of the fertile soil layer is regulated by GOST 17.4.3.02-85[1], and the guidelines for its removal can be found in GOST 17.5.3.06-85[2] (Shuparsky, 2019).

Restoration of soil properties is a complex system of measures consisting of several stages:

1) preparatory, where a feasibility study of remediation measures is conducted;

2) technical (engineering) – terrain leveling, earthworks, removal of temporary structures and construction waste, construction of hydraulic structures, application of soil layer, etc.;

3) the biological stage involves restoring forest vegetation (in the forestry sector), landscaping, planting perennial or annual grasses, implementing crop rotations, and taking various land reclamation measures.

The reclamation period, which combines the technical and biological stages, can last for a long time (for example, the overgrowth of quarries formed during open-pit mining takes several decades).

There are several directions of reclamation, depending on the planned land use: the agricultural (carried out in developed farming regions with fertile soils, when the soil cover is restored and degraded land transforms into agricultural lands); forestry (planting of forests for operational or special purposes such as soil protection, water protection, etc.); recreational (recreational facilities such as parks, etc.), environmental protection, sanitary and health improving, etc. (Mikhno, 2018; Vasilieva and Baranova, 2017; Vasilieva et al., 2020). The direction of reclamation is justified in the project, which must undergo State Environmental Expert Review and receive a positive conclusion. At the same time, the disturbed lands must be reclaimed regardless of the form of ownership (Stifeev and Skripin, 2008).

[1] GOST 17.4.3.02-85. Nature protection. Soils. Requirements for fertile soil layer conservation in performing earth-moving.

[2] GOST 17.5.3.06-85. Nature protection. Lands. Requirements for determination of the fertile soil layer standard disposal while performing earth-moving.

Maintenance and planned reconstruction of a wide network of pipelines is often carried out without considering the characteristics of adjacent areas, leading to negative changes in ecosystems and the emergence of areas with varying degrees of disturbance. It should be taken into account that during the construction and maintenance of a linear facility, a significantly larger area is affected than during its operation, since equipment, building materials, and workers need to be placed on the designated land; whereas during the facility operation, 1-2 inspections per year are usually sufficient in case of its proper functioning.

There are a large number of pipeline transport facilities in Samara oblast. They are mainly trunk pipelines with a diameter of 1220 and 1420 mm, through which oil from the Siberian and Far Eastern federal districts is transported to the European part of Russia and other countries. For example, the “Druzhba” oil pipeline, the largest system of main oil pipelines in the world, runs through Samara oblast. Thus, the issue of planning and implementing measures to reclaim the areas disturbed as a result of accidents on pipelines and during their maintenance is a significant concern for the region.

The aim of this study is to review the condition of lands disturbed during the construction and operation of linear facilities such as pipelines, as well as to assess the effectiveness of methods of their reclamation (using Samara oblast as an example).

The state of disturbed lands in Samara oblast

According to statistical data published in the reports of the Ministry of Forestry, Environmental Protection and Nature Management of Samara oblast, the Federal Service for Registration, Cadastre and Cartography for Samara oblast, the Territorial Body of the Federal State Statistics Service[3] for Samara oblast, etc., the total area of disturbed land in the region tends to increase. For example, according to the “Report on the environmental situation in the Samara oblast for 2023[4]”, 64,095.2 hectares of disturbed lands were recorded (62463.7 ha more than in 2022) (Table 1).

Land occupied by pipeline transport facilities belong to the category of "industrial, energy, transportation, communication, and other special-purpose lands"[5]. According to the "Report on the Environmental Situation in the Samara oblast for 2022", 71.8 thousand ha of land in the region fall into this category (1.3% of the total area). Transportation infrastructure occupies the largest area (36.7 thousand ha); it includes roads (18.8 thousand ha), railways (17.4 thousand ha) and pipelines (0.5 thousand ha) (Doklad..., 2023).

The distribution of the lands studied in this category, according to the type of land, is shown in Fig. 1.The majority of the land is in held in state and municipal ownership (68.2 thousand ha, or 96.8%), 1.6 thousand ha – in the ownership of legal entities, and 0.7 thousand ha is in private ownership (as of 01.01.2020) (Doklad..., 2023).

The oil and gas industry is the basis for the economic development of Samara oblast, and the efficiency of its operation depends to a large extent on the condition of the main pipelines. This type of transport, which passes through the territories of almost all regions of the Russian Federation, transports 100% of produced gas, approximately 99% of produced oil, and more than 50% of refined products (Faizova, 2022).

The maintenance, construction and reconstruction of linear facilities can cause various types of damag to adjacent natural areas – from changes in groundwater flow and microclimate deterioration to the disappearance of the most sensitive species, changes in animal migration routes and the destruction of entire ecosystems. In addition, foreign chemicals can penetrate and accumulate in the soil cover. For example, during oil pipeline maintenance and reconstruction, petroleum product spills and their subsequent accumulation in the soil are often allowed. A survey of the area near the Ufa-Zapadnoye oil pipeline showed that the maximum concentration of petroleum products in the soil was 1.8 times higher than the background level (Doklad..., 2023).

---

[3] The Federal State Statistics Service. Web page. URL: https://rosstat.gov.ru/ (accessed:20.05. 2025).

[4] Website of the Ministry of Natural Reseurces and Ecology of Samara oblast. Web page. URL: https://priroda.samregion.ru/wp-content/uploads/sites/11/2024/06/doklad-2023.pdf (accessed:20.05. 2025).

[5] The Land Code of the Russian Federation No. 136-FZ of 25.10.2001 (as amended on 20.03.2025)

Table 1. The area of disturbed and reclaimed lands in Samara oblast in 2023.

Parameter	Area (ha)
The total area of disturbed lands as of 01.01.2023	8179.1
Lands disturbed in a 2023	64095.2
Land reclaimed, total	62607.4
– of them for arable land	1223.6
– for other agricultural land	262.2
– forest plantations	2.1
– water bodies and other purposes	73.1
The total area of disturbed lands as of 01.01.2024	9666.9

Reclamation of land occupied by pipeline transport

The construction of embankments of various shapes and sizes (canals, dams, dikes, etc.), excavation of foundation pits and other cases of anthropogenic relief transformation along linear facilities causes land disturbance during the construction and operation of pipelines. This involves removing the top fertile soil layer, rock excavation, and moving volumes of soil extracted from mine workings. The specifics of disturbed land recultivation are reflected in the design documentation of linear facilities (Shuparsky, 2019).

To reduce the anthropogenic load on the lands adjacent to linear facilities, the environmental legislation of the Russian Federation[6] provides for the mandatory removal of the upper fertile soil layer before construction works begin. The fertile layer is moved to a specialized storage pile (dump), which is often located along the pipeline right-of-way. After the construction is completed, this material is used for land reclamation in order to restore the fertile soil layer.

At the technical stage of reclamation after the construction, repair or reconstruction are completed, the building structures are dismantled, construction debris is removed and the pipeline trenches are backfilled with soil to form an embankment, the height of which can ensure land leveling after the soil compaction and subsidence. The final stage involves applying a layer of humus-accumulative soil to the leveled land. If there is an excess amount of this type of soil, it should be evenly spread over the reclaimed land area or transported to the storage sites planned for the project.

The choice of further direction of reclamation depends on how the land will be used in the future (Stefantsova, 2018; Voronin et al., 2013). At the same time, the best available reclamation technologies should be used in areas affected by accidental oil spills (Sivkov, 2024; Trots, 2019).

When laying pipeline transport in specially protected natural areas, reclamation should be based on field survey reports (which include data on the flora and fauna) conducted by specialized research organizations prior to the implementation of construction works.

Reclamation of oil-contaminated land

The reclamation of lands disturbed as a result of oil pipeline ruptures or unauthorized tie-ins is also conducted in several stages. The preparatory stage usually includes clearing and localization of the polluted area; removal of contaminated soil from the site if the level of its contamination with petroleum products is more than 15%; planning for further preparatory work.

[6] Decree of the Government of the Russian Federation No. 800 of July 10, 2018 "On Land Reclamation and Conservation". Web page. URL: https://base.garant.ru/71985800/?ysclid=mawr0yrl7o874597179 (accessed: 20.05.2025).

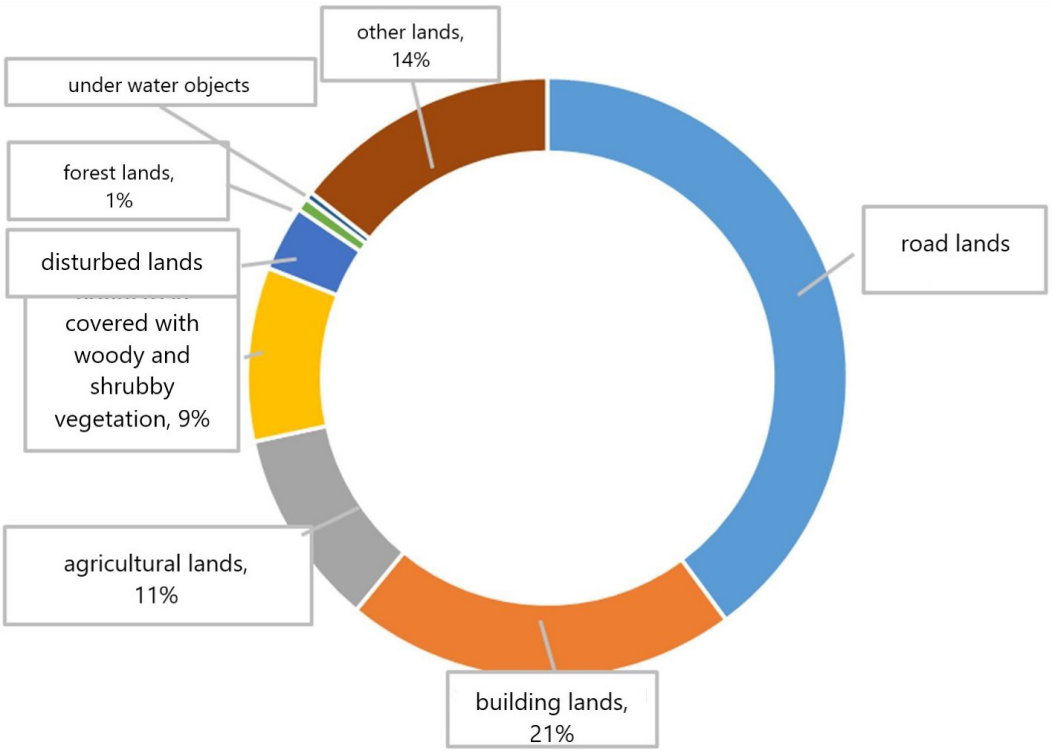

Fig. 1. The structure of industrial and other special-purpose lands in Samara oblast.

Next, at the technical stage, in accordance with RD 153-112-014-97[7], the engineering preparation of the area is carried out, followed by the biological stage of remediation. It involves treating contaminated soil with biopreparations and ameliorants that accelerate the biodegradation of harmful chemicals and restore soil fertility.

The required doses of the reagents used (mineral fertilizers, reagents for soil liming, sorbents and structure-forming agents, humic mineral preparations, etc.) are calculated based on the incoming control of soil contamination with oil (Rusinov and Kholopov, 2016).

Reclamation of disturbed lands in Samara oblast

The analysis of reclamation measures used to restore the properties of oil-contaminated soils at production facilities in Samara oblast revealed the following shortcomings of standard methods of reclamation of the soils with altered chemical composition: firstly, pollutants can remain virtually unchanged, as technologies for their complete extraction and disposal are either very expensive or unavailable; secondly, cleaning contaminated soil with biologically active reagents poses a high risk of secondary pollution and damage to other environmental components. At the same time, a review of the technologies used in Samara oblast, which utilize natural materials available in the region, showed the economic feasibility of using biosorbents as part of multicomponent mixtures with a high absorption capacity based on sand, clay and other common minerals (Kuznetsova and Amosova, 2021).

In light of the above, biosphere-compatible soil purification technologies that do not have these drawbacks are of particular interest. For example, native microorganisms-destructors, which are capable of decomposing and eliminating pollutants under both aerobic and anaerobic conditions, are used in bioremediation. Methods of stimulating the growth of microorganisms are used to accelerate biodegradation (Rusinov and Kholopov, 2016; Tankikh et al., 2019; Zabolotskikh et al., 2014, 2018).

[7] RD 153-112-014-97. Guidelines on Accident Response and Repair at Petroleum Product Trunk Pipelines.

To restore the disturbed lands in Samara oblast, where agricultural reclamation is a priority, methods using biopreparations based on genetically modified microorganisms, biodestructor strains from native microflora of the soil of a particular type, and sorbents based on local natural materials can be recommended as biosphere-compatible technologies (Zabolotskikh et al., 2014). At the final stage of restoration work, phytomelioration measures are necessary (sowing perennial grasses which are resistant to a specific type of pollution).

The outcome of these multifaceted efforts aimed to restore the disturbed lands should be an ecologically balanced sustainable landscape (Sinyavsky and Istomina, 2019).

An additional advantage of using biosphere-compatible technologies is the potential product – purified organomineral soil, which, according to GOST R 59057-2020[8], can be used for biological reclamation of disturbed lands and areas where the soil cover was completely destroyed. It can also be used as soil for ornamental plants, for creating an insulating layer on landfills, etc. Reclaimed soils with a residual oil content of 20–30 g/kg can be used for the construction of wells, roads, pipelines, landscaping , etc.

Also, one can choose the water management direction of land reclamation. The created water bodies (lakes and ponds) can be used for environmental protection, irrigation, and fisheries. Even if a trunk pipeline is located in a forested area, perennial herbaceous vegetation is planted over the pipeline to restore its right-of-way, since trees and shrubs can interfere with the linear facility operation (Vasilieva, 2020).

Conclusion

Thus, the large-scale use of pipeline transportation in Samara oblast necessitates the restoration of soil properties degraded as a result of the construction, reconstruction, and operation of linear facilities. The conversion of disturbed lands into arable or other agricultural lands is the primary goal of reclamation in the region.

To restore the ecological balance of the disturbed areas in Samara oblast, it is suggested to utilize methods which include the use of biologicals and strains of native microorganisms, as well as the treatment of soil with sorbents based on natural materials that are widely available in the region.

References

Doklad ob ekologicheskoi situacii v Samarskoi oblasti za 2022 god [Report on the environmental situation in the Samara region for 2022], 2023. Ministry of Forestry, Environmental Protection and Nature Management of the Samara Region, Samara, Russia, 175 p. (In Russian).

Faizova, K.V., 2022. O pravovyh i ehkologicheskikh problemakh ehkspluatacii gazoprovodov [On legal and environmental problems of gas pipeline operation]. *Agrarnoe i zemel'noe pravo [Agrarian and Land Law]* **12** (216), 53–55. (In Russian).

Kuznetsova, K.O., Amosova, A.A., 2021. Osobennosti processa razrabotki sorbentov dlya vosstanovleniya neftezagryaznennykh pochv Samarskoi oblasti [Features of the process of development of sorbents for restoration of oil-contaminated soils of Samara region]. *Sbornik statej VIII Mezhdunarodnoi nauchno-prakticheskoi konferencii "Studencheskie nauchnye issledovaniya" [Collection of articles of VIII International Scientific and Practical Conference "Student Scientific Research"], Penza, 10 November 2021.* Penza, Russia, 34–36. (In Russian).

Mikhno, P.B., 2018. Modelirovanie zhiznennogo cikla narushennykh zemel' [Modelling the life cycle of disturbed land]. *Vestnik Polockogo gosudarstvennogo universiteta. Seriya F. Stroitel'stvo. Prikladnye nauki [Vestnik of Polotsk State University. Series F. Construction. Applied Sciences]* **16**, 143–149. (In Russian).

Ola, I., Drebenstedt, C., Burgess, R.M., Mensah, M., Hoth, N., Külls, C., 2024. Remediating oil contamination in the Niger delta region of Nigeria: technical options and monitoring strategies. *The Extractive Industries and Society* **17**, 101405. https://doi.org/10.1016/j.exis.2024.101405

[8] GOST R 59057-2020. Environmental protection. Lands. General requirements for the reclamation of disturbed lands.

Ponomarev, V.S., 2014. O rekul'tivacii narushennykh zemel' i ikh landshaftnom osvoenii pri likvidacii shakht i kar'er, monitoring [On the reclamation of disturbed lands and their landscape development during the liquidation of mines and quarries, monitoring]. *Nauka i tekhnika [Science and Technology]* **2** (19), 46–53. (In Russian).

Rusinov, D.A., Kholopov, Y.A., 2016. Sposoby ochistki pochv i gruntov, zagryaznennykh nefteproduktami na zheleznodorozhnom transporte [Methods of cleaning of soils and soils contaminated with oil products on railway transport]. *Materialy III mezhdunarodnoi nauchno-prakticheskoi konferencii "Innovacii v prirodoobustroistve i zashchite v chrezvychainykh situaciyakh" [Proceedings of the III International Scientific and Practical Conference "Innovations in environmental engineering and protection in emergency situations"], Saratov, 18–20 May 2016.* Saratov, Russia, 35–39. (In Russian).

Shuparsky, A.I., 2019. Rekul'tivaciya narushennykh zemel' v sostave proektnoi dokumentacii linejnykh ob'ektov [Recultivation of disturbed lands as part of the design documentation of linear facilities]. *Vestnik gosudarstvennoi ehkspertizy* [*Vestnik of State Expertise]* **3** (12), 42–49. (In Russian).

Sivkov, Y.V., 2024. Nailuchshie dostupnye tekhnologii rekul'tivacii zemel' zagryaznennykh uglevodorodami [The best available technologies for reclamation of lands contaminated with hydrocarbons]. *Materialy Mezhdunarodnoi nauchno-prakticheskoi konferencii "Arktika: sovremennye podkhody k proizvodstvennoi i ehkologicheskoi bezopasnosti v neftegazovom sektore" [Proceedings of the International Scientific and Practical Conference "Arctic: modern approaches to industrial and environmental safety in the oil and gas sector"], Tyumen, 29 November 2023*. Tyumen, Russia, 363–365. (In Russian).

Sinyavsky, I.V., Istomina A.V., 2019. Rekul'tivaciya narushennykh zemel' i razrabotka kompleksa rabot, napravlennykh na vosstanovlenie biogeocenoza [Recultivation of disturbed lands and development of a set of works aimed at restoration of biogeocenosis]. *Evraziiskoe Nauchnoe Ob'edinenie [Eurasian Scientific Association]* **1-7** (47), 404–407. (In Russian).

Smetanin, V.I., 2004. Rekul'tivaciya zemel': obzor tekhnologii [Land reclamation: a review of technologies]*. Ehkologiya i promyshlennost' Rossii [Ecology and Industry of Russia]* **5**, 42–45. (In Russian).

Stefantsova, T.V., 2018. Osobennosti organizacii zemleustroitel'nykh rabot pri rekul'tivacii narushennykh zemel' [Features of the organisation of land surveying works in the reclamation of disturbed lands]. *Aktual'nye problemy ehkonomiki, sociologii i prava* [*Actual Problems of Economics, Sociology and Law]* **4**, 56–58. (In Russian).

Stifeev, A.I., Skripin, V.A., 2008. Biologicheskaya rekul'tivaciya narushennykh zemel' pri dobyche torfa, nefti, prokladke truboprovodov [Biological recultivation of disturbed lands during peat, oil and pipeline extraction]. *Vestnik Kurskoi gosudarstvennoi sel'skokhozyaistvennoi akademii [Vestnik of Kursk State Agricultural Academy]* **4**, 9–10. (In Russian).

Tankikh, S.N., Zabolotskikh, V.V., Vasiliev, A.V., 2019. Istoriya razvitiya osnovnykh podkhodov k vosstanovleniyu neftezagryaznyonnykh zemel' [History of development of the main approaches to the restoration of oil-contaminated lands]. *Sbornik statei VI Mezhdunarodnoi nauchno-prakticheskoi konferencii "Molodezhnaya nauka" [Collection of articles of the VI International Scientific and Practical Conference "Youth Science"].* Voronezh, Russia, 227–232. (In Russian).

Trots, N.M., 2019. Rekul'tivaciya chernozemov Syrtovogo Zavolzh'ya, narushennykh processami neftedobychi [Recultivation of chernozems of Syrtovy Zavolzhye disturbed by oil production processes]. *Izvestiya Samarskoi gosudarstvennoi sel'skokhozyaistvennoi akademii [News of Samara State Agricultural Academy]* **3**, 16–22. (In Russian).

Ruseva, A., Minnikova, T., Kolesnikov, S., Trufanov, D., Minin, N., Revina, S., Gayvoronsky, V., 2024. Assessment of the ecological state of haplic chernozem contaminated by oil, fuel oil and gasoline after remediation. *Petroleum Research* **9** (1), 155–164. https://doi.org/10.1016/j.ptlrs.2023.03.002

Vasilieva, D.I., 2020. Osobennosti rekul'tivacii zemel', narushennykh pri stroitel'stve i ehkspluatacii truboprovodnogo transporta [Features of land reclamation disturbed during construction and operation of pipeline transport]. *Nauka i obrazovanie transportu [Science and Education to Transport]* **2**, 70–73. (In Russian).

Vasilyeva, D.I., Baranova, M.N., 2017. Vosstanovlenie narushennykh zemel' na primere rekul'tivacii kar'erov v Samarskoi oblasti [Restoration of disturbed lands on the example of quarry reclamation in the Samara region]. In: Balzannikov, M.I. (ed.), *Tradicii i innovacii v stroitel'stve i arkhitekture. Stroitel'stvo [Traditions and innovations in construction and architecture. Construction]*. Samara State Technical University. Samara, 284–288. (In Russian).

Vasilieva, D.I., Vlasov, A.G., Kholopov, Y.A., Tarbaev, V.A., 2020. Narushennye zemli: sovremennoe sostoyanie i problemy racional'nogo ispol'zovaniya (na primere Samarskoi oblasti) [Disturbed lands: current state and problems of rational use (on the example of the Samara region)]. *Ekologiya i promyshlennost' Rossii [Ecology and Industry of Russia*] **24** (4), 60–65. (In Russian).

Voronin, V.V., Vlasov, A.G., Vasilieva, D.I., Most, E.S., 2013. Ekologicheskoe sostoyanie i kachestvo zemel' Samarskoi oblasti [Ecological state and land quality of the Samara region]. *Ekologiya urbanizirovannykh territorii [Ecology of Urbanised Territories]* **4**, 76–86. (In Russian).

Yang, H., Zhan, Q., Diao, H., Xia, S., 2024. Improving soil health and carbon sequestration through land reclamation in shale gas fields: A case study from Fuling's Jiaoshi Town. *Environmental Pollution and Management* **1**, 15–23. https://doi.org/10.1016/j.epm.2024.05.001

Zabolotskikh, V.V., Tankikh, S.N., Vasiliev, A.V., 2018. Tekhnologicheskie podkhody k detoksikacii i biovosstanovleniyu neftezagryaznennykh zemel' [Technological approaches to detoxification and bioremediation of oil-contaminated land]. *Izvestiya Samarskogo nauchnogo centra RAN [News of Samara Scientific Centre of the Russian Academy of Sciences]* **20** (5 (3)), 341–351. (In Russian).

Zabolotskikh, V.V., Vasiliev, A.V., Andrianova, L.V., 2014. Razrabotka i ehksperimental'noe issledovanie ehffektivnosti primeneniya smesi “Bioaktivator” dlya ochistki pochv ot nefteproduktov [Development and experimental study of the effectiveness of the mixture “Bioactivator” for cleaning soils from oil products]. *Izvestiya Samarskogo nauchnogo centra RAN [News of Samara Scientific Centre of the Russian Academy of Sciences]* **16** (1 (7)) 1840–1844. (In Russian).

Список литературы

Васильева, Д.И., 2020. Особенности рекультивации земель, нарушенных при строительстве и эксплуатации трубопроводного транспорта. *Наука и образование транспорту* **2**, 70–73.

Васильева, Д.И., Баранова, М.Н., 2017. Восстановление нарушенных земель на примере рекультивации карьеров в Самарской области. В: Бальзанников, М.И (ред.), *Традиции и инновации в строительстве и архитектуре. Строительство*. Самарский государственный технический университет, Самара, Россия, 284–288.

Васильева, Д.И., Власов, А.Г., Холопов, Ю.А., Тарбаев, В.А., 2020. Нарушенные земли: современное состояние и проблемы рационального использования (на примере Самарской области). *Экология и промышленность России* **24** (4), 60–65.

Воронин, В.В., Власов, А.Г., Васильева, Д.И., Мост, Е.С., 2013. Экологическое состояние и качество земель Самарской области. *Экология урбанизированных территорий* **4**, 76–86.

Доклад об экологической ситуации в Самарской области за 2022 год, 2023. Министерство лесного хозяйства, охраны окружающей среды и природопользования Самарской области, Самара, Россия, 175 с.

Заболотских, В.В., Танких, С.Н., Васильев, А.В., 2018. Технологические подходы к детоксикации и биовосстановлению нефтезагрязненных земель. *Известия Самарского научного центра РАН* **20** (5 (3)), 341–351.

Заболотских, В.В., Васильев, А.В., Андрианова, Л.В., 2014. Разработка и экспериментальное исследование эффективности применения смеси «Биоактиватор» для очистки почв от нефтепродуктов. *Известия Самарского научного центра РАН* **16** (1 (7)) 1840–1844.

Кузнецова, К.О., Амосова, А.А., 2021. Особенности процесса разработки сорбентов для восстановления нефтезагрязненных почв Самарской области. *Сборник статей VIII Международной научно-практической конференции «Студенческие научные исследования», Пенза, 10 ноября 2021 г.* Пенза, Россия, 34–36.

Михно, П.Б. 2018. Моделирование жизненного цикла нарушенных земель. *Вестник Полоцкого государственного университета. Серия F. Строительство. Прикладные науки* **16**, 143–149.

Пономарев, В.С., 2014 О рекультивации нарушенных земель и их ландшафтном освоении при ликвидации шахт и карьер, мониторинг. *Наука и техника* **2** (19), 46–53.

Русинов, Д.А., Холопов, Ю.А., 2016. Способы очистки почв и грунтов, загрязненных нефтепродуктами на железнодорожном транспорте. *Материалы III международной научно-практической конференции «Инновации в природообустройстве и защите в чрезвычайных ситуациях», Саратов, 18–20 мая 2016 г.* Саратов, Россия, 35–39.

Сивков, Ю.В., 2024. Наилучшие доступные технологии рекультивации земель загрязненных углеводородами. *Материалы Международной научно-практической конференции «Арктика: современные подходы к производственной и экологической безопасности в нефтегазовом секторе», Тюмень, 29 ноября 2023 г.* Тюмень, Россия, 363–365.

Синявский, И.В., Истомина А.В., 2019. Рекультивация нарушенных земель и разработка комплекса работ, направленных на восстановление биогеоценоза. *Евразийское Научное Объединение* **1-7** (47), 404–407.

Сметанин, В.И., 2004. Рекультивация земель: обзор технологий. *Экология и промышленность России* **5**, 42–45.

Стефанцова, Т.В., 2018. Особенности организации землеустроительных работ при рекультивации нарушенных земель. *Актуальные проблемы экономики, социологии и права* **4**, 56–58.

Стифеев, А.И., Скрипин, В.А., 2008. Биологическая рекультивация нарушенных земель при добыче торфа, нефти, прокладке трубопроводов. *Вестник Курской государственной сельскохозяйственной академии* **4**, 9–10.

Танких, С.Н., Заболотских, В.В., Васильев, А.В., 2019. История развития основных подходов к восстановлению нефтезагрязнённых земель. *Сборник статей VI Международной научно-практической конференции «Молодежная наука».* Воронеж, Россия, .227–232.

Троц, Н.М., 2019. Рекультивация черноземов Сыртового Заволжья, нарушенных процессами нефтедобычи. *Известия Самарской государственной сельскохозяйственной академии* **3**, 16–22.

Фаизова, К.В., 2022. О правовых и экологических проблемах эксплуатации газопроводов. *Аграрное и земельное право* **12** (216), 53–55.

Шупарский, А.И., 2019. Рекультивация нарушенных земель в составе проектной документации линейных объектов. *Вестник государственной экспертизы* **3** (12), 42–49.

Ola, I., Drebenstedt, C., Burgess, R.M., Mensah, M., Hoth, N., Külls, C., 2024. Remediating oil contamination in the Niger delta region of Nigeria: technical options and monitoring strategies. *The Extractive Industries and Society* **17**, 101405. https://doi.org/10.1016/j.exis.2024.101405

Ruseva, A., Minnikova, T., Kolesnikov, S., Trufanov, D., Minin, N., Revina, S., Gayvoronsky, V., 2024. Assessment of the ecological state of haplic chernozem contaminated by oil, fuel oil and gasoline after remediation. *Petroleum Research* **9** (1), 155–164. https://doi.org/10.1016/j.ptlrs.2023.03.002

Yang, H., Zhan, Q., Diao, H., Xia, S., 2024. Improving soil health and carbon sequestration through land reclamation in shale gas fields: A case study from Fuling's Jiaoshi Town. *Environmental Pollution and Management* **1**, 15–23. https://doi.org/10.1016/j.epm.2024.05.001