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Agroecological condition of soils in forest ecosystems of Zhytomyr Polissya

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ABSTRACT

The research proved that the territory of the state enterprise Korosten Forestry, which were contaminated as a result of the Chornobyl accident, are characterised by uneven radiological contamination of soils with uneven distribution. The density of soil contamination with ^{137}Cs varied widely – from 49.95 to 367.04 kBq/m^2 (1.35–9.92 Ci/km^2), and ^{90}Sr – from 1.55 to 4.48 kBq/m^2 (0.042–0.121 Ci/km^2). The gamma background in the surveyed areas of forest and vegetation conditions depended not only on radiation from artificial radionuclides but also on natural radionuclides and was in the range of 22–47 μR/h. The results of agrochemical studies of the different types of forest conditions – A1, A2, B1, B2 showed that all soils were poor in nutrients. The nitrogen content was in the range of 30.18–55.34 mg/kg and corresponded to a very low level of supply. The humus content was also very low at all the study sites, ranging from 0.26–0.45%. Soil availability of mobile phosphorus and exchangeable potassium in the groups of forest vegetation conditions was at a low and medium level of availability and ranged from 34.00 to 58.79 mg/kg and from 34.60 to 60.00 mg/kg of soil, respectively. The acidity of the soils in the studied teritorial units of the quarters (here and after - units) of forest vegetation groups A1, A2, B1, B2 varied widely – from 4.03 to 5.03 pH units, i.e. from very strongly acidic (< 4.1) to medium acidic (4.6–5.0). The results showed that the content of heavy metals, namely plumbum, cadmium, zinc, and copper in the examined soils was significantly below the TLV. The investigated soils correspond to typical forest soils of Polissya in terms of their chemical composition.

Keywords: ecosystem, biodiversity, monitoring, heavy metals, radionuclides, research methods.

INTRODUCTION

The Chornobyl nuclear power plant (CNPP) accident was the largest man-made disaster that significantly changed the radiation situation in the former Soviet Union and Europe (Romanchuk et al. 2021). Forests were one of the most affected landscape types, with more than 20–30% higher levels of radioactive contamination compared to open areas (Ustymenko et al., 2021).

The radioactive contamination affected 14.5 million hectares of land, including 1.23 million hectares of forest land, which is 39% of the state forest fund of Ukraine in the early 1990s. Radioactive contamination of ^{137}Cs in soil at a level of more than 37 kBq/m^2 was recorded in 60% of the forest areas of the Zhytomyr region (Ipatev, 1999).

The forests of the Zhytomyr region were also characterised by the highest maximum contamination rates in its northern regions. In particular, in the Narodychi and Korosten districts, forestry enterprises had a density of radioactive soil contamination of more than 555 kBq/m^2 on an area of 14.9 thousand ha and 14.2 thousand ha, respectively. In Korosten forestry, the density of ^{137}Cs radioactive contamination of soil was more than

1480 kBq/m^2 on the area of 4.5 thousand hectares. The level of radioactive contamination of soil gradually decreased towards the west and south, with the most significant decrease observed in the southern direction.

Thus, radioactive fallout in forest ecosystems is highly gradient and mosaic in nature, which leads to a heterogeneous distribution of radionuclides in the territory. One of the factors that influenced the formation of radioactive contamination of forest ecosystems was meteorological conditions, such as wind direction and speed, which could contribute to the movement of radioactive substances in a certain direction. In addition, the physicochemical properties of radioactive substances, which depended on their chemical composition and method of release, played an important role in the interaction of radioactive substances with forest biota.

Another consequence of the Chornobyl disaster was the contamination of forest areas not only with radioactive substances but also with heavy metals. High levels of heavy metal accumulation in certain regions, particularly those with high levels, are responsible for changes in plant communities, diversity, and productivity potential (Ghosh et al., 2020). Soil contamination caused by heavy metals can be suspended or accelerated by their dispersion into the environment as a result of wind, precipitation, rainfall, and infiltration of contaminated water (Meng et al., 2021). Heavy metals also pollute surrounding ecosystems and affect soil quality by changing its physical properties (Jeong et al., 2020).

Scientists focused on studying the migration of long-lived and environmentally hazardous radioisotopes, such as ^{137}Cs and ^{90}Sr, in forest ecosystems, the impact of ionising radiation on ecosystem components, and the development of methods for the remediation of contaminated areas. Radionuclides can migrate through trophic chains, affecting different levels of the ecosystem (Kaletnik et al., 1992). The radioactive cesium and strontium can accumulate in mushrooms, berries and other wild plants, which poses a significant risk to the health of people who consume them. The radioecological state of the forests of Polissia in Ukraine has a high level of radionuclide contamination, which requires constant monitoring and study of the consequences of radioactive releases into these ecosystems (Krasnov et al., 2016). The need for constant radiological monitoring after significant releases of radionuclides into the environment (Berkovskyy et al., 2017). Mathematical modelling of ^{137}Cs migration in forest ecosystems of Ukrainian Polissya was carried out by Krasnov et al., 2016. The role of mycorrhizal fungi in migration and accumulation of radionuclides, as well as practical approaches to reduce the negative impact of radiation on the environment. The studies of the impact of radioactive contamination on medicinal plants and focus on various aspects of radioecology, including the migration of radionuclides in plants of forest ecosystems (Krasnov et al., 2016; Korotkova et al., 2016).

According to Shcheglov and Tsvetnova, (2002) releases from the Chornobyl NPP caused changes in the biogeochemical cycle of radionuclides in forest ecosystems, which may affect the functioning of these ecosystems and increase their vulnerability to other negative impacts. After entering the components of forest ecosystems, radionuclides gradually moved from the upper to the lower tiers of vegetation and the soil surface. Vertical and horizontal migration of radionuclides occurred under the direct influence of precipitation and wind, as well as as a result of falling leaves, needles, branches and bark. Vertical migration in the chain crown - litter - soil - roots, during which up to 95% of radionuclides move from the crown to the forest litter, takes about one year in deciduous plantations and up to three years in coniferous plantations; according to other estimates, it takes from 3 to 7 years. After radionuclides move to the forest floor and depending on the type of forest vegetation and composition of the tree layer, migration of radionuclides of different intensity in the genetic horizons of forest soils begins.

Although there is a significant number of studies on radiological monitoring of forest ecosystems, our research has highlighted the significant spatial heterogeneity of agrochemical and physicochemical soil properties observed in all types of forest vegetation conditions. Such variability is not always reflected in detail in other studies, which may provide generalised data without an in-depth analysis of the variation between plots. A detailed analysis of changes in the content of humus, exchangeable calcium, nitrogen and phosphorus after fires was carried out, focusing on the significant decrease in these indicators in the damaged areas. Thus, our studies provide a more detailed description of spatial and temporal changes in soils and radioactive contamination, and emphasise the importance of an integrated approach to assessing the impact of radionuclides on forest ecosystems.

MATERIALS AND METHODS

The study was carried out in 2023 in the conditions of radionuclide-contaminated soils of the Polissia zone of Ukraine on the territory of the subsidiary enterprise Korosten. The company was established in 2000 on the basis of former collective farm forests. The company's forest fund is located in Korosten district. The total area of the forest fund is 24204.4 hectares, of which 23024.3 hectares (95.1%) are under forests.

Korosten Forestry is focused on preserving the forest fund and biodiversity; logging; and protecting forests from fires, diseases and pests. The structure of Korosten Forestry includes: Horshchykivka forestry; Korosten forestry; Melenivka forestry; Ushomyr forestry departments. The nature reserve fund is represented by two nature reserves.

In the course of our research, we used general and special methods of scientific research. Among the general methods, we used the following: observation, comparison, measurement, monitoring, induction, formalisation, synthesis and modelling. A number of special methods were also used.

Soil surveys of the forest fund were carried out in 12 quarters of forest vegetation conditions: group A 1 (22, 33, 40 quarters); group A 2 (12, 18, 52 quarters); group B 1 (18, 25, 29 quarters). Soil samples were collected at ten sites (plots) in twelve quarters. The area of the studied plots ranged from 0.9–1.7 hectares each.

Soil sampling for determination of ^{137}Cs and ^{90}Sr was carried out in accordance with DSTU 4287:2004 'Soil Quality. Sampling', DSTU ISO 10381-2:2004 'Soil quality. Sampling. Part 2. Guidelines on sampling methods'.

Since the survey was carried out in the area affected by the Chornobyl accident, prior to sampling, the gamma radiation dose rate (gamma background) in the air above the ground was measured with a DRG-01T dosimeter.

Spot samples were taken with a sampler (drill). The radiological drill has a working area of at least 0.001 m^2 and allows soil sampling to a depth of 0.2 m. Its design guarantees the completeness of soil sampling and prevents soil from entering its working area from an adjacent area that is not taken into account during sampling.

To form a combined soil sample, 5 point samples were used, which were collected using the envelope method. The soil samples were thoroughly mixed and a mixed sample weighing up to 2 kg was formed. The combined sample was formed directly at the time of the point sampling.

The sample package was marked with a waterproof marker with the sample code, date, time and place of collection.Laboratory studies were carried out in accordance with the current regulatory documents in the measuring laboratory of agrochemical research, environmental safety of land and product quality of the Institute of Agriculture of Polissya of the National Academy of Agrarian Sciences of Ukraine. Soil samples for radiological studies were first collected from plant residues, dried, and crushed.

The density of soil contamination with radionuclides was determined by the spectrometric method using a scintillation gamma-beta spectrometer MKS-AT-1315 according to the methodology of BS EN ISO 18589-1:2019.

The determination of 137Cs and 90Sr in soil was carried out in a one-litre geometry of a Marinelli vessel with an exposure time of 1 hour. The relative error in determining the specific activity of radionuclides was 10–20%. The minimum specific activity was measured in the geometry of the Marinelli vessel in standard shielding for 1 hour with a measurement error of up to 20 %. Laboratory studies of soil samples for the content of mobile heavy metal compounds were determined in a buffered ammonium acetate extract with a pH of 4.8 by atomic absorption spectrometry in accordance with the current regulatory documents: copper – DSTU 4770.6:2007; zinc – DSTU 4770.2:2007; lead – DSTU 4770.9:2007; cadmium – DSTU 4770.3:2007.

Prior to the laboratory tests for heavy metals, soil samples were ground to a fraction of 0.2 mm in a laboratory mill, poured with an extracting solution, then shaken for 1 hour on rotary shakers, then filtered, and then measured on a device.

The mass concentration of heavy metals in the soil samples was determined using a Quantum-2A atomic absorption spectrophotometer.

The selected soil samples were also analysed in the laboratory for agrochemical parameters:

- exchangeable acidity by potentiometric method according to DSTU ISO 10390:2007;

- mobile phosphorus compounds were determined by the Kirsanov spectrometric method according to DSTU 4405:2005;
- exchangeable potassium was determined by the method of flame photometry according to DSTU 4405:2005;
- alkaline hydrolysed nitrogen was determined titrometrically by Kornfield according to DSTU 7863:2015;
- humus content was determined by Tyurin according to DSTU 4289:2004.

RESULTS AND DISCUSSION

The study of soil properties in Korosten, located within the Polyssia and Forest-Steppe regions of Ukraine were conducted mostly in the early period after Chornobyl catastrophe 1986–1990s. Hoshi et al., (1994); Pietrzak-Flis et al., (1994) and Konoplev et al., (1992) reveals significant variability in key indicators that influence land use and management practices.

The region is characterized by a diverse soil composition, dominated by Phaeozems Albic, which occupy 21.7% of the area, followed by Albeluvisols Umbric (17.1%), Phaeozems Luvic (12.1%), and Chernozems Chernic (15.6%). Other soil groups, including Cambisols, Fluvisols, Gleysols, and Histosols, contribute to the region's heterogeneity but cover smaller areas.

Soil fertility and erosion dynamics are closely linked to the distribution and composition of soil types (Nykytiuk and Kravchenko, 2024). Albeluvisols and Podzols, which dominate the northern region, have low organic carbon content and limited agricultural productivity. The transition zones between Polissia and the Forest-Steppe illustrate distinct contrasts, with Polissia soils characterized by sandy textures and mixed forest coverage, and Forest-Steppe soils displaying higher silt and clay content, making them more suitable for agricultural use.

The soils of the Korosten region are significantly impacted by radioactive contamination, primarily due to fallout from the Chernobyl accident. The main radionuclides examined in the region include iodine isotopes (^{129}I and ^{131}I) and cesium (^{137}Cs), with distinct migration patterns and concentration levels across soil profiles.

The average ^{129}I inventories in Korosten range from 130 mBq/m² in contamination zone III to 848 mBq/m² in the more contaminated zone II. In Korosten's zone III, typical ^{137}Cs deposition densities are reported between 185 and 555 kBq/m², while in the highly contaminated Narodichi district (zone II), levels range from 555 to 1480 kBq/m². These values reflect the intensity of fallout deposition, with the Korosten region serving as a moderately to highly contaminated area.

These findings suggest that Korosten's soils have retained a significant fraction of the radioactive fallout within the topsoil, which could be crucial for retrospective dosimetry and assessing the long-term environmental impact of the Chernobyl disaster (Michel et al., 2005).

As the previous studies of this territory were conducted 15–20 years ago and they didn't focus on the forests of Korosten agroindustial forestry complex it was decided to conduct a study of the modern state of soils on this territory.

The results of our radiological soil studies showed that the density of ^{137}Cs contamination varied widely - from 49.95 to 367.04 kBq/m² (1.35–9.92 Ci/km²), and ^{90}Sr – from 1.55 to 4.48 kBq/m² (0.042–0.121 Ci/km). This is due to the fact that the fallout of radionuclides after the Chornobyl accident due to wind, rain and other factors was uneven (Fig. 1).

During the survey of the quarters of the A 1 forest and vegetation group, it was found that the density of ^{137}Cs contamination of soil was 149.85–214.23, and ^{90}Sr – 2.52–3.03 kBq/m². The highest density of radionuclide contamination was observed in soil samples from the 27th quarter with toxicant concentrations of 198.69–214.23 and 2.89–3.03 kBq/m² for ^{137}Cs and ^{90}Sr, respectively (Fig. 2).

The lowest density of ^{137}Cs and ^{90}Sr was recorded in the discharges of the 22nd quarter. The contamination was 149.85–158.36 Bq/m² and 2.52–2.63 Bq/m² for the elements, respectively. The average ^{137}Cs value of Group A1 soils was 182.11 kBq/m², and the average ^{90}Sr value was 2.78 kBq/m².

The contamination of the studied soils of the A2 group of forest–vegetation conditions with ^{137}Cs ranged from 71.78 to 367.04 kBq/m², and ^{90}Sr – from 1.96 to 4.48 kBq/m². The highest density of ^{137}Cs and ^{90}Sr was observed in the areas (allocations) of the 18th quarter. The contamination of the studied areas with ^{137}Cs was at the level of 292.30–367.04 kBq/m², and ^{90}Sr – at the level of 3.18–4.48 kBq/m². Lowest radionuclide contamination were found in the soils of the 13th quarter. The content of contaminants was in the

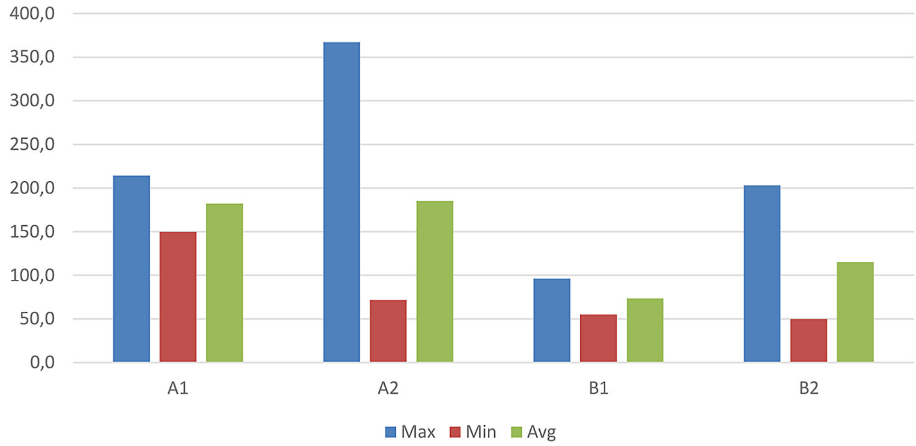

Figure 1. Radionuclide density of ^{137}Cs in the soil (kBq/m²)

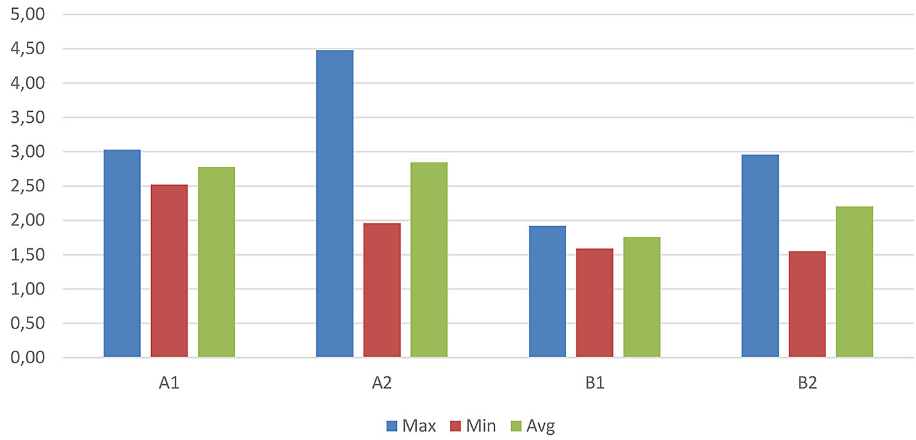

Figure 2. Radionuclide density of ^{90}Sr in the soil (kBq/m²)

range of 71.78–112.85 and 1.96–2.48 kBq/m² for ^{137}Cs and ^{90}Sr, respectively. The average values of ^{137}Cs and ^{90}Sr in the soils of the A2 forest–vegetation group were 185.15 and 1.96 kBq/m².

The study of the density of soil contamination with radionuclides in the quarters of the B1 forest vegetation group revealed that the density of soil contamination with ^{137}Cs was in the range of 55.13–96.20 kBq/m², and ^{90}Sr – in the range of 1.59–1.92 kBq/m². The most contaminated soils were in the 29th quarter. The density of ^{137}Cs contamination in these areas was 94.35–96.20 kBq/m², and the density of ^{90}Sr contamination ranged from 1.78 to 1.92 kBq/m². The lowest density of radionuclides was found in the soils of Quarter 17. Soil contamination with ^{137}Cs was in the range of 55.13–60.31 kBq/m², and ^{90}Sr – 1.59–1.67 kBq/m². The average values of soil contamination density with radionuclides were 73.59 and 1.76 for ^{137}Cs and ^{90}Sr, respectively. When examining the soils of the quarters of the forest vegetation group B2, it was found that the density of soil contamination with ^{137}Cs ranged from 49.95 to 203.13 Bq/kg, and ^{90}Sr – from 1.55 to 2.96 kBq/m². The highest density of radionuclide contamination was observed in soil samples from the 43rd quarter with toxicant concentrations of 136.90–203.13 and 2.41–2.96 kBq/m² for ^{137}Cs and ^{90}Sr, respectively. The lowest density of ^{137}Cs and ^{90}Sr was recorded in the 50th quarter. The contamination was at the level of 49.95–74.74 Bq/m² and 1.55–1.85 Bq/m² for the elements, respectively. Average values of soil contamination density in the quarters of the B2 forest conditions group were 115.13 kBq/m² for ^{137}Cs and 2.20 kBq/m² for ^{90}Sr.

Comparing the indicators of contamination density of the surveyed plots of quarters of forest conditions A1, A2, B1, B2 of the subsidiary enterprise Korosten Forestry, it can be noted that the density of ^{137}Cs and ^{90}Sr contamination was higher in the plots of quarters of group A, except for plot 43 of quarter B2, where ^{137}Cs and ^{90}Sr were at the level of 136.90–203.13 and 2.44–2.96 kBq/m^2, respectively. The more contaminated areas of the quarters of forest vegetation group A1 and group A2 can be explained by the fact that sandy grey forest soils have a greater ability to retain radionuclides compared to grey forest soils.

In the Figure 1 A2 demonstrates the highest average values of radionuclide contamination among all forest types studied. The variability of concentrations is the highest for all indicators, which indicates a significant heterogeneity of the territory or the influence of external factors on contamination. B1 and A1 are characterised by the lowest levels of pollution and the lowest coefficients of variation, which indicates the stability of pollution in these conditions. B2 has moderate contamination values with high variability for ^{137}Cs, indicating some areas of heterogeneity or different sources of contamination. Thus, our radiological surveys of the surveyed areas of the quarters of the forest vegetation group A1, A2, B1, B2 showed that even 38 years after the Chornobyl accident, not only agricultural land needs radiological surveys, but also the country's forests that were exposed to radioactive impact.

The survey results showed that significant areas of the forest still have a high density of radionuclide contamination. Of the 10 surveyed quarters, only areas of 3 quarters, namely 50 (B2), 29 (B1), 13 (A2), have a ^{137}Cs contamination density of up to 111 kBq/m^2 (3.0 Ci/km^2), and ^{90}Sr – up to 2.50 kBq/m^2 (0.067 Ci/km^2).

The gamma background in the surveyed areas of forest and vegetation conditions depended not only on radiation from artificial radionuclides but also on natural radionuclides and was in the range of 22–47 μR/h, with the permissible level being up to 20 μR/h.

Soil is one of several environmental factors that control the distribution of vegetation types, but under certain conditions it can be the most important. For example, the further a tree is located from its climatic optimum, the more the range of soil conditions favourable to its growth during a period of unfavourable climatic conditions for that species is narrowed.

Soil agrochemical parameters are the main parameters that determine the quality of land. The main indicators used to determine the agrochemical condition of soils are the following: the content of humus, nitrogen, mobile phosphorus, exchangeable potassium, soil acidity, etc. (Ipatev, 1999). When determining agrochemical parameters in the selected soil samples, it was found that all soils were poor in nutrients. The nitrogen content in the soils of quarters of groups A1, A2, B1, B2 ranged from 38.72–45.78 mg/kg, 30.18–44.19 mg/kg, 47.69–55.34 mg/kg, 34.62–54.83 mg/kg, respectively, and corresponded to a very low level of supply. The weighted average content of easily hydrolysable nitrogen in the soils of the groups of forest vegetation conditions A1, A2, B1, B2, respectively, was in the range of 41.54, 37.04, 51.87, 43.28% (Fig. 3)

The humus content in all the studied plots was also very low and was at the level of 0.33–0.40%, 0.26–0.37%, 0.39–0.45%, 0.31–0.44%, respectively, in the soils of quarters of groups A1, A2, B1, B2. The average values of humus content were 0.36, 0.32, 0.42, 0.39, respectively, in groups of forest-vegetation conditions A1, A2, B1, B2, which were also at a rather low level.

The acidity of soils in the studied plots of quarters of the group of forest vegetation

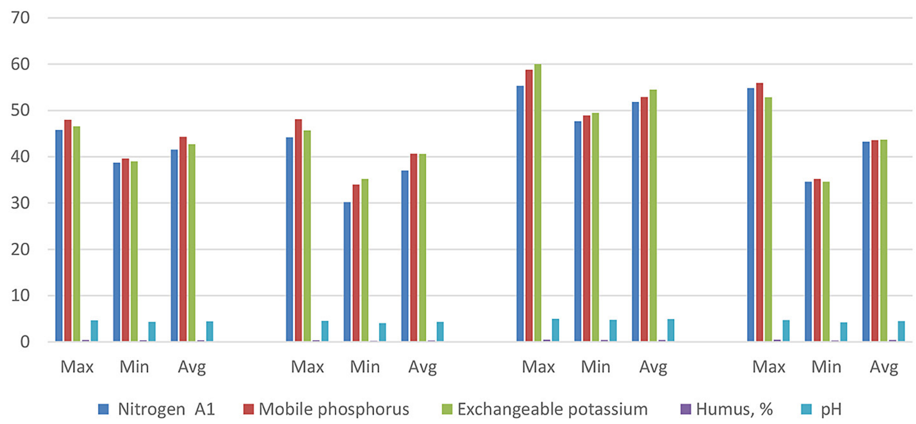

Figure 3. Agrochemical parameters of the soil (mg/kg)

conditions A1, A2, B1, B2 varied widely – from 4.03 to 5.03 pH units, i.e. from very strongly acidic (< 4.1) to medium acidic (4.6–5.0). The average acidity values of the surveyed soils in the groups of forest vegetation conditions A1, A2, B1, B2 were at the level of 4.43, 4.32, 4.91, 4.52%, respectively. Laboratory studies have established that the lowest soil acidity was in the quarters of forest vegetation conditions B1 and ranged from 4.77 to 5.01 pH units.

With regard to the availability of mobile phosphorus in the studied plots by groups of forest vegetation conditions, it was found that in the extracts of quarters of groups A1 and A2, the content of this element was at a low level of availability (26–50 mg/kg) and ranged from 39.64 to 48.00 mg/kg and from 34.00 to 48.11 mg/kg of soil. In the allotments of the quarters of the forest vegetation conditions group B1 and B2, the content of mobile phosphorus varied from low (26–50 mg/kg) to medium (51–100 mg/kg) availability, with a content of 48.93 to 58.79 mg/kg and 35.23 to 55.94 mg/kg of soil, respectively. The average values of mobile phosphorus in the surveyed soils in the groups of forest vegetation conditions A1, A2, B1, B2 were 44.33, 40.68, 52.92, 43.60 mg/kg soil, respectively.

The content of exchangeable potassium in all the studied plots of the quarters of the groups of forest vegetation conditions was also at a low (< 41 mg/kg) and medium level of availability (41–80 mg/kg). The potassium content in the soils of the plots of quarters of groups A1 and A2 was at the level of 39.00–46.55 and 35.18–45.69 mg/kg, and in the soils of the plots of quarters of groups B1 and B2 at the level of 49.48–60.00 and 34.60–52.87 mg/kg of soil, respectively. The weighted average content of exchangeable potassium in the soils of groups of forest vegetation conditions A1, A2, B1, B2 was 42.73, 40.61, 54.54, 43.68, respectively, for the groups of studies.

Summing up the results of nutrient content in the studied soils, it was found that the indicators of nitrogen, phosphorus, potassium, humus were higher in the soils of the quarters of the group of forest vegetation conditions B 1 and amounted to 51.87, 52.92, 54.54, 0.42, respectively, for the elements. The acidity of the soils of forest-vegetation conditions B 1 was also lower compared to the soils of other groups of forest-vegetation conditions (4.91 pH units). In technogenically contaminated areas, the content of heavy metals in soil is an additional negative factor to radioactive contamination, the joint effect of which is currently poorly understood.

Soil is a unique irreplaceable natural resource, a solar energy storage device, the basis of plant, animal and human life, and a natural indicator of environmental pollution. Soil contamination with heavy metals is of global interest to modern science due to the growing man-made impact on the environment. The danger from heavy metals is determined by the fact that, unlike organic pollutants, they are not destroyed but transferred from one form to another, in particular, they are included in the composition of salts, oxides, and organometallic compounds.

The research results showed that the content of toxicants in the soil under conditions of radioactive contamination was significantly below the TLV. The concentration of plumbum in the studied areas of the quarters of the forest vegetation group A1 varied from 1.45 to 1.68 mg/kg, and the average value was 1.56 mg/kg. The concentration of plumbum in the studied plots of the quarters of the A2 forest vegetation group ranged from 1.29 to 1.84 mg/kg, with an average value of 1.56 mg/kg. As for the contamination with mobile plumbum in the surveyed plots of the quarters of the forest vegetation group B1 and B2, the maximum toxicant content was 1.44 and 1.66 mg/kg, respectively. The lowest content of plumbum was 1.21 mg/kg in the soils of group B1 and 1.22 mg/kg in the soils of group B2.

The content of cadmium in the soils of forest vegetation group A1 and A2 was in the range of 0.057–0.070 mg/kg and 0.047–0.077 mg/kg, respectively, in the groups. The average values of cadmium were 0.061 and 0.060 mg/kg. The content of cadmium in the soils of the forest-vegetation group B1 and B2 ranged from 0.048 to 0.060 mg/kg and from 0.043 to 0.069 mg/kg, respectively. The average values of cadmium in the soils of group B 1 and B 2 were 0.053 and 0.057 mg/kg, respectively.

The content of mobile copper compounds was in the range of 0.150–0.172 mg/kg; 0.128–0.177 mg/kg; 0.120–0.150 mg/kg; 0.112–0.168 mg/kg, respectively, in the soils of the quarters of the forest vegetation conditions group A1, A2, B1, B2. The average metal content in the groups of forest vegetation conditions A1, A2, B1, B2 was 0.157, 0.151, 0.134, 0.112 mg/kg of soil, respectively (Fig. 4).

The concentration of zinc in the studied areas of the quarters of the group of forest vegetation

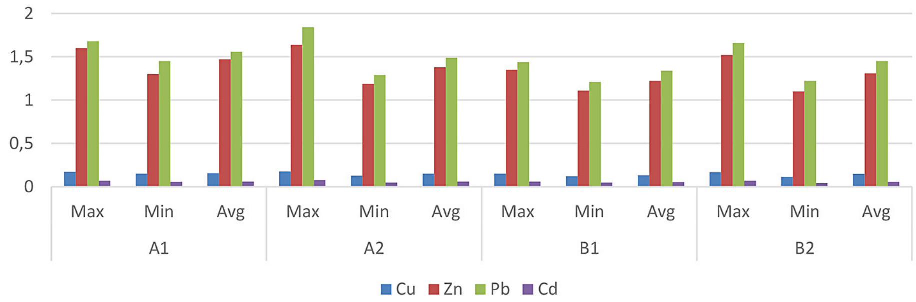

Figure 4. Content of heavy metals in soil (mg/kg)

conditions A1 and A2 varied at the level of 1.30–1.60 and 1.19–1.64 mg/kg, respectively. The content of mobile zinc compounds in the soils of the quarters of the group of forest vegetation conditions B1 and B2 was in the range of 1.11–1.35 and 1.10–1.52 mg/kg. The average values of mobile zinc content in the groups of forest vegetation conditions A1, A2, B1, B2 were 1.47, 1.38, 1.22, and 1.31 mg/kg of soil, respectively.

The results of the study of the content of mobile heavy metal compounds in the studied soils of the quarters of forest vegetation conditions showed that the content of toxicants was higher in the soils of the quarters of groups A1 and A2.

CONCLUSIONS

According to the results of our research, it was found that the soils of the subsidiary enterprise Korosten correspond to typical forest soils of Polissya in terms of their chemical composition. The analysis of the soil's physicochemical and agrochemical parameters indicates a low level of macro- and microelements, as well as a strongly acidic reaction of the environment, which is typical for forest conditions such as boron.

It was found that the lowest soil acidity was in the quarters of forest vegetation conditions B1 and ranged from 4.77 to 5.01 pH units.

The density of soil contamination with ^{137}Cs varied widely – from 49.95 to 367.04 kBq/m^2 (1.35–9.92 Ci/km^2), and ^{90}Sr – from 1.55 to 4.48 kBq/m^2 (0.042–0.121 Ci/km^2).

During the survey of the quarters of the A 1 forest and vegetation group, it was found that the density of soil contamination with ^{137}Cs was 149.85–214.23, and ^{90}Sr – 2.52–3.03 kBq/m^2. The highest density of radionuclide contamination was observed in soil samples from the 27th quarter with toxicant concentrations of 198.69–214.23 and 2.89–3.03 kBq/m^2 for ^{137}Cs and ^{90}Sr, respectively. The lowest density of ^{137}Cs and ^{90}Sr was observed in the discharges of the 22nd quarter. The study of the density of soil contamination with radionuclides in the quarters of the forest vegetation group B 1 revealed that the density of soil contamination with ^{137}Cs was in the range of 55.13–96.20 kBq/m^2, and ^{90}Sr – in the range of 1.59–1.92 kBq/m^2.

The most contaminated soils were in the 29th quarter. The density of ^{137}Cs contamination in these areas was 94.35–96.20 kBq/m^2, and the density of 90Sr contamination ranged from 1.78 to 1.92 kBq/m^2. The lowest density of radionuclides was found in the soils of Quarter 17.

Comparing the indicators of contamination density of the surveyed areas of quarters of forest vegetation conditions A1, A2, B1, B2 of the subsidiary enterprise Korosten Forestry, it can be noted that the density of ^{137}Cs and ^{90}Sr contamination was higher in the allotments of quarters of Group A, except for the areas of ^{43} quarters of Group B2, where ^{137}Cs and ^{90}Sr were at the level of 136.90–203.13 and 2.44–2.96 kBq/m^2, respectively.

The content of toxicants in the soil under conditions of radioactive contamination was significantly below the TLV. The content of toxicants was higher in the soils of quarters of Group A1 and A2.

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