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Titarenko O.M.
Vinnytsia National Agrarian University,
Vinnytsia, Ukraine
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THE STATE OF NATURAL FODDER MEADOWS OF THE EASTERN PODILLYA OF UKRAINE IN MODERN ECOLOGICAL CONDITIONS OF THE ENVIRONMENT

Abstract.
The article presents an analysis of the state of natural fodder meadows of the Eastern Podillya of Ukraine. It was found that in the conditions of dry lowland meadows the safest and most suitable for providing herbivores with plant biodiversity are normal land.

Keywords: *agricultural landscapes, heavy metals, soil, land, natural forage lands, lead, cadmium, zinc, copper.*

In Ukraine, natural forage lands cover an area of about 6.7 million hectares, of which about 4.6 million hectares are pastures, up to 2.3 million hectares - hay and about 0.9 million hectares - swamps. In the Forest-Steppe zone there is about 10% of natural fodder lands from the total area of agricultural lands.

In the Forest-Steppe of Ukraine, natural forage lands cover an area of about 2.1 million hectares, which is 3.4% of the total area of this natural-climatic zone. The forest-steppe zone includes mainland and flood-plain meadows.

Natural forage lands are a source of plant food for both domestic and wild ruminants. Although natural plant communities are less nutritious than the vegetation of cultivated pastures, however, its use is costly, which plays an important role in providing food to the population of Ukraine. Modern use of natural lands provides a sufficiently cheaper feed, the possibility of free grazing. In addition, the vegetation of natural forage lands dramatically reduces soil erosion and is one of the factors stabilizing disturbed agricultural landscapes [7].

As part of the plant groups of natural fodder meadows, 71% has fodder value, which includes cereal legumes, sedge and herbaceous groups. Cereal group of phytocenoses includes 104 species, which is a percentage of 7.5%, which have different fodder value. 35 species of plants are characterized by high fodder value, while low - 23 species [3].

The legume group of phytocenoses of natural forage lands includes 79 species, which is 5.7%. Sedge vegetation includes 95 species (6.9%). This vegetation is characterized by low forage quality. There are 39 highly digestible species of natural forage lands, which is 2.8%. The poisonous plants grow among the natural fodder meadows, their number reaches 83 species (4.9%) and 59 (4.2%) harmful species that negatively affect the economic value. Natural forage lands include 61 species of vitamin-bearing plants, 53 species of plants containing tannins and 42 species containing essential oils [9].

It is known that the plant phytodiversity of natural forage lands is constantly undergoing certain changes, among which synthetic changes dominate (overgrowing of reservoirs, sands, landslides). Demutation changes have also been identified, which to some extent restore the original groups of plant biodiversity. Among modern demutation changes, demutation and anthropogenic-demutation changes are distinguished. Due to the actual demutation changes, the anthropogenic impact on the restoration of plant diversity of natural forage lands is insignificant and has characteristic changes close to natural ones [10].

Analysis of geobotanical survey of natural forage lands of the Forest-Steppe of Ukraine showed that they are in unsatisfactory condition due to high anthropogenic load and need to be restored [5]. According to the coenotic structure, the studied lands include mainly cereals and cereal-herbaceous, less often - cereal-sedge, sedge-herbaceous, herbaceous and even less - cereal-legume and monodominant legumes, so they need radical restoration in some areas. A perspective direction of recovery of natural forage lands is the optimization of biotechnology of growing meadows, which is based on the use of low-cost energy-saving technologies [1].

Energy-saving technologies consist in the selection of individual species and grass mixtures, the application of fertilizers, modes of use of natural forage lands and the establishment of their impact on the composition, structure and productivity of grasslands, forecasting their development.

Analyzing the plant phytodiversity of natural forage lands of the Forest-Steppe zone, it should be noted that the largest share is occupied by cereals, in particular: cocksfoot grass (Dactylis glomerata), timothy grass (Phléum praténse L.), awnless brome (Bromus_inermis), tall oat grass (Arrhenatherum elatius), meadow grass (Poa pratensis L.), creeping bent (Agrostis stolonifera), reed canary grass (Phalaris arundinacea) and others.

Among the vegetation that grows on natural fodder meadows and has a high fodder value, it is necessary to single out meadow clover (Trifolium pretense), pink clover (Trifolium hybridum), white clover (Trifolium repens), birds-foot trefoil (Lotus corniculatus) and timothy grass (Phléum praténse L.), cocksfoot grass (Dactylis glomerata) and pasture ryegrass (Lolium perenne) (cereals).

Anthropogenic load is typical for natural forage lands of Ukraine, especially in the conditions of urbanized territories. The main sources of pressure on natural ecosystems, including forage lands, are significantly affected by industry, motor wastewater and household waste, as well as agricultural production, which is characterized by excessive intake and biosphere of toxic elements. Among a large number of toxic elements, heavy metals occupy a prominent place.

In particular, there is an increased supply of lead, cadmium, zinc, copper and others. Among these heavy metals, zinc and copper are at the same time microelements, which are part of biocatalysts and bioregulators of the most important physiological processes and are part of individual protein components. However, the entry of heavy metals into living organisms above acceptable levels has a negative impact.

Once in the atmosphere, heavy metals eventually settle on the surface of the lithosphere, contaminating its components. Under such conditions, the soil is the main source of heavy metals, from which heavy metals in the food chain migrate into the vegetation, reducing its quality and safety. The predominant amount of heavy metals that enters the soil is concentrated mainly in its upper layer, which is characterized by high fertility. Heavy metals in the soil are fixed in the humus layers from where, being in exchange form, they are quickly included in the cycle and spread in the biome. The intensity of movement of heavy metals depends on many factors, in particular, the content of organic matter, soil pH, mechanical and mineral composition, and others. Chernozems are characterized by the highest sorption capacity, relatively lower - gray-forest and sod-podzolic soil.

According to various sources in the soils of the Forest-Steppe of Ukraine, the average concentration of mobile forms of cadmium in conditions of local pollution is 0.12 mg / kg, lead 10 mg / kg, zinc 2.8 mg / kg and copper 7 mg / kg.

Man-made activity of the population, which grows from year to year, leads to an increase in the environment of various harmful substances, in particular, heavy metals, which in metabolic form, move in trophic chains from soil to vegetation, reducing the quality and safety of food [2].

Powerful sources of environmental pollution by heavy metals are complexes: mining, metallurgy, engineering, chemical, transport, agro-industrial, housing and communal, and others [6]. It is known that mine effluents and water after mining in mines contain a number of pollutants, among which the most dangerous are heavy metals. In steelmaking, up to 40 kg of solid particles, including Mn, Cu, Zn, Cd and Pb compounds, enter the atmosphere when only one ton of steel is smelted. Powerful amounts of heavy metals also enter the environment through chemical production, in particular from wastewater, in which compounds of cadmium, lead and zinc are found. Rapidly growing sources of environmental pollution today are vehicles, agricultural production and industrial waste. In agricultural production, especially in crop production, mineral fertilizers are a powerful source of heavy metals in the environment.

It is known that the number of vehicles has grown rapidly in recent years, which has significantly increased the power of man-made impact on the environment. At the same time, the number of facilities serving it is growing, which is also a source of environmental pollution by various toxicants. The main ones are transport companies, bases of road construction equipment, garages, parking lots, gas stations, service stations [2].

The objects of pollution from the exploitation of transport vehicles are air, water, soil, as well as vegetation, especially near highways, where about 20% of gaseous emissions are deposited, creating local pollution. The predominant share of emissions from motor vehicles is concentrated on the soil surface, from where it is included in the form of mobile forms in trophic chains, accumulating in the phytomass.

The accumulation of toxicants in soils leads to their degradation, which is accompanied by toxic effects on plants, causing a decrease in their reproductive quality. Quite a noticeable man-caused load of vehicles was found on the soils of the roadside, which is accompanied by their contamination with heavy metals [8]. The intensity of soil pollution by emissions from mobile sources depends on the number of vehicles, usually higher in the city and lower outside.

There is a constant migration of substances in the soil and their transfer over long distances, including plants [4]. There is a clear relationship between the level of heavy metals in the soil and their accumulation in crops. The soil intensively accumulates cadmium, zinc, lead and copper. Heavy metals that got into the soil mainly accumulate in its near-surface layer 0–10 and 0–20 cm [5]. A significant source of soil contamination with heavy metals is the systematic application of fertilizers and pesticides, which can increase the concentration of these metals in the soil. Within 90% of heavy metals from their total supply of mineral fertilizers accumulates in the soil, and the rest is included in the cycle and enters the plants and their products. It is known that the largest amount of heavy metals is contained in phosphorus fertilizers, relatively less in potassium and nitrogen. It was found that during the cultivation of winter rape and sunflower with a total area of 405370 ha with mineral fertilizers annually gets into the soil about 908 kg of lead and 214 kg of cadmium [7].

Among the large number of toxicants that enter the environment as a result of man-made activities of the population in terms of revenue and toxicity are heavy metals, mobile forms of which are in constant circulation [10]. Heavy metals are characterized by a density of more than 5 g / cm3 and an atomic mass of 40. Heavy metals include trace elements, in particular Zn and Cu, which are toxic in high concentrations. The greatest attention is focused on the study of the cycle of Zn, Pb, Cd and Cu in the environment.

At the same time, it is necessary to take into account that the microelements B, Na, Cl, V, J, Mn, Co, Cu, Zn and Mo are indispensable for maintaining the physiology of vital activity of organisms in microconcentrations (less than 0.001%). Conditionally necessary, present in plants in different quantities are Li, F, Al, Si, Ag, Ti, Cr, Ni, Se, Sr, Cd and Pb. Their usefulness or irreplaceability has not been conclusively proven. Instead, the toxicity of many of these elements has been unequivocally proven to enter plants in increased quantities. In terms of phytotoxicity, heavy metals at the same concentrations are arranged in the following sequence: Cd> Ni> Zn> Mn> Cu> Pb.

It is established that heavy metals in the soil environment are in exchangeable and non-exchangeable forms. Non-exchangeable forms of heavy metals are those that bind to soil minerals and are inaccessible to plants. Metabolic forms of heavy metals are in the free state, so constantly migrate in the system soil - plants and their products. Depending on the acidity of the soil, heavy metals in the soil can change from one form to another. In particular, the high acidity of soils increases the migration of heavy metals, turning them into more accessible forms [5].

Natural forage lands as a component of the natural environment are constantly man-made by modern sources of pollution, which increases the risk of their productive use. Of particular concern is the increase in soil inputs with the subsequent inclusion in plant migration chains of toxicants such as cadmium and lead, which can accumulate tens of times or more in the phytomass compared to soils. The critical areas of natural fodder meadows today are those that are close to the sources of pollution, which requires constant control over the quality and safety of plant raw materials [8].

Materials and methods of research. The research was carried out in the conditions of the Eastern Podillya of Ukraine on gray forest soils in the conditions of absolute, normal lands and lands of excessive humidification within the limits of technogenic emissions.

Table 1

Content of mobile forms of heavy metals in soils of natural forage lands, mg / kg (on average for 2016-2018 based on absolutely dry matter), (n = 4, M ± m)

Research material	Lead	Cadmium
	Average	Average
Soils of absolute land	2,90±0,07**	0,48±0,03**
Soils of normal land	2,96±0,06**	0,49±0,05**
Land soils of excessive moisture	3,20±0,02	0,51±0,047

The content of lead in the soils of absolute land was lower than the MPC by 2.06 times, and cadmium by 1.45 times. In soils of normal land in the study areas, the concentration of lead ranged from 2.8 mg / kg to 3.1 mg / kg, while cadmium ranged from 0.47 mg / kg to 0.51 mg / kg. The content of lead and cadmium in the soils of normal land was lower than the MPL (Maximum permissible level) by 2.02 times and 1.42 times, respectively. In the conditions of land of excessive moisture in the studied areas, the content of lead in the soil ranged from 3.1 mg / kg to 3.3 mg / kg, cadmium from 0.49 mg / kg to 0.53 mg / kg. The content of lead and cadmium in the soils in these areas was lower than the MPC by 1.87 times and 1.37 times, respectively.

The highest level of lead and cadmium pollution (Fig. 1) was characterized by soils of excessively moist soils, relatively lower than normal dry soils and absolute dry soils. Thus, the concentration of lead and cadmium in the soils of the lands of excessive moisture was 1.1 times and 0.6 times higher, respectively, and 1.08 times and 1.04 times higher in comparison with the absolute and normal lands. The concentration of zinc in the soils of absolute drylands (1) ranged from 9.3 mg / kg to 14.2 mg / kg, and copper from 0.14 mg / kg to 0.17 mg / kg. The content of zinc and copper in the soils of absolute land on average in the studied areas was lower than the MPC by 2.0 times and 20 times, respectively.

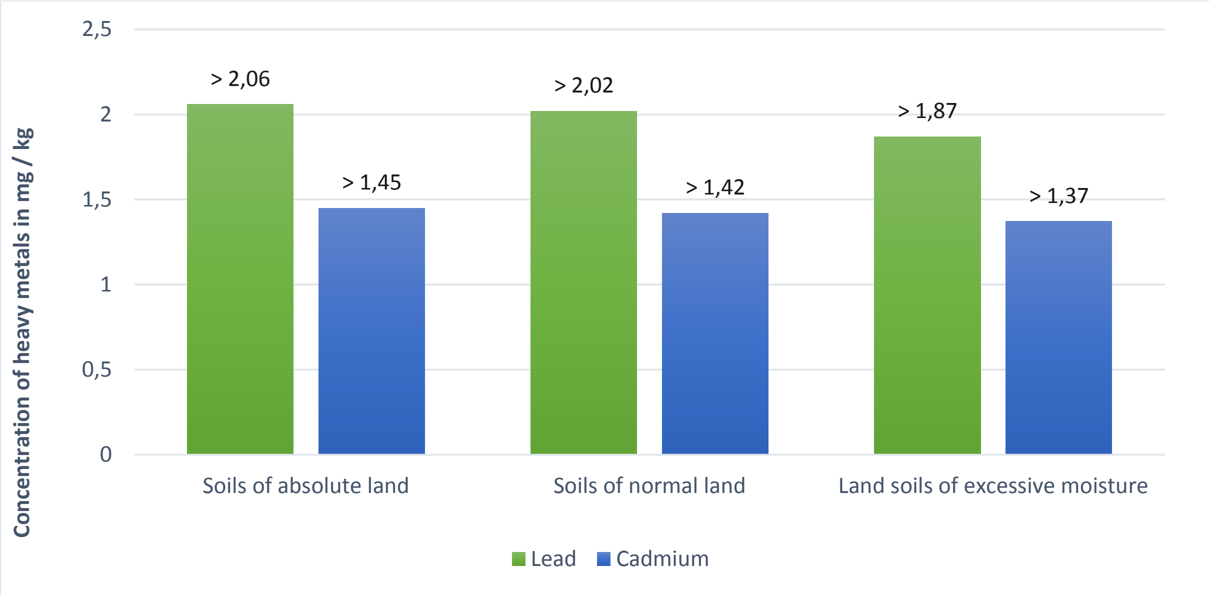

Fig. 1. Comparative assessment of the content of heavy metals in the soil to the MPC, times

Note. The maximum concentration limit for lead is 6.0 mg / kg, cadmium is 0.7 mg / kg

In soils of normal land, the content of zinc ranged from 10.5 mg / kg to 14.7 mg / kg, and copper from 0.18 mg / kg to 0.19 mg / kg. The content of zinc and copper was lower than the MPC by 1.84 times and 16.6 times, respectively. The content of heavy metals in the soils of the lands of excessive moisture was on zinc in the range from 17.2 mg / kg to 20.1 mg / kg, and on copper from 0.19 mg / kg to 0.21 mg / kg. The content of lead and cadmium in soils was 1.25 times and 1.5 times lower than the MPC, respectively.

Table 2

The content of mobile forms of heavy metals (trace elements)
in soils of natural forage lands, mg / kg
(on average for 2016-2018 based on absolutely dry matter), (n = 4, M ± m)

Research material	Zinc	Copper
	Average	Average
Soils of absolute land	11,4±1,42***	0,15±0,07***
Soils of normal land	12,5±0,09**	0,18±0,03**
Land soils of excessive moisture	18,3±1,22	0,20±0,04

The highest levels of zinc and copper (Fig. 2) were characterized by soils of excessively moist soils, relatively lower - normal dry and absolute drylands. Thus, the concentration of zinc and copper in the soils of overmoistened drylands was 1.6 times and 1.33 times and 1.46 times and 1.11 times lower compared to absolute drylands and overmoistened drylands. That is, the soils of the land of excessive moisture had a high content of lead and cadmium, as well as zinc and copper.

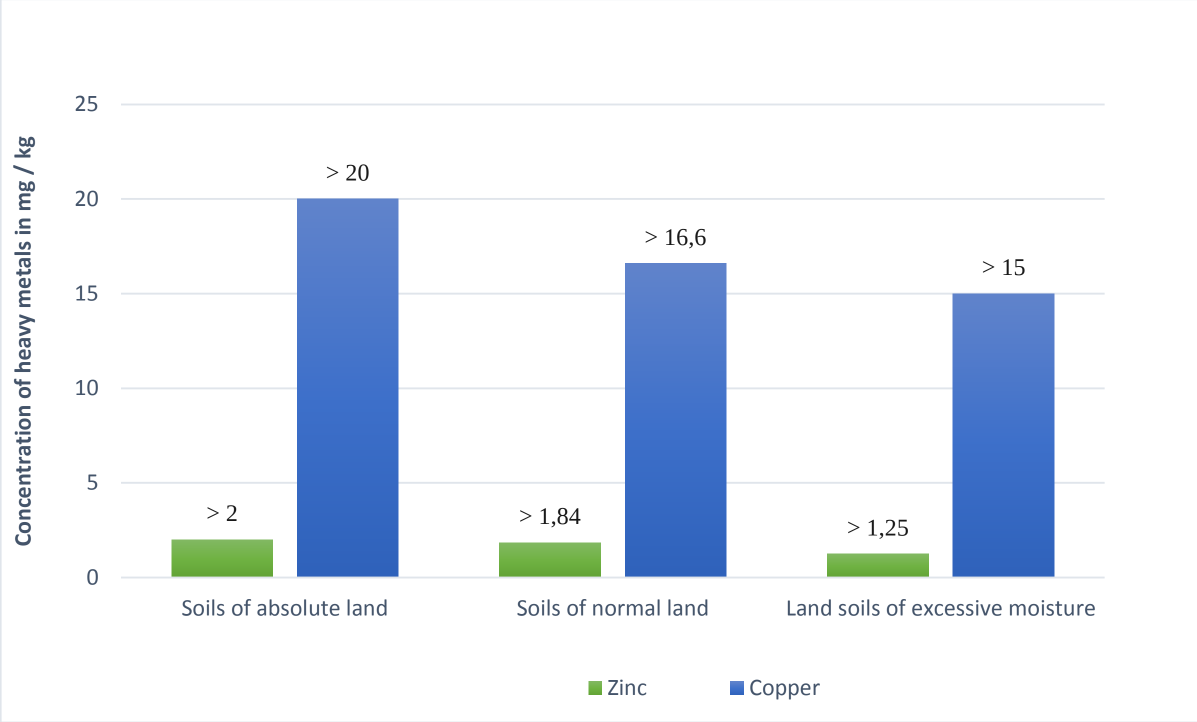

Fig. 2. Comparative assessment of the average content of heavy metals (trace elements) in the soil (for 2016-2018) to the MPC, times

Note. MPC for zinc - 23 mg / kg, copper - 3.0 mg / kg

The risk factor for lead in soils (Table 2) of natural forage lands ranged from 0.48 to 0.53. The highest risk factor for lead of 0.53 was in soils of excessively moist soils, relatively lower in 1.08 times and 1.1 times in soils of normal and absolute soils, respectively.

Table 3

The coefficient of danger of mobile forms of heavy metals in the soils of natural forage lands on average for 2016-2018

Research material	Lead			Cadmium		
	MPC	Actual concentration, mg / kg	The coefficient of danger	MPC	Actual concentration, mg / kg	The coefficient of danger
Soils of absolute land	6,0	2,9	0,48	0,7	0,48	0,68
Soils of normal land	6,0	2,96	0,49	0,7	0,48	0,79
Land soils of excessive moisture	6,0	3,2	0,53	0,7	0,49	0,72

The risk factor for cadmium in natural forage soils ranged from 0.68 to 0.72. The highest risk factor for lead was also characterized by soils of overland moisture, relatively lower by 1.05 times and 1.3 times, respectively, soils of normal land and absolute land.

Table 4

The coefficient of danger of mobile forms of heavy metals (trace elements) in the soils of natural forage lands on average for 2016-2018

Research material	Zinc			Copper		
	MPC	Actual concentration, mg / kg	The coefficient of danger	MPC	Actual concentration, mg / kg	The coefficient of danger
Soils of absolute land	23	11,4	0,49	3,0	0,15	0,05
Soils of normal land	23	12,5	0,54	3,0	0,18	0,06
Land soils of excessive moisture	23	18,3	0,79	3,0	0,20	0,06

The risk factor for zinc in soils (Table 3) of natural forage lands ranged from 0.49 to 0.79. The highest risk factor for zinc was found in soils of excessive moisture, relatively lower in 1.46 times and 1.61 times in soils of normal and absolute soils. The coefficient of danger of copper in the soils of natural forage lands in the study area ranged from 0.05 to 0.06. In soils of land with excessive moisture and normal land, the risk factor for copper was 0.06. Whereas in absolute land soils the risk factor for copper was 1.2 times lower.

Conclusions. Analysis of the intensity of accumulation of heavy metals by dry lowland meadows in the studied areas of Vinnytsia region showed that the content of lead in soils ranged from 2.9 mg / kg to 3.2 mg / kg, cadmium from 0.48 mg / kg to 0.51 mg / kg, zinc from 11.4 mg / kg to 18.3 mg / kg and copper from 0.15 mg / kg to 0.20 mg / kg. It did not exceed the MPC, which is respectively 6.0 mg / kg; 0.7 mg / kg; 23 mg / kg and 3.0 mg / kg. The highest level of accumulation of lead, cadmium, zinc and copper in the soils was observed in the lands of excessive moisture, relatively lower in the conditions of normal and absolute lands.

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