

The impact of oil and gas production facilities on the accumulation of pollutants in soil and plants

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Abstract. The impact of heavy metals on plants near industrial facilities requires comprehensive investigation due to increasing pollution risks in adjacent agricultural areas. The aim of this study was to comparatively assess the concentrations of heavy metals in plants and soils of agricultural lands located near a flare installation and in more distant agroecosystems. The heavy metal content in the above-ground parts of plants from agrophytocenoses located 4 km from the flare installation was analyzed and compared with that in cultivated plants from uncontaminated sites. Soil and plant samples were analyzed for Cd, Cr, Cu, Mn, Ni, Pb, and Zn using atomic absorption spectrophotometry. Contamination of the root-inhabited soil layer with cadmium, zinc, and copper was detected. Analysis of the vegetative parts of *Panicum miliaceum* L. revealed Zn and Cr concentrations 1.32 and 1.1 times higher than the baseline values, respectively, at Site No. 1. In *Cicer arietinum* L., Zn accumulation was 2.2 times higher than the baseline value at Site No. 1, located near the gas flaring site, and 1.4 times higher at Site No. 2, located in the Orenburg Region. The accumulation of elements in the soil facilitates their uptake by plants, while the heavy metal transformation coefficients for *Panicum miliaceum* and *Cicer arietinum* exhibit a similar sequence: Zn > Cu > Cd > Ni = Mn > Pb = Cr. The results demonstrate the need for environmental monitoring of croplands to identify changes in agroecosystems and to develop approaches for their restoration.

Keywords: plants; flare installation; heavy metals.

1. Introduction

Emissions from oil extraction and other industrial activities are major sources of environmental pollutants, constituting a global concern. Gas flaring systems pose a particular threat due to the combustion of associated petroleum gas and the release of sulfur, nitrogen, and carbon oxides, as well as heavy metals, into the atmosphere. Although industrial processes are now automated and operations associated with significant anthropogenic emissions have been cut down, heavy metals remain present in biological environment and threaten human health (Mousavi et al., 2020; Al-Farraj & Al-Wabel, 2007). Classified as trace elements, heavy metals exhibit high bioaccumulation potential, environmental persistence, significant

reactivity, and toxicity; consequently, their elevated concentrations in ecosystems drive global environmental changes (Tang et al., 2022; Dambiec et al., 2022). The Orenburg region is a center for active mineral extraction and processing - an area significantly altered by human activity (Ryabinina Z.N. et al., 2019). All components of the natural environment - and plants in particular - are affected by these elements. Agricultural soils and the crops growing on them are susceptible to anthropogenic changes driven by various factors, including wastewater pollution, the use of chemical soil amendments, and emissions from industry and transport (Shi et al., 2022). Distinguishing between the total and mobile forms of elements in the soil makes it possible to assess the potential risk they pose to living organisms (Li et al., 2021; Zhong et al., 2020). The aim of the study is a comparative assessment of heavy metal content in plants and soils of agricultural lands located in close proximity to a flare installation and in agroecosystems unaffected by its impact.

2. Materials and methods

The primary research was conducted in the Southern Cis-Urals between 2022 and 2025 at four experimental sites consisting of agroecosystems with spring crops. Averaged data from several years of study were used. The map was created in program «Surfer».

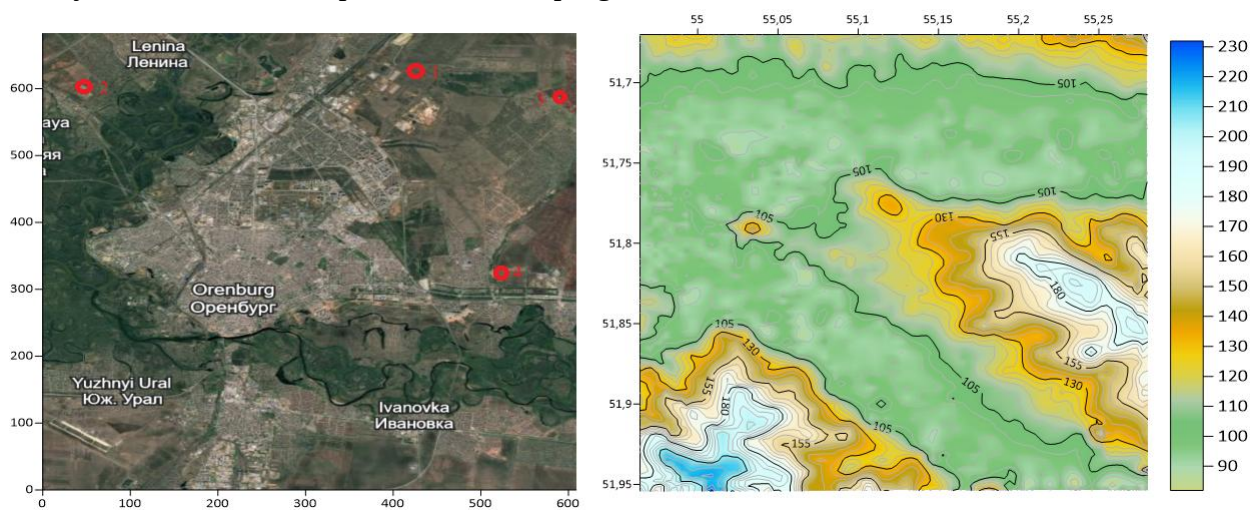


Figure 1. Study areas of the Orenburg district of the Southern Urals

Study site (agrophytocenosis) No. 1 is located within 4 km of the gas flaring site. In terms of landscape position, the plot is classified as an eluvial facies with a terrain slope of 1–2°. The site was characterized by its proximity (up to 4 km) to the flare unit and exposure to pollutants resulting from associated petroleum gas flaring.

No. 2 is located in the vicinity of the settlement of Lenina in the Orenburg Region. The study area forms a unified geosystem of eluvial facies with a 1° slope; the groundwater depth ranges from 80 to 100 m.

No. 3 is situated in the vicinity of the Chebenki settlement in the Orenburg Region; it is located on the flat summits of watershed areas, free from significant soil erosion, with a groundwater depth ranging from 35 to 88 meters.

No.4 is located in the vicinity of the settlement of Prigorodny in the Orenburg Region. The site is classified as an eluvial facies, with the groundwater table lying at a depth of 25 to 88 meters.

Soil and plant samples were collected in triplicate using the envelope method (with side lengths of 5 m and 10 m). Five soil samples were taken from points within the monitored elementary plot (or each sampling site) (GOST 702229-2022). At least 0.5 kg of soil was collected at each point (GOST R 58595-2019). Sampling of soil and plant material was carried out by the "envelope" method (the length of the sides of which was 5 and 10 m) in triple repetition. Five soil samples were taken from the points of the controlled elementary site (or each sampling site) (GOST 17.4.3.04-85, Vasilenko).

At least 0.5 kg of soil was taken from each point (GOST 17.0.0.01-76; ST SEV 1364-78; Fedoseeva, 1994).

Each soil sample was collected from the arable horizon (the root-inhabited layer, 0–20 cm depth). A composite sample was prepared from the five individual point samples, air-dried at 20–25°C and 50–60% relative humidity, manually crumbled, and stored in a dark, dry location. Subsequently, the sample was quartered, and one-quarter was sieved through a 2 mm mesh to obtain the analytical subsample. In this manner, 12 soil samples were collected annually, resulting in the analysis of 36 samples over a three-year period. To ensure analytical accuracy and internal laboratory quality control, each soil sample was analyzed in triplicate over the three years.

Pollutant extraction from soil samples was performed as follows: 5 g of air-dried soil was placed in a 100-mL flask, and 50 mL of ammonium acetate buffer (pH 4.6) was added. The mixture was heated in a water bath at 90°C for 20 minutes, then filtered through folded filter paper (blue ribbon grade). The extract was filtered through folded filter paper (blue ribbon grade). The initial portions of the filtrate were discarded, and the subsequent filtrate samples were used for trace element determination. Chemical elements in the soil and plant samples were determined using atomic absorption spectrophotometry. Specific spectral lines were used for trace element detection: Zn (213.8 nm), Cu (324.7 nm), Pb (283.3 nm), and Cd (228.8 nm). An air-acetylene flame was used for atomization. Reference solutions for instrument calibration and standard curve construction were prepared using acid solutions, with calibration standards supplied by the instrument manufacturer.

In this way, 12 soil samples were taken annually; that is, 36 samples were analyzed within 3 years. To adjust the analysis and internal control of the laboratory, each soil sample was analyzed three times over the course of 3 years.

The process of extraction of pollutants in soil samples was carried out as follows. Air-dry soil of 5 g was placed in a flask with a capacity of 100 ml, 50 ml of acetate-ammonium buffer solution with pH = 4.6 was added. Then it was kept in a water bath at a temperature of 90°C for 20 minutes. The extract was filtered through a pleated filter (blue tape). Determination of chemical elements in soil and plant samples (atomic absorption spectrophotometry). To determine trace elements, light filters with a bandwidth for Zn-213.8 nm, Cu-324.7 nm, Pb-283.3 nm, Cd-228.8 nm were used. An air-acetylene flame was used to atomize the elements. Reference solutions were prepared for setting up the device and building a graduated graph during the extrusion of heavy metals with acid solutions. Colibrating reference solutions were prepared from the set for the device.

The agrocoenoses under study are characterized by the dominance of cultivated common millet (**Panicum miliaceum** L.) and chickpea (**Cicer arietinum** L.). Samples of millet (cultivar Orenburgskaya 27) and chickpea (cultivar Krasnokutsky) were collected from four plots at the end of the growing season. The above-ground parts of the plants were cut at the level of the lowest leaves to obtain a composite plant sample weighing 0.5–1 kg (fresh weight). The climate of the study area is continental, with an average annual precipitation of approximately 330–550 mm. Although atmospheric dust was actively deposited on the leaf surfaces, heavy precipitation washed it off, resulting in minimal heavy metal absorption through the above-ground plant organs; therefore, a preliminary washing procedure for the plant samples was not performed. A series of plant samples was collected from the study plots. 24 plant samples were taken from the study sites.

Soil and plant samples were analyzed for elemental content (Cd, Cr, Cu, Mn, Ni, Pb, and Zn) using atomic absorption spectrophotometry with a Kvant-2AT instrument (KORTEK LLC, Russia).

The geoaccumulation index (I_{geo}) is widely used to assess soil contamination; specifically, the geoaccumulation index proposed by Müller (1981) was used to characterize the level of contamination in sedimentary deposits, calculated using formula (1):

$$I_{geo} = \log_2 \left(\frac{C_n}{1.5 \cdot B_n} \right) \quad (1)$$

C_n - metal concentration in soil;

1.5 - a coefficient used to correct for possible background variations caused by lithogenic effects;

B_n - the background value for the metal. The geoaccumulation index (Igeo) was calculated for bulk and mobile soil forms at a depth of 0-20 cm.

The geo-accumulation index (Jgeo) was distinguished into seven classes by Muller (1969):

$J_{geo} \leq 0$ = uncontaminated

$0 < J_{geo} \leq 1$ = uncontaminated to moderate contamination

$1 < J_{geo} \leq 2$ = moderate contamination

$2 < J_{geo} \leq 3$ = moderate to heavy contamination

$3 < J_{geo} \leq 4$ = heavy contamination

$4 < J_{geo} \leq 5$ = heavy to extreme contamination

$5 < J_{geo} \leq 6$ = extreme contamination

The results were evaluated against the "List of Maximum Permissible Concentrations (MPC) and Tentative Permissible Concentrations (TPC) of Chemical Substances in Soil," approved by Deputy Chief State Sanitary Physician G.G. Onishchenko.

The translocation factor (TF) (Shi X et al., 2022) was calculated by dividing the heavy metal concentration in the collected plant sample by the total heavy metal concentration in the soil, using formula (2)

$$TF = C_p / C_s \quad (2)$$

C_p plants - metal concentration in plant tissue;

C_s soils - metal concentration in dry soil.

In statistical and mathematical procedures, the significance level for hypotheses is defined as the level ensuring an error probability of less than 5% ($P < 0.05$) or less than 1% ($P < 0.01$). Student's t-test was used to calculate the p-value (significance).

Laboratory tests were conducted by an accredited organization.

No AI was used in writing the article.

3. Results

Heavy metals may originate from lithogenic or anthropogenic sources. Lithogenic elements exhibit lower bioavailability because they are incorporated into mineral crystal lattices and remain stable for extended periods. The mobile form of heavy metals is often anthropogenic in origin; it can be introduced via dust, is found in surface soil layers, and exists predominantly in an ionic form (Han et al., 2017). Table 1 presents the calculated Jgeo values for the root-zone soil layer. The tables provide averaged annual pollutant data, including the calculated probable error (P).

Table 1. Geoaccumulation index (Jgeo) for the total content of heavy metals in soils of the study areas

Element	Study sites			
	№ 1	№ 2	№ 3	№ 4
Pb	-0.48**	-0.63*	-0.48*	-0.85**
Cd	0.97**	0.01*	0.38*	1.25*
Zn	-0.52*	-0.64*	-0.69**	-0.97**
Mn	0.25*	0.25*	0.34*	0.16*
Ni	0.11*	-0.007*	0.05*	-0.007*

Cr	0.57**	0.53**	0.43**	0.54**
Cu	-0.88**	-0.97**	-1.06*	-1.57*

Designations: P < 0.05 – *, P < 0.01 – **

Legend: Jgeo<0 uncontaminated soils, Jgeo = 0–1 slightly contaminated soils, Jgeo = 1–2 moderate soil contamination, Jgeo = 2–3 moderate to strong soil contamination, Jgeo = 3–4 strong soil contamination, Jgeo = 4–5 strong to extreme soil contamination, Jgeo > 5 extreme soil contamination.

The geo-accumulation index was calculated to determine the level of pollutant contamination in arable soils near the flare unit and to compare the results with those from study sites located in a relatively favorable environmental setting. Analysis of Table 1 showed that at study sites Nos. 1, 3, and 4, the Jgeo values for Cd content ranged from 0.01 to 1.25; according to Müller's scale (Müller G., 1981), this indicates slight soil contamination at the first two sites and moderate contamination at site 4.

Analysis of Jgeo values revealed slight contamination with mobile forms of Mn and Ni in the soils near the flare unit, and moderate contamination with Cr (Table 2). Slight lead contamination was observed in the arable soils of Site 1, with moderate contamination at Site 3. Regarding copper content, the first three study sites exhibited contamination ranging from moderate to severe, while zinc contamination across all four sites ranged from severe to extreme.

Table 2. Geoaccumulation index (Jgeo) for the content of mobile forms of heavy metals in soils of study areas

Element	Study sites			
	№ 1	№ 2	№ 3	№ 4
Pb	0.85**	-1.07*	1.10*	-1.83*
Cd	-3.25*	-2.006*	-2.05*	-1.49*
Zn	5.47*	4.79*	4.44*	3.01*
Mn	0.19*	-0.20*	-0.40*	-0.24*
Ni	0.29*	-0.83*	-1.05*	-1.26*
Cr	1.47*	-1.58*	-2.28*	-2.79*
Cu	3.89*	2.39*	2.16*	-0.92*

Designations: P < 0.05 – *, P < 0.01 – **

The geoaccumulation index for mobile forms of cadmium was negative in all experimental variants.

In the next stage of the study, samples of the above-ground parts of cultivated plants were analyzed for toxic metal content (Mushtaq et al., 2023). The results showed that **P. miliaceum** is capable of accumulating zinc at concentrations slightly exceeding the sanitary limit, with a maximum value of 66 mg/kg (Figure 1). **C. arietinum** accumulates zinc at levels more than double the permissible limit (Figure 2), indicating contamination of the food product with this heavy metal.

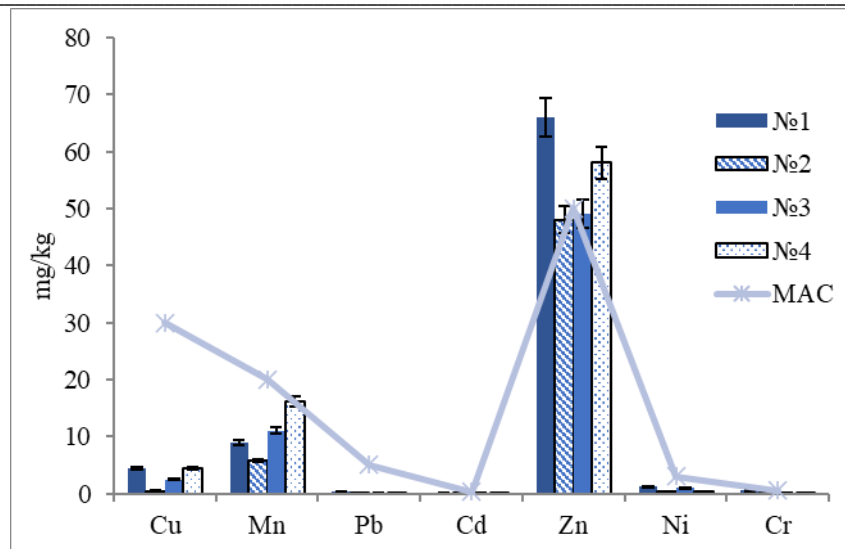


Figure 2. Pollutant content in the vegetative parts of *P. miliaceum* plants across the study sites

Analysis of **P. miliaceum** revealed zinc levels 1.1 times the limit at Site No. 4 and nearly 1.32 times the limit at Site No. 1. Thus, zinc content in **P. miliaceum** and **C. arietinum** at all sites equals or exceeds the maximum permissible concentration. Chromium accumulation in the above-ground parts of **P. miliaceum** at Site No. 1 exceeded sanitary-hygienic standards by a factor of 1.1, a level that may affect redox processes and reduce chlorophyll formation (Ali S. et al., 2023).

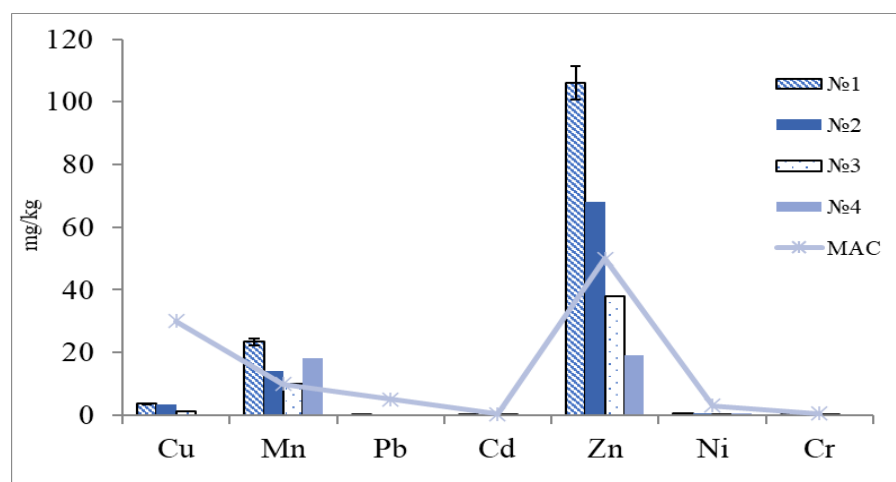


Figure 3. Content of pollutants in the vegetative part of *C. arietinum* plants

Research findings indicate that chickpea (**C. arietinum**) actively accumulates Zn in its above-ground parts at the first two study sites. Zinc concentrations in the plant tissue exceeded sanitary-hygienic standards by a factor of 2.0 at Site 1 and 1.36 at Site 2 (Figure 3). Manganese levels in the above-ground biomass exceeded the standard at all study sites; some researchers attribute this to the genetic characteristics of this legume species (Neugschwandtner et al., 2015).

The transformation coefficient is a parameter used to determine the transfer of trace elements from soil to plants. The mean transformation coefficient values for **P. miliaceum** regarding Pb, Cd, Zn, Mn, Ni, Cr, and Cu content were 0.012, 0.053, 1.215, 0.012, 0.015, 0.007, and 0.188, respectively (Table 3).

Table 3. Elemental transformation coefficient for *P. miliaceum*

Parameter	Study sites				Average data TF
	№ 1	№ 2	№ 3	№ 4	
Pb	0.025*	0.001*	0.01*	0.009*	0.012*
Cd	0.027*	0.057*	0.05*	0.08*	0.053*
Zn	1.27*	1**	1.065*	1.526*	1.215*
Mn	0.015*	0.008*	0.010*	0.013*	0.012*
Ni	0.024*	0.007*	0.022*	0.008*	0.015*
Cr	0.014*	0.001*	0.005*	0.005*	0.007*
Cu	0.219*	0.024*	0.141*	0.366*	0.188*

Designations: P < 0.05 – *, P < 0.01 – **

Calculating the average TF values made it possible to construct the following series: Zn > Cu > Cd > Ni > Mn = Pb > Cr.

The mean values of this parameter for chickpeas were 0.004, 0.063, 1.197, 0.023, 0.011, 0.005, and 0.114 for lead, cadmium, zinc, manganese, nickel, chromium, and copper, respectively (Table 4). Based on the transformation factor (TF) value, the elements form the following sequence: Zn > Cu > Cd > Mn > Ni > Cr > Pb. A higher TF value indicates greater accumulation of heavy metals in the vegetative parts of the plants (Alama et al., 2020).

Table 4. Elemental transformation coefficient for *C. arietinum*

Parameter	Study sites				Average data TF
	№ 1	№ 2	№ 3	№ 4	
Pb	0.007*	0.002*	0.004*	0.006*	0.004*
Cd	0.035*	0.146*	0.043*	0.027*	0.063*
Zn	2.038*	1.417*	0.826**	0.505**	1.197*
Mn	0.032*	0.019*	0.013*	0.026*	0.023*
Ni	0.013*	0.013*	0.007*	0.012*	0.011*
Cr	0.009*	0.005*	0.002*	0.005*	0.005*
Cu	0.180*	0.178*	0.071*	0.028*	0.114*

Designations: P < 0.05 – *, P < 0.01 – **

Our study demonstrated an accumulation of total manganese, chromium, and cadmium, as well as mobile forms of chromium, zinc, and copper, in the soil adjacent to the flare installation. The active accumulation of these elements in the above-ground parts of plants near the pollution source was most pronounced in chickpeas; this underscores the need for a more rigorous analysis of crop produce to ensure compliance with sanitary standards in areas of intense industrial activity.

4. Discussion

This study examines the impact of an oil and gas production facility on the accumulation of total and mobile pollutant forms in soils and cultivated plants. An analytical review (Flared Gas Utilization Strategy, 2004) by the World Bank states that 'the flaring of associated petroleum gas - particularly when optimal combustion conditions are not maintained - results in the release of various pollutants into the atmosphere. Studies have identified the following among these emissions: over 250 hazardous chemical compounds, including carcinogenic 3,4-benzopyrene, benzene, carbon disulfide, phosgene, and toluene; heavy metals such as mercury, arsenic, and chromium; and nitrogen and sulfur oxides, as well as hydrogen sulfide.' These substances cause pollution of the atmosphere, surface water bodies, and soil. Furthermore, the natural environment and the local population may be subjected to other adverse impacts resulting from associated petroleum gas flaring (Kadafa, 2012). According to the State Report 'On the State and Protection of the Environment in the Orenburg Region,' flare emissions impact an area at least three to four times larger than the site itself.

Tyumen scientists reported that after anthropogenic soil disturbance, total heavy metal concentrations did not exceed maximum permissible limits, except for Zn and Pb (Getman et al., 2016). Our study indicates low levels of anthropogenic contamination regarding total soil concentrations of manganese, chromium, and cadmium (with the exception of Site 4, where cadmium contamination was moderate; we hypothesize that this is unrelated to the impact of the flare installation). Such cadmium levels in arable soils may stem from long-term agricultural activity in the area. Indeed, several authors (Shabanov et al., 2025; Mousavi et al., 2020; Ashinov et al., 2020) have noted the significant input of cadmium into arable soils via mineral fertilizers, particularly phosphate-based ones. Researchers in the Republic of Belarus found that soil in agricultural zones showed only a slight exceedance of the maximum permissible concentration (MPC) for cadmium - specifically 1.04–1.16 times the MPC (Matveeva et al., 2010). Our research demonstrated that proximity to infrastructure (construction sites, roads, power lines, etc.) also increases the concentration of mobile cadmium forms in the soil (Mousavi et al., 2020). The moderate manganese and chromium contamination observed across all study sites is likely attributable to similar factors. Geo-accumulation indices for copper, lead, and zinc were negative, indicating an absence of anomalously high total concentrations of these elements at the study sites; this may be due to the neutral soil solution reaction characteristic of chernozems, as well as exchange and non-exchange sorption processes that reduce metal ion mobility by converting them into forms unavailable to plants.

A study by Chinese scientists (Li et al., 2025) investigated mobile forms of heavy metals in soils under anthropogenic influence. The results indicate that all eight pollutants studied (As, Cr, Ni, Cu, Zn, Cd, Pb, and Hg) in the study area exhibit varying degrees of cumulative contamination, with the highest levels observed for Cd. Our research demonstrated that the geo-accumulation index for mobile forms of cadmium was negative across all experimental variants; slight soil contamination by Mn and Ni was observed at the flare installation site, along with moderate contamination by Cr. Slight lead contamination was found in the arable soil of Site 1, while moderate contamination was observed at Site 3. Regarding copper content, the first three study sites showed contamination ranging from moderate to severe, whereas zinc contamination ranged from severe to extreme across all four sites. Elevated levels of mobile Zn were observed at all four sites; the excess of mobile zinc in the local soils is likely attributable to geochemical soil factors and anthropogenic agricultural activity, particularly the use of fertilizers. Compared to other chemical elements, Zn is the most soluble element in the soil, and its concentration depends on soil reaction (pH). The low availability of Zn to plants in the soils of the Orenburg region - which are often calcareous - is largely due to their neutral or slightly alkaline reaction [5]; mobile Zn levels increase under acidic soil conditions, a state that can arise from intensive fertilizer use.

Throughout the entire observation period, sporadic exceedances of the maximum permissible concentrations (MPCs) for metals were recorded in the total and mobile soil fractions; overall, these did not follow a consistent pattern. An increased content of mobile forms of Zn is observed at all 4

sites; it is possible that in this area the excess of mobile forms of zinc in soils is associated with geochemical factors of soils and anthropogenic agricultural activities, in particular, the use of fertilizers. Compared with other chemical elements, Zn is the most dissolved element in soil; its concentration depends on soil-environment reactions. The small amount of Zn available to plants in Orenburg, often carbonate, soils is largely due to their neutral or slightly alkaline reaction (Blokhin, 1997); with an acidic reaction of soils, the amount of mobile Zn increases. This is possible with intensive use of fertilizers.

Throughout the observation period, sporadic exceedances of maximum permissible concentrations (MPCs) for metals were recorded in the total and mobile soil fractions; however, these did not follow a consistent pattern.

The impact of flares on the lower vegetation strata manifests as a depletion of species composition (Lugansky, 2000; Khaustov & Redin, 2006; Yudakhin et al., 2002). The radius of direct thermal damage extends up to 50 m for low-capacity flares and up to 200 m for high-capacity ones; effects of vegetation suppression caused solely by thermal radiation are observed up to 4 km away. In the impact zone extending from 4 to 10 km, the penetration and accumulation of combustion product residues are observed (Yashchenko et al., 2014). Our studies of agrocenoses within 4 km of the flare installation demonstrated that manganese levels in **P. miliaceum** and **C. arietinum** across all sites were either within the maximum permissible concentration (MPC) limits or showed only slight exceedances. Zinc accumulated in **C. arietinum** at concentrations exceeding sanitary-hygienic standards by a factor of 2.0 at Site No. 1 and by a factor of 1.36 at Site No. 2.

5. Conclusion

1. The geo-accumulation index for total copper, lead, zinc, and nickel in soils across all study sites yielded negative values. Low-level soil contamination with manganese, chromium, and cadmium was observed at all study sites (with the exception of Site 4, where cadmium contamination was moderate); this is likely attributable to the long-term agricultural use of these areas.

2. Analysis of Jgeo values revealed slight contamination with mobile forms of Mn and Ni in the soils near the flare unit, and moderate contamination with Cr. Slight lead contamination was observed in the arable soils of Site 1, with moderate contamination at Site 3. Regarding copper content, the first three study sites exhibited contamination ranging from moderate to severe, while zinc contamination across all four sites ranged from severe to extreme.

3. Heavy metal analysis in common millet and chickpeas revealed zinc levels exceeding sanitary-hygienic standards and slight manganese exceedances of the maximum permissible concentration (MPC).

4. The heavy metal transfer factor values for *Panicum miliaceum* L. follow the sequence $Zn > Cu > Cd > Ni > Mn = Pb > Cr$, while those for *Cicer arietinum* L. form the series $Zn > Cu > Cd > Mn > Ni > Cr > Pb$.

5. The results highlight the need for thorough crop product analysis to ensure sanitary standard compliance and for environmental monitoring of the region's agroecosystems to timely detect anthropogenic changes and develop restoration strategies. Monitoring pollutants in crop production is essential for assessing year-to-year variations in the chemical composition of soils and plants; statistical analysis enables the assessment of potential risks associated with the transfer of metals into the food chain.

6. Supplementary Materials: No supplementary material.

7. Author Contributions

Conceptualization – T.V.; methodology – T.V.; software – M.V.; formal analysis – M.V.; investigation – M.V.; resources – T.V.; data curation – M.V.; writing - original draft preparation – T.V.; writing - review and editing – M.V.; visualization – M.V.; supervision – T.V.; project

administration – T.V.; funding acquisition – T.V. All authors have read and agreed to the published version of the manuscript.

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11. Conflicts of Interest: The authors declare no conflicts of interest.

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Мұнай-газ өндіру нысандарының топырақ пен өсімдіктерде ластаушы заттардың жинақталуына әсері

Мария Васильева, Татьяна Васильева

Аңдатпа. Оңтүстік Оралдағы өнеркәсіптік нысандар маңындағы өсімдіктерге ауыр металдардың әсері жақын маңдағы ауыл шаруашылығы алқаптарының ластану проблемасының артуына байланысты мұқият зерттеуді талап етеді. Зерттеудің мақсаты - факелды қондырғыдан аз қашықтықта орналасқан ауыл шаруашылығы жерлерінің және оның әсеріне ұшырамаған агроценоздардың өсімдіктері мен топырағындағы ауыр металдардың деңгейін салыстыру болды. Мұнай-газ конденсаты кешенінің факелды қондырғысынан 4 км қашықтықта орналасқан агрофитоценоздардағы өсімдіктердің жер үсті бөліктеріндегі ауыр металдардың мөлшері талданып, таза аймақтарда өсетін мәдени өсімдіктермен салыстыру жүргізілді. Топырақ пен өсімдік үлгілері атомарлық-абсорбциялық спектрофотометрия әдісімен Cd, Cr, Cu, Mn, Ni, Pb және Zn мөлшеріне талданды. Зерттеу аймақтарында тамырлы аймақтың кадмиймен, мырышпен және мыспен ластануы анықталды. *Panicum miliaceum* L. вегетативті бөліктерін талдау №1 учаскеде Zn (нормадан 1,32 есе жоғары) және Cr (нормадан 1,1 есе жоғары) деңгейлерінің артқанын көрсетті. *Cicer arietinum* L. газ жағу аймағында орналасқан №1 учаскеде санитарлық-гигиеналық нормалардан 2,2 есе, ал Оңтүстік Оралдағы Ленин ауылының жанында орналасқан №2 учаскеде нормадан 1,4 есе жоғары Zn жинақтады. Элементтердің топырақта жинақталуы олардың өсімдіктерде жиналуына ықпал етеді, ал

Panicum miliaceum және *Cicer arietinum* үшін ауыр металдардың трансформациялану коэффициенттері ұқсас қатар түзеді: $Zn > Cu > Cd > Ni = Mn > Pb = Cr$. Зерттеу мәліметтері агроэкожүйе параметрлерінің өзгерістерін дер кезінде анықтау және оларды қалпына келтіру тәсілдерін әзірлеу үшін өңірдегі ауыл шаруашылығы жерлеріне экологиялық мониторинг жүргізу қажеттілігін көрсетеді.

Түйін сөздер: өсімдіктер; факелдік кондырғы; ауыр металдар.

Влияние объектов нефтегазодобычи на накопление загрязняющих веществ в почве и растениях

Мария Васильева, Татьяна Васильева

Аннотация. Влияние тяжелых металлов на растения у промышленных объектов на Южном Урале требует тщательного изучения в связи с растущей проблемой загрязнения близлежащих сельскохозяйственных угодий. Целью исследования является сравнение уровней загрязнения тяжелыми металлами растений и почв сельскохозяйственных угодий, расположенных на незначительном удалении от факельной установки, и агроценозов, не подверженных ее воздействию. Проанализирован состав тяжелых металлов в надземных частях растений агрофитоценозов, расположенных в 4 км от факельной установки нефтегазоконденсатного комплекса, и проведено сравнение с показателями культурных растений, произрастающих на чистых территориях. Образцы почв и растений проанализированы на содержание Cd, Cr, Cu, Mn, Ni, Pb и Zn методом атомно-абсорбционной спектрофотометрии. На исследуемых участках выявлено загрязнение корнеобитаемой зоны Cd, Zn и Cu. Анализ вегетативных органов *Panicum miliaceum* L. выявил на участке №1 повышенный уровень Zn (в 1,32 раза выше нормы) и Cr (в 1,1 раза выше нормы). *Cicer arietinum* L. накопил Zn в количествах, превышающих санитарно-гигиенические нормы в 2,2 раза на участке №1, расположенном в зоне сжигания газа, и в 1,4 раза выше нормы на участке №2, расположенном вблизи поселка Ленин на Южном Урале. Накопление элементов в почвах способствует их аккумуляции в растениях, а коэффициенты трансформации тяжелых металлов для *Panicum miliaceum* и *Cicer arietinum* образуют аналогичные ряды: $Zn > Cu > Cd > Ni = Mn > Pb = Cr$. Данные исследования доказывают необходимость проведения экологического мониторинга сельскохозяйственных угодий региона для своевременного выявления изменений параметров агроэкосистем и разработки подходов к их восстановлению.

Ключевые слова: растения; факельная установка; тяжелые металлы.