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SOME AGROCHEMICAL CHARACTERISTICS OF THE SOILS OF THE VOLYN' POLISSYA ECOSYSTEMS

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The results of the study and analysis of the chemical composition of the soils of the Volyn' Polissya of Ukraine are presented in this work. This region includes the northern regions of Rivne and Volyn' regions. We characterized the geographical and ecological features of Western Polissya. Changes in the chemical composition of the soil were analyzed under the influence of climatic changes and changes in the structure of crops. The analysis was made over the last three decades. Changes in humus content in soils were also analyzed. The dynamics of the content of the main chemical elements in the soil is determined. These are nitrogen, phosphorus, potassium, zinc, manganese, copper, cobalt, boron. Prospects are defined for the further development of the field of crop production. The possible consequences are analyzed in relation to disturbances in the exchange of such an important biogenic element as nitrogen for ecosystems, in particular aquatic ones. These are, in particular, eutrophication, changes in species biodiversity, toxicity to aquatic organisms, impact on food chains in aquatic ecosystems, acidification of water bodies. The obtained results are important both for the planning and further development of agricultural production, and for the preservation of natural ecosystems.

Key words: *Volyn' Polissya, soil, agroecological assessment, chemical elements, nitrogen, environmental monitoring, agricultural production, hydroecosystems.*

ДЕЯКІ АГРОХІМІЧНІ ОСОБЛИВОСТІ ҐРУНТІВ ЕКОСИСТЕМ ВОЛИНСЬКОГО ПОЛІССЯ

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У роботі наведено результати вивчення та аналізу хімічного складу ґрунтів Волинського Полісся України. До складу цього регіону входять північні райони Рівненської та Волинської областей. Цей унікальний регіон має певні особливості які вимагають свого висвітлення і більш детального дослідження. Дано характеристику географічним та екологічним особливостям Волинського

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Полісся. Проаналізовано зміни хімічного складу ґрунту під впливом кліматичних факторів та особливостей структури посівів. Аналіз проводився за останні три десятиліття. Досліджено також зміни вмісту гумусу в ґрунтах сільгоспугідь. Визначено динаміку вмісту основних хімічних елементів у ґрунті. Це Нітроген, Фосфор, Калій, Цинк, Манган, Купрум, Кобальт, Бор. Визначено перспективи подальшого розвитку галузі рослинництва. Проаналізовані можливі наслідки порушень обміну для екосистем, зокрема водних, такого важливого біогенного елементу як Нітроген. Це зокрема евтрофікація, зміни видового біорізноманіття, токсичність для водних організмів, вплив на харчові ланцюги у водних екосистемах, підкислення водойм. Отримані результати мають значення як для планування та подальшого розвитку агровиробництва, так і для збереження природних екосистем.

Ключові слова: *Волинське Полісся, ґрунт, агроекологічна оцінка, хімічні елементи, Нітроген, екологічний моніторинг, сільськогосподарське виробництво, гідроекосистеми.*

Introduction

Volyn' Polissya of Ukraine is a complex of biocenoses, unique both for Europe and for the whole world. We include the northern districts of Rivne and Volyn' regions in Western Polissya, or another name is Volyn' Polissya. This unique region has its own characteristics that require their coverage and more detailed research. A noticeable expansion over the past 50 years of the scale of agricultural production on the territory of Volyn' Polissya has largely influenced its natural complexes and flora, as their integral component. Growing of cultivated plants on large areas that were previously occupied by natural phytocenoses, and the use of grasslands for grazing animals or haymaking cause significant negative changes in the species composition of the spontaneous flora of the region (Oitsius et al., 2020). Monitoring of the agro-ecological condition of the soils of the Volyn' Polissya (Krupko et al., 2023) and the impact of agricultural production on hydro-ecosystems also remain important issues.

The purpose of our research is to analyze the impact of agricultural production and climatic changes on the agrochemical properties of the soils of the region and to determine the prospects for the further development of the field of crop production, and also determine the possible consequences of nitrogen exchange violations on aquatic ecosystems.

Analysis of Recent Research and Discussion

The region is characterized by a flat relief, a temperate climate, a zone of mixed forests, and a large number of wetlands. The tectonic and geo-logical structure determines a significant variety of agrosoil conditions. On the territory of Polissya, acidic soils with low humus content prevail: turf-gleied, turf-hidden-podzolized sandy (brown sands), low-lying and peat-boggy peatlands, in the lowlands of rivers there are meadow and meadow-chernozem soils (Korotun & Korotun, 1996; Dolzhenchuk & Krupko, 2015). Over the past 30 years, the average annual air temperature has increased by 1.0-1.5 °C. The sums of active temperatures increase, the amount of precipitation decreases, and the conditions for atmospheric humidification deteriorate. At the same time, there is an increase in conditions and phenomena dangerous for agriculture: the frequency of occurrence of atmospheric drought, the number of days with dry wind, the number of days with frost, the duration of the frost-free period and the frequency of years with freezing of winter crops. Proceeding from eco-nomic feasibility and climatic possibilities for the period after 1991 there have been changes in the structure of cultivated areas. The range of cultivated crops has expanded, namely, significant areas of industrial crops – corn, rapeseed, sunflower and soybeans have appeared. The production of grain and leguminous crops has decreased by 2 times; sugar beet by 140 times, the cultivation of flax has completely stopped. Potato production has increased by 80% and vegetable production by 130%. The main trends of the last three decades: an increase in the sown area of industrial crops, which, in turn, displace traditional crops, attempts to intensify farming, a decrease in the number of mineral fertilizers applied by 2.0 times, organic fertilizers by 15.0 times, a decrease in the number of cattle by 6.0 times, pigs by 2.2 times, sheep and goats by 9.3 times. All this increases the imbalance of the agroecosystems of the region, as a result of which their self-reproduction and self-regulation is disrupted (Sobko & Voznyuk, 2018).

Sufficient humidification and the increase in the supply of heat contributed to the production of technical crops in the territory of the Rivne region commensurate with the indicators of the southern regions of Ukraine (Odesa, Mykolaiv, Kherson and Zaporizhzhya). These cultures are typical for these regions. The yield of rapeseed in the Rivne region is on average 28% higher than in the south of Ukraine. Sunflower yield is 50% higher. The yield of soybeans is similar to the indicators of the south of Ukraine (Sobko & Voznyuk, 2018).

In recent years, with scientific and technical development, significant transformations have been observed in the structure and technological processes of various branches of production, including agriculture. Of course, such changes affect the natural properties of soils, changing their condition and functions.

A significant part of the soil cover of the Volyn' Polissya consists of sod-podzolic soils of various granulometric composition, degrees of gley and podzolicity, which were formed mainly on non-carbonate sandy and sandy loam deposits of light granulometric composition, in conditions of increased moisture, under mixed forests with a dense grassy cover.

Turf-podzolic gley soils have a sandy and light loam granulometric composition. They are characterized by low moisture content and water permeability, very low hygroscopicity, they have low indicators of the number of absorbed bases and buffering, low supply of humus and nutrients. Therefore, these soils require anthropogenic regulation in the process of agricultural use. In the Polissya zone, annual losses of humus amount to 0.7-0.8 tons/ha. The reason for this is also the insufficient compensation of humus losses with organic fertilizers and plant residues of sideral crops. Therefore, agrotechnical measures for the cultivation of sod-podzolic soils should be aimed at maintaining the optimal level of the quantitative and qualitative composition of humus (Skrypchuk et al., 2020).

The output of humus from one ton of organic fertilizers is 42 kg in the Polissya zone.

The study area is located in the North Atlantic-Continental climatic region. The climate is moderately continental: mild winters with frequent thaws, warm summers, average annual precipitation is 650-700 mm.

The soil cover of the Volyn' Polissya is heterogeneous, it is characterized by a large variety of soil-forming rocks. They contributed to the formation of a significant number of agricultural soil groups. Samples of various agricultural production groups were selected to determine the physical, physicochemical, agrochemical and ecological condition of sod-podzolic soils of the Volyn' Polissya zone (Lyko et al., 2018). These are samples: 5b of sod-podzolic and sod unglazed and silty clay-sandy soils on sandy deposits, used under hayfields and pastures in the Berezne district (Yarynivka village) and Goshchan district (Zhalyanka village) districts; 27b of sod-podzolic gley drained clay-sand – under arable land in Dubrovytskyi district (Lyudin village); 14b of sod-podzolic and podzolic-sod clay loamy-sandy – under hayfields in the Rokytnivskyi (Rokytne village) district. The main criteria for soil sampling locations were the differences in agricultural production groups based on different methods of use.

The greatest thickness of the humus layer is observed on the sod-podzolic soil of agro-production group 14b under the hayloft and is 30 cm. The thickness of the humus layer is slightly lower for 5b under the pasture and hayloft – 22 cm; the lowest thickness is for agricultural production group 27b under arable land – 15 cm (Lyko et al., 2018; Krupko, 2020).

Therefore, for the creation of special raw material territories, according to the capacity of the humus layer, the sod-podzolic soil 14b under hayfield is suitable, limitedly suitable (22-15 cm) – 27b under arable land, 5b under pasture and hayfield.

Turf-podzolic soils in the studied areas are characterized by a low and medium degree of calcium supply: 27b low degree of supply (3.3 mg-eq/100g), 14b (5.3 mg-eq/100g) and 5b (8.0-10.5 mg-eq/100g) – average; a very low level of magnesium supply (<0.6 mg-eq/100g); low content of mobile sulfur (3.1-6.0 mg/kg), with the exception of the arable layer (0-30 cm) of arable land, where it is 7.8 mg/kg, this indicates an average degree of security (6.1-12.0 mg/kg). The indicated indicators decrease with depth.

Sod-podzolic soils of various agricultural production groups in the studied areas are characterized by an average (14b – 2.3 %) and low (27b, 5b – 1.7-1.9 %) degree of humus provision, which decreases with depth. According to this indicator, 14b is suitable for creating special raw material zones, all others are limited.

Agricultural production groups have a very low content of nitrogen, which is easily hydrolyzed (<101 mg/kg). With the depth of the soil profile, similarly to the previously considered indicators, a decrease in its content is observed.

According to the indicator of the content of mobile phosphorus compounds, 14b are characterized by a very high degree of supply (311 mg/kg), 5b under pasture is high (101-150 mg/kg), and the others are average (51-100 mg/kg of soil). 14b and 5b under pasture are suitable for creating special raw material zones, the others are of limited use.

Plots 14b and 5b under haymaking are characterized by a very low degree of availability of mobile potassium compounds (<41 mg/kg of soil). Areas under pasture have a low potassium content of 27b (48 mg/kg) and 5b (60 mg/kg). According to this indicator, the land is not suitable for the creation of special raw material zones.

Plots 14b and 5b have a very low degree of security in terms of the content of mobile zinc compounds (<1.1 mg/kg), 27b – low (1.3 mg/kg). According to the zinc content, the land is not suitable for the creation of special raw material zones.

Plot 5b under the pasture is characterized by the content of mobile manganese compounds with a high degree of supply (group V, 15.98 mg/kg), other sites have a higher degree (group IV, 10.1-15.0 mg/kg). According to this indicator, the lands are limitedly suitable for the creation of special raw material zones (20-10 mg/kg).

All agro-production groups of sod-podzolic soils are included in the II group with a low degree of security in terms of the content of mobile copper compounds (0.11-0.15 mg/kg). According to this indicator, the lands are not suitable for the creation of special raw material zones.

According to the indicator of the content of mobile cobalt compounds, agricultural production groups 14b and 5b are included in the VI group, which is characterized by a very high degree of availability (0.30-0.49 mg/kg), 27b – in the V group with a high degree of availability (0.21-0.30 mg/kg). According to this indicator, arable land is limitedly suitable (0.30-0.15 mg/kg) for creating special raw material zones, other types of land are suitable (>0.30 mg/kg).

Agricultural production groups 27b and 14b belong to the V group with a high degree of security in terms of the content of mobile boron compounds (0.51-0.70 mg/kg), 5b belongs to the IV group with an increased boron content. According to this indicator, the studied lands are suitable for the creation of special raw material zones (0.70-0.33 mg/kg), with the exception of 5b under the pasture, this area is limitedly suitable (Lyko et al., 2018; Krupko, 2020; Lysytsya, 2023).

The dynamics of the humus balance in different regions indicates the strengthening of the dehumification processes. The negative balance of humus in the agriculture of the Polissya zone is observed during all periods of research. Starting from 1981-1985, the negative balance of humus continued to grow. Its deficit increases by 2.5 times and amounts to -0.73 tons/ha (2006-2010). At the same time, it should be noted that the most significant difference in the negative balance of humus is observed in the Rokytniv and Volodymyretsky districts of the Rivne region. According to the data of 2006-2010, it decreased in Rokytne district by 0.40 tons/ha, and decreased in Volodymyretsk district by 1.05 tons/ha. In the period 2011-2015, the humus balance deficit decreased in the Polissya zone to -0.29 tons/ha (Dolzhenchuk & Krupko, 2015).

Separately, we should dwell on the issue of nitrogen balance in the soil. How can excess nitrogen affect ecosystems, particularly hydroecosystems? It is known that nitrogen fertilizers can be washed off fields located in catchment areas and enter lakes and other aquatic ecosystems. Increased inputs of reactive nitrogen (N) by fertiliser production cause adverse effects on terrestrial and aquatic ecosystems as well as human health, through impacts on air, soil and water quality. The best quantified adverse impacts include: the loss of plant diversity in terrestrial ecosystems and excess algal growth in aquatic ecosystems, leading to oxygen-deficient 'dead zones', by N-induced eutrophication and acidification and human health impacts due to increased concentrations of nitrogen dioxide, NO_x-induced ozone and N-induced particulate matter (Wim de Vries, 2021).

Changes in nitrogen concentration in water can significantly impact aquatic ecosystems (Rabalais, 2002; Trommer et al., 2019; Trommer et al., 2020). Nitrogen is an essential nutrient for plant growth, but excessive amounts can lead to various ecological issues. This is, for example, eutrophication, which is an important environmental problem for various regions of the world (Conci et al., 2022). Elevated nitrogen levels, often from agricultural runoff or sewage, can cause eutrophication. This excess nitrogen acts as a fertilizer, promoting the rapid growth of algae and aquatic plants. When these organisms die, they are decomposed by bacteria, consuming oxygen in the process. Consequently, oxygen levels in the water decrease, leading to hypoxic (low-oxygen) or anoxic (no oxygen) conditions, harming fish and other organisms that require oxygen to survive.

Changes in nitrogen levels can favor the growth of certain species over others. Some species may thrive in nutrient-rich environments, while others may struggle or die off. This imbalance can disrupt the natural balance of the ecosystem, potentially reducing overall biodiversity. It is clear that the form in which nitrogen is contained is also important (Britto & Kronzucker, 2013).

High levels of nitrogen can also be toxic to aquatic organisms (Collos & Harrison, 2014; Glibert et al., 2016). For instance, elevated levels of ammonium, a form of nitrogen, can directly harm fish and other aquatic animals, affecting their reproduction, growth, and overall health.

Altered nitrogen levels can impact the food chain in aquatic ecosystems. Excessive nitrogen can lead to algal blooms, which, when they die and decompose, can disrupt the food web. This can lead to a decrease in certain species, affecting predators that rely on them for food. Elevated nitrogen concentrations can contribute to acidification in water bodies. Acidification can affect the physiology of aquatic organisms, particularly those with shells or skeletons made of calcium carbonate, such as certain shellfish.

Conclusions

The soil cover of the Volyn' Polissya is heterogeneous, it is characterized by a large variety of soil-forming rocks. Calculations of average losses and inputs of organic and nutrient substances during the cultivation of agricultural crops in the territory of the Rivne region for the period 2000-2020 prove that agroecosystems are losing their dynamic balance.

One of the features of this region is also the large number of water ecosystems (rivers, lakes, marshes, reclamation canals). A large number of biogenic chemical elements get here from agrocenoses. For example, change of nitrogen concentration can have cascading effects on aquatic ecosystems, impacting the water quality, biodiversity, and overall health of these environments. Managing nitrogen inputs into water systems is crucial to maintaining a balanced and healthy aquatic ecosystem.

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