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ALTERAÇÕES NOS PARÂMETROS FÍSICO-QUÍMICOS DOS SOLOS CASTANHOS DO CAZAQUISTÃO OCIDENTAL SOB A INFLUÊNCIA DAS TECNOLOGIAS DE PASTAGEM

CHANGES IN THE PHYSICOCHEMICAL PARAMETERS OF CHESTNUT SOILS IN WESTERN KAZAKHSTAN UNDER THE INFLUENCE OF THE GRAZING TECHNOLOGIES

ИЗМЕНЕНИЕ ФИЗИКО-ХИМИЧЕСКИХ ПОКАЗАТЕЛЕЙ КАШТАНОВЫХ ТИПОВ ПОЧВ ЗАПАДНОГО КАЗАХСТАНА ПОД ВЛИЯНИЕМ ТЕХНОЛОГИЙ ВЫПАСА

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RESUMO

O gerenciamento dos recursos de pastagem do Cazaquistão Ocidental é complicado devido à deterioração dos parâmetros físico-químicos dos solos, manifestando degradação e alcalinização como resultado de pastoreio intensivo. A pesquisa teve como objetivo estudar a tecnologia de pastejo de gado para preservar os parâmetros físico-químicos dos solos e aumentar a eficiência do uso de pastagens. A avaliação e análise estatística dos indicadores físico-químicos dos solos foram realizadas com métodos padronizados durante o período de 2018 a 2019, o que permitiu identificar a melhor tecnologia de pastejo. Os resultados da pesquisa mostraram que, sob a influência de pastoreio intensivo, os parâmetros físico-químicos pioraram, foi detectada uma diminuição nas reservas de húmus em 10,88-12,35%, o solo degradado até o terceiro grau e tornou-se alcalino como resultado do aumento da permutabilidade. sódio a 1,65 cmol (equiv.)/kg. A tecnologia de pastejo moderado afeta positivamente os parâmetros físico-químicos dos solos dos ecossistemas de pastagem. Os solos castanhos das pastagens, onde foi aplicada tecnologia moderada de pastejo, permaneceram resistentes à degradação e salinização. Com essa tecnologia, o húmus do solo foi preservado de forma confiável no nível de 1,15-2,50%, o fósforo móvel estava dentro da faixa ideal de 0,87-1,60 mg/100g. Concluiu-se que é importante usar a tecnologia de pastoreio moderado para melhorar o manejo dos recursos das pastagens, que é a novidade científica da pesquisa.

Palavras-chave: *solo castanho, índices, degradação, pastoreio, tecnologias*.

ABSTRACT

Managing pasture resources of Western Kazakhstan is complicated due to the deterioration of the physicochemical parameters of soils, manifesting degradation, and alkalinization as a result of intensive grazing. The research has been aimed at studying the technology of cattle grazing for preserving the physicochemical parameters of soils and increasing the efficiency of pasture use. The assessment and statistical analysis of physicochemical indicators of soils were carried out with standard methods during 2018 – 2019, which allowed identifying the most optimal grazing technology. The results of the research showed that under the influence of intensive grazing, physicochemical parameters worsened, a decrease in the humus reserves by 10.88-12.35% was detected, soil degraded to the third degree, and became alkaline as a result of the increase in exchangeable sodium to 1.65 cmol (equiv.)/kg. The technology of moderate cattle grazing favorably affects the physicochemical parameters of the soils of pasture ecosystems. The chestnut soils of the pastures, where moderate grazing technology was applied, remained resistant to degradation and salinization. With this technology, the soil humus was reliably preserved at the level of 1.15-2.50%, mobile phosphorus was within the optimal range of 0.87-1.60 mg/100g. It has been concluded that it is important to use the technology of moderate cattle grazing to improve the management of pasture resources, which is the scientific novelty of the research.

Keywords: *chestnut soil, indices, degradation, grazing, technologies*.

ABSTRACT

Процесс управления пастбищными ресурсами Западного Казахстана усложняется из-за ухудшения физико-химических показателей почв с проявлением процессов деградации и солонцевания в результате интенсивного выпаса скота. Целью исследований является изучение технологии выпаса с.х. животных для сохранения физико-химических показателей почв и повышения эффективности использования пастбищ. Применение стандартных методов оценки и статистического анализа физико-химических показателей почв проводились с 2018 по 2019 годы, что позволило выделить наиболее оптимальную технологию выпаса. Результаты исследований показали, что под воздействием интенсивного выпаса ухудшаются физико-химические показатели, выявлено снижения запаса гумуса на 10,88-12,35%, в результате увеличения обменного натрия до 1,65 cmol(equiv.)/kg почва деградировалась до 3 степени и перешла в категорию солонцеватой. Умеренная технология выпаса с.х. животных благоприятно действует на физико-химические показатели почв пастбищных экосистем. Каштановые почвы пастбищ, где применялись умеренная технология выпаса сохраняли устойчивость к деградации и осолонцеванию. При такой технологии гумус почвы достоверно сохранился на уровне 1,15-2,50%, подвижный фосфор находился в оптимальных пределах 0,87-1,60 мг/100г. В этой работе был сделан вывод, что важно использовать умеренную технологию выпаса с.х. животных для повышения эффективности управления пастбищными ресурсами, в чем заключается и научная новизна исследований.

Keywords: *Каштановые почвы, показатели, деградация, выпас скота, технологии.*

1. INTRODUCTION:

The global growth of the population (the world's population in 2050 is expected to be about 9.2 billion people), the global climate changes and their adverse effects on the agriculture, the depletion of natural resources, which is of great importance for the development of the world's agriculture, food safety, and new ethical requirements for the producers are the future challenges associated with sustainable management of natural resources, and investments in food production and agriculture (Kučera *et al*., 2020).

Grasslands, which constitute a significant part of the global ecosystem, occupy 37 % of the Earth's land area and contribute significantly to the food security, providing the largest part of energy and proteins required by ruminant animals for the production of meat and milk. It is believed that proper pasture management and improvement of the state of degraded pastures can play a fundamental role in mitigating the effect of greenhouse gas emissions, especially concerning carbon accumulation and absorption (Conant *et al*., 2011; O'Mara, 2012; Nordborg and Röös, 2016).

Multiple scientific studies and developments of agricultural and biological scientific institutions show that in order to maintain the pastures' capability of constant seed and vegetative regeneration and reproduction of the required level of feed resources, they are to be used within the environmental imperative. The first environmental commandment for the rational use of the pastures is the compliance with the principle of matching their natural capacity with the number of grazing animals. Multiyear scientific studies performed in the second half of the 20th century by the scientists from various countries show that, without harm to the subsequent productivity of the pastures, it is possible to withdraw 25 – 75 % of the aboveground plant mass in various natural zones. In the arid conditions of Russia and Central Asia, 60 – 75 % of the annual plants' growth may be withdrawn (Shamsutdinov, 2012; Nasiyev *et al*., 2015; Gayevskaya and Krasnopolin, 2016; Nasiyev, 2016; Baytkanov, 2017).

One of the essential levers for restoring and preserving the pastures' biodiversity is grazing management and ecological optimization of the grazing load, which would also improve the productivity of the pastures and ensure environmental sustainability and economic efficiency (Costas *et al*., 2015).

Among the agrotechnical methods of increasing the pastures' productivity, providing rest from grazing for medium- and highly-degraded pastures is of paramount importance. Even one year's rest will allow pastures to significantly restore their sparse grass cover (Loris *et al*., 2019).

Studies of the scientists from the USA and China have shown reduced productivity and deteriorated state of vegetation in the heavy grazing conditions (Raiymbekov *et al*., 2017; Kubenkulov *et al*., 2019). For improving the state and the rational use of pastures, monitoring the current state of pasture soil resources is the priority task.

2. MATERIALS AND METHODS:

2.1 Study area

The research was conducted during 2018 and 2019 years at the initiative of the Ministry of Agriculture in the territories of three zones of Western Kazakhstan with different types of chestnut soils for detecting changes in the physicochemical parameters of the soil cover under the influence of different technologies of cattle grazing, and efficient managing pasture resources.

Zone 1 was the dry-steppe zone with the following coordinates of the reference plot and the pastures: reference plot — *49⁰01′N; 018⁰27′103″*E, moderate grazing pastures — 5*0⁰57'N; 050⁰46'390"E*, weak grazing pastures — 50⁰57′N; 050⁰48′049″E, and intensive grazing pastures — *50⁰59′N; E050⁰47′223″E.*

Zone 2 was the arid steppe zone with the following coordinates of the reference plot and the pastures: reference plot — *50⁰21′N; 051⁰00′073″E*, moderate grazing pastures — *50⁰19′N; 050⁰58′091″*E, weak grazing pastures — *50⁰19′N; 050⁰57′064″E,* and intensive grazing pastures — *50⁰20′N; E050⁰53′225″E.*

Zone 3 was the semi-desert zone with the following coordinates of the reference plot and the pastures: reference plot — *49⁰05′N; 049⁰08′101″E*, moderate grazing pastures — *49⁰08′N; 048⁰42′751″E*, weak grazing pastures — *49⁰09′N; E048⁰42′452″E*, and intensive grazing pastures — *49⁰08′N; 048⁰41′017″E.*

Soil sampling. To determine the effect of grazing on these indicators, soil samples were taken at three farms with moderately, weakly, and intensively used pastures located in three zones of Western Kazakhstan with dark chestnut (Haplic, Luvic), chestnut (Luvic Kastanozems) and Light chestnut soils (Calcic Kastanozems) from the 0 – 10 cm, 10 – 20 cm, and 20 – 30 cm layers. To identify the changes in the soil parameters through comparison, soil samples were taken from the reference plots (without grazing) from the 0 – 10 cm, 10 – 20 cm, and 20 – 30 cm layers in each zone. The experiment was repeated four times.

2.2 Physicochemical soil analysis

The changes in the physicochemical parameters of pastures were detected both in the field and in the laboratory environment with the use of modern generally adopted methods.

Soil density was determined in the field environment using cylinder bores by N.A. Kachinsky. In the field, samples were taken from the soil horizon with a cylinder bore with a volume of about 500 cm^3. At the same time, soil samples were collected in weighing bottles to determine moisture. In the laboratory, the soil was dried at 105°C to constant weight. Knowing the mass of the weighing bottle with dried soil and the mass of the empty weighing bottle, the mass of air-dry soil was found. Then, dividing the mass of dry soil by its volume (ring volume), the density of the soil was established.

The structural state of the soil was assessed by aggregate analysis using the dry sieving method. According to the results of the aggregate analysis, the structural coefficient (Cstr) was calculated, which was understood as the ratio of the number of aggregates from 0.25 to 10 mm (in%) to the total content of aggregates less than 0.25 and more than 10 mm (in%). The more Cstr was, the better the structure of the soil was. A scale developed by S.I. Dolgov and P.U. Bakhtin was used to assess the structural state of soils (Gabdulov *et al.*, 2018).

In the laboratory environment, the soil content of humus, mobile phosphorus, and exchangeable sodium was determined by the analysis of soil samples.

The content of humus in the soil was determined by the method of I.V. Tyurin based on the oxidation of soil organic matter by chromic acid until the release of carbon dioxide. A solution of $K_2Cr_2O_7$ in sulfuric acid was used as an oxidizing agent.

Mobile phosphorus compounds were determined by the photometric method of I. Machigin based on the extraction of mobile phosphorus and potassium compounds from the soil with ammonium carbonate solution at a concentration of 10 g/dm^3 with soil to solution ratio of 1:20 and the subsequent determination of phosphorus in the form of a phosphorus-molybdenum blue complex on photoelectric colorimeter and of potassium on a flame photometer (Gabdulov *et al.,* 2018).

The content of exchangeable sodium in the soil was established by the photometric method by extracting exchangeable and soluble sodium with ammonium acetate solution at a concentration of 1 mol/dm^3 with soil sample mass to solution volume ratio of 1:20 and the subsequent determination of sodium in the extract using a flame photometer. At the same time, soluble sodium in the aqueous extract was determined, and the difference in sodium was calculated. According to the content of the exchangeable sodium in the cation exchange capacity, the degree of soil alkalinization was established.

The degree of soil cover degradation was established by the physical criteria for land assessment approved by the Ministry of Agriculture of the Republic of Kazakhstan (Order No.185 of the Minister of Agriculture of the Republic of Kazakhstan, 2017).

Statistical analysis. The results of the studies were statistically processed following the method of the analysis of variance (Dospekhov, 2015) in the Statistica 6.0 application. Two individual samples were analyzed nonparametrically using the Mann-Whitney U-test, and statistical diagrams were made).

3. RESULTS AND DISCUSSION:

Agrochemical parameters of the pastures. The dynamics of decreasing the humus content. Studying the content and humus reserves in the pastures of Western Kazakhstan is a prerequisite for assessing their fertility and for addressing the issues of the rational use of pasture ecosystems. In the studies, the content and humus reserves depended on the technology of farm animals' grazing on the pastures. With that, more dynamic changes in the humus content occurred on the pastures with the arid climate of the third semi-desert zone with light chestnut soils. In the pastures with moderate grazing conditions in this zone, the humus content in the 0 – 30 cm soil layer reduced by 0.15 %, compared to the reference. The humus reserves were 44.16 t/ha, which was less by 7.19 %, compared to the reference. The humus content in the pastures with weak grazing conditions on light chestnut soils was 1.25 % with the humus reserves of 46.50 t/ha.

In the territory of the third semi-desert zone, the lowest humus content was found in the pastures with intensive grazing conditions. With the humus content of 0.83 %, the humus reserves in the 0 – 30 cm soil layer were 34.36 t/ha. Compared to the reference, the reduction of the humus reserves amounted to 27.78 %. In terms of the humus reserves, the soil in this plot degraded to the second degree. Since grazing has a significant effect on some ecosystem services (e.g., retention of nutrients, water storage, reduction of pollution), reduction of these parameters may result in decreased soil fertility and, consequently, land degradation (Mamontov *et al*., 2012). According to the hypotheses of the authors, a strong change in the content and reserves of humus in the pastures of the third semi-desert zone was the result of excessive loads from farm animals' grazing on the background of the arid climate (Nasiyev *et al*., 2015).

On dark chestnut and chestnut soils of the pastures in zones 1 and 2 with the technology of weak and moderate grazing, compared to the soil in the reference plots, the humus content reduced insignificantly (from 0.11 to 0.22 %), and the humus reserves in the 0 – 30 cm soil layer amounted to 4.59 – 6.67 %. With a certain degree of conditionality, it may be assumed that the humus in the soil in these zones was as though "preserved" under the influence of grazing, accompanied by the reduced ingress of the live and dead plant materials into the soil. It should be noted that oxidation of the organic matter in the soil does not occur in the pastures, i.e., the phenomena resulting in the dehumification of the arable land due to its annual plowing do not manifest themselves; hummus is not consumed there, and formation of plants biomass changes its species composition and productivity under the influence of failure (Tesla, 2016; Nasiyev and Bekkaliyev, 2019).

In the case of intensive grazing, the content of humus in chestnut and light chestnut soils reduced by 0.35 - 0.42 %, while the humus reserves reduced by 10.88 - 12.35 %. With that, in terms of humus reserves, the soil degraded to the first degree.

The results of the statistical analysis confirmed the dependence of the humus content on the intensity of the pasture use. The intensity of the changes in the humus content was determined by the type of soil and had a negative tendency. This tendency was described by a linear regression equation. The most significant reduction in the percentage of humus with an increase in the grazing intensity was observed in light chestnut soils of the third semi-desert zone (Figure 1).

The changes in the humus reserves also occurred according to the linear function in all types of soil. Regression analysis showed that the highest rate of humus reserves reduction depended on the type of soil and had a linear tendency. The most intensive reduction of humus content in the soil with increasing the intensity of pasture use was observed on the light chestnut soils of the third semi-arid zone.

The content of mobile phosphorus and exchangeable sodium. In chestnut soils, one of the limiting elements of soil fertility is the content of phosphorus (Barbara *et al*., 2016). In this regard, it is important to maintain the content of mobile phosphorus in chestnut soils in agricultural use. According to the results of the studies, the grazing of farm animals insignificantly changed the content of mobile phosphorus in chestnut soils of the three zones of Western Kazakhstan. In the zone of dark chestnut soils, the reduction of mobile phosphorus content ranged from 0.23 to 0.59 mg/100 g of soil, compared to the reference. In chestnut soils of the pastures in the second zone, the changes in the content of mobile phosphorus from the reference were 0.43 - 0.69 mg/100 g of soil. In the third zone in the light chestnut soils, the content of mobile phosphorus reduced from 0.10 to 0.41 mg/100 g of soil, compared to the reference (Table 1).

The U-test showed the effect of the grazing technology on the response of the effective index of mobile phosphorus content. In the column with the *p-value* in the table, the significance of the effective index (F) response to the technology by the soil zones takes the p-value < 0.05. The exception is the technology of moderate grazing for the third zone. Based on this indicator, a conclusion may be drawn that all technologies in the first, second, and third zones have a significant effect on the content of mobile phosphorus.

The quantitative expression of this effect is determined by the difference between the median for the corresponding technology and the technology without grazing.

On dark chestnut soils of the first zone, the difference between the median values of phosphorus in the case of the technology of weak grazing, compared to that without grazing, was 0.24 mg/100 g, in the case of the technology of moderate grazing, the difference was 0.41 mg/100 g, and in the case of the technology of intensive grazing — 0.61 mg/100 g.

For chestnut soils in the second zone, the difference between the median values of the content of mobile phosphorus in the case of the technology without grazing and that of weak grazing was 0.45 mg/100 g, in the case of the technology without grazing and that of moderate grazing — 0.61 mg/100 g, and in the case of the technology without grazing and that of intensive grazing — 0.69 mg/100 g.

For light chestnut soils in the third zone, the response to the grazing technologies was the following: weak grazing — 0.1 mg/100 g and intensive grazing — 0.41 mg/100 g, respectively. By the significance level of the *p*-value, the technology of moderate grazing in this sample did not cause a significant response to the quantitative indicator of mobile phosphorus content (F, mg/100 g).

Thus, it was found that the content of mobile phosphorus increased with increasing the intensity of grazing in all types of soil, except for the moderate grazing technology in the third zone of light chestnut soils.

In turn, the deterioration of the physicochemical properties resulted in the increased content of metabolic sodium in the soil, which was an indicator of salinity and increased soil salinization (Nasiev, 2016). In chestnut soils of pastures of the second zone, the content of exchangeable sodium, depending on the grazing technology, increased from 0.08 to 0.32 cmol (equiv.)/kg, compared to the reference. In the soils of the pastures, the content of exchangeable sodium ranged from 4.98 to 5.92 % of the amount of exchange bases, which corresponded to the degree of weak alkalinity. In light chestnut soils in the third zone, with the sum of exchange bases of 15.10 – 15.65 cmol (equiv.)/kg, the content of exchangeable sodium was 1.41 – 1.65 cmol (equiv.)/kg, or 9.33 – 10.54 % of the cationic exchange. By the content of exchangeable sodium, the soil in the pastures with weak and moderate grazing was weakly alkaline, and the soil with intensive grazing was medium alkaline.

In dark chestnut soils, the content of exchangeable sodium, depending on the grazing technology, amounted to 0.36 – 0.61 cmol (equiv.)/kg, or 1.71 – 2.77 % of the total amount of exchangeable bases. By the content of exchangeable sodium, dark chestnut soils in the first pasture zone were non-alkaline (Table 2).

The U-test showed the effect of the grazing technology on the response of the effective index of exchangeable sodium content. In the column with the *p*-value in the table, the significance of the effective index response to the technology by the soil zones takes the *p*-value < 0.05. Therefore, all technologies in the first, the second, and the third zones had a significant effect on the content of exchangeable sodium. The technology in this sample caused a significant response to the quantitative indicator of exchangeable sodium content.

The quantitative expression of this effect was determined by the difference between the median for the corresponding technology and the technology without grazing.

In terms of the grazing technology on the dark-chestnut soils in the first zone, the difference between the median value of the exchange of sodium in the case of the technology of weak grazing and without grazing was 0.09 cmol (equiv.)/kg, in the case of the technology of moderate grazing and without grazing — 0.29 cmol (equiv.)/kg, and in the case of the technology of intensive grazing and without grazing — 0.33 cmol (equiv.)/kg.

For chestnut soils in the second zone, the difference between the median value for the technology without grazing and weak grazing was 0.09 cmol (equiv.)/kg, for the technology without grazing and that of moderate grazing — 0.29 cmol (equiv.)/kg, and for the technology without grazing and that of intensive grazing — 0.33 cmol (equiv.)/kg.

For light chestnut soils in the third zone, the responses to the grazing technologies were the following: weak grazing — 0.10 cmol (equiv.)/kg, moderate grazing — 0.19 cmol (equiv.)/kg, and intensive grazing — 0.34 cmol (equiv.)/kg.

The tests confirmed the presence of a statistical regularity of increasing the content of exchangeable sodium in all types of soil with increasing the intensity of grazing.

Agrophysical indicators. Soil density and structural coefficient are the most important indicators of its fertility. They do not provide the required nutrients to plants, but they can influence their growth and development. Therefore, the knowledge of the soil physical characteristics and the ability to adjust them are required for extended reproduction of soil fertility (Nasiyev, 2014; Blanco *et al.*, 2016; Tesla, 2016).

Assessment of the density and the structural coefficient of chestnut soils in Western Kazakhstan by the main indicators, depending on the grazing technology, showed their sensitivity to trampling. The agrophysical properties of chestnut soils depended on their types and grazing technology. However, with the reduction of loads by the use of weak and moderate grazing technologies, the physical properties of the pastures varied considerably compared to the virgin areas, which could be explained mainly by grass restoration processes in pastures and, therefore, by solid soil phase properties and soil structure stability. Therefore, in the case of weak and moderate grazing, the deterioration of the physicochemical properties of the pasture ecosystems occurred less rapidly than in the case of intensive grazing (Angassa, 2014; Tesla, 2016).

The analysis of the dynamics of the structural-and-aggregate composition of dark chestnut, chestnut, and light chestnut soils showed certain deterioration in the soil structure under the influence of prolonged pasture use and the pronounced tendency to the restoration that had been observed during the observation period.

Despite the certain deterioration of the structure under the influence of grazing, the soil in the pasture areas with weak and moderate grazing conditions showed good content of agronomically valuable aggregates and structure due to the restoration of vegetation. For instance, on dark chestnut soils with moderate and weak grazing, the soil structure was 63.83 – 71.20 %, with a structural coefficient of 1.80 – 2.48.

On chestnut soils in the case of weak grazing, the soil structure was 65.57 % with the structural coefficient of 2.73, while in the case of moderate grazing, the structure was 65.57 % with the structural coefficient of 1.92.

In the case of moderate grazing, the soil structure of the pastures with light chestnut soils (67.50 %), compared to the structural properties of the soil of the reference plot (75.03 %), reduced by 7.53 %. The structural coefficient of the soil in this pasture plot was 2.10.

In the case of moderate grazing, the structural coefficient of the pastures on light chestnut soils was 1.88, while the soil structure was 64.41 %, which was 10.62 % less than in the reference. In all the soil and climatic zones on the pastures with weak and moderate grazing, the state of the soil structure was "good".

Intensive grazing can change the soil structure (Řeháček *et al.*, 2017). In all the types of chestnut soils with strong grazing, the soil structure reduced to 53.06 – 60.57 % with the structural coefficient of 1.22 – 1.50; the soil structure and the structural coefficient corresponded to "satisfactory" (Table 3).

The U-test showed the effect of the grazing technology on the response of the effective index of agronomically valuable structural aggregates. In the column with the p-value in Table 3, the meaning of the response of the content of agronomically valuable structural aggregates to soil-zone technologies takes a p-value < 0.05. The exception is the technology of weak grazing for the second zone. Based on this indicator, it may be concluded that all the technologies in the first, the second, and the third zones have a significant effect on the content of the agronomically valuable structural aggregates. The quantitative expression of this effect is determined by the difference between the corresponding technology median and non-grazing technology.

On dark chestnut soils of the first zone, the difference between the median values of structural aggregates in the case of the technology of weak grazing, compared to that without grazing, was 5.6 %, compared to that of moderate grazing — 12.95 %, and compared to that of intensive grazing — 16.89 %.

For chestnut soils in the second zone, the difference between the median values for the technology without grazing and that of moderate grazing was 10.46 %, for the technology without grazing and that of intensive grazing — 21.2 %. The technology of weak grazing in this sample did not cause a significant response in the quantitative indicator of the content of the agronomically valuable structural aggregates.

For light chestnut soils in the third zone, the response to the grazing technologies was the following: weak grazing — 7.53 %, medium grazing — 10.13 %, and intensive grazing — 21.97 %.

Based on the obtained results, it may be concluded that there is a statistical regularity of decreasing the content of agronomically valuable structural aggregates with increasing the grazing intensity for all types of soil, except for the technology of weak grazing in the second zone of chestnut soils.

Another fundamental property of the soil is its density. In contrast to the soil structure, which is a well-known regulator of the physical conditions in it, and has only an indirect effect on plants, the density of the soil directly influences the processes of their life activity (Khadka *et al.*, 2019).

Without knowing the soil density, it is impossible to perform quantitative soil assessment. Therefore, the data about the density of the soil layers and horizons necessarily accompany a full description of the soil profile (Wojciechowski *et al.*, 2020).

Overgrazing may lead to soil degradation and loss of the fertile topsoil, especially in the case of little rainfall and significant evaporation (Khadka *et al.*, 2019). It was confirmed by the results of the research studies. In the third semi-arid zone with an arid climate, the soil in the pastures with intensive grazing in terms of the density degraded to the third degree, the soil density in the 0 – 30 cm soil layer was 1.38 g/cm^3, or the level of light chestnut soils density under the influence of grazing was 13.11 %. Such high soil compaction creates anaerobic-like conditions in the root layer and changes the structure of the soil horizons (Tesla, 2016; Lobanov *et al.*, 2020).

The destructive effect of intensive grazing on physical properties, especially on soil density, was reported by many researchers (Nasiyev, 2014; Angassa, 2014; Blanco *et al.*, 2016).

On light chestnut soils in the third zone, the soil density in the reference plot in the 0 – 30 cm horizon was 1.22 g/cm^3. When grazing was organized following the technology of weak grazing, the density changes in the 0 – 30 cm soil layer were insignificant (1.24 g/cm^3 or soil compaction by 0.02 g/cm^3). In the case of moderate grazing, slight soil compaction from 1.22 to 1.28 g/cm^3, or by 4.91 %, was also observed.

The studies also revealed compaction of chestnut and dark chestnut soils in the first and the second zones upon the increased load on the pastures. For instance, in the first dry steppe zone of dark-chestnut soils with intensive grazing, the soil was compacted, compared to the density of the reference plot, by 5.38% (from 1.30 to 1.37 g/cm^3). In the second zone of arid steppes on chestnut soils, in the case of intensive grazing, the soil density increased from 1.23 g/cm^3 (reference) to 1.30 g/cm^3, or by 5.69 %. The soil of these zones in the case of intensive grazing degraded to the first degree.

The variation of physical conditions is one of the factors for preserving and maintaining the biodiversity, which is important ecological component of any ecosystem, including the soil one. Assessment of the parameters of linear regression allowed concluding that light chestnut soils had the greatest tendency toward compaction under the influence of grazing. The growth rate in the case of changing the technology was 0.052 g/cm^3. The degree of degradation was the third one. In this regard, the study was very relevant (Figure 2).

4. CONCLUSIONS:

1. The deterioration of physicochemical indicators, soil degradation, and salinization processes are the most common and significant complications in the management of pasture ecosystems in Western Kazakhstan, requiring for the right decisions due to their environmental impact, as well as reduction of the production rate of safe livestock products.
2. Physicochemical indicators affect the soil quality, which leads to deterioration of the ecological situation in agrocenoses and the

productivity and state of vegetation of pasture ecosystems.

3. Technology of moderate cattle grazing is necessary to solve the problems of qualitative and efficient use of pastures.

4. The main principle of moderate grazing technology implies the use of 65-75% of plants in the grazing season, which, resulting from the vital activity of plants, contributes to the improvement of the physicochemical parameters of soils. This hypothesis is confirmed by the data of standard assessment methods and statistical analysis of physicochemical parameters of chestnut soil types of pasture ecosystems in the territories of three zones of Western Kazakhstan.

5. The idea and research data serve as a prerequisite for the development of conservation measures for the efficient use of pasture ecosystems outside Kazakhstan, in countries and regions with similar pasture management systems.

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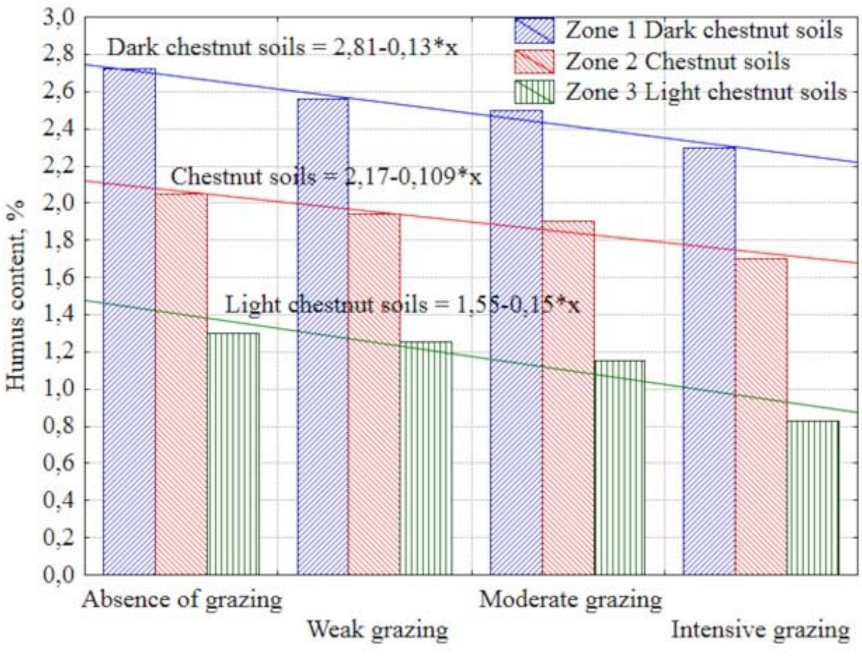

Figure 1. The humus content in chestnut soils in the pastures of Western Kazakhstan, depending on the grazing technology

Table 1. *The content of mobile phosphorus in chestnut soils of the pastures in Western Kazakhstan, depending on the grazing technology, in the 0 – 30 cm soil layer, mg/100 g*

Grazing technology	**Zone 1** **Dark chestnut soils**	**Zone 2** **Chestnut soils**	**Zone 3** **Light chestnut soils**
No grazing	2.00 ± 0.047	1.54 ± 0.023	1.05 ± 0.008
Weak grazing	1.77 ± 0.016	1.11 ± 0.015	0.95 ± 0.009
Moderate grazing	1.60 ± 0.018	0.94 ± 0.009	0.87 ± 0.093
Intensive grazing	1.41 ± 0.030	0.85 ± 0.007	0.64 ± 0.004

Table 2. *Exchange sodium content in the 0 – 30 cm soil layer of chestnut soils in the pastures of Western Kazakhstan, depending on the grazing technology, cmol (equiv.)/kg*

Grazing technology	Zone 1 Dark chestnut soils	Zone 2 Chestnut soils	Zone 3 Light chestnut soils
No grazing	0.29 ± 0.011	0.92 ± 0,014	1.30 ± 0.010
Weak grazing	0.36 ± 0.005	1.00 ± 0,015	1.41 ± 0.004
Moderate grazing	0.57 ± 0.007	1.20 ± 0.013	1.50 ± 0.015
Intensive grazing	0.61 ± 0.015	1.24 ± 0.012	1.65 ± 0.015

Table 3. *The content of agronomically valuable structural aggregates and the structural coefficient of chestnut soils in the pastures of Western Kazakhstan, depending on the grazing technology in the 0 – 30 cm soil layer, %*

Grazing technology	Zone 1 Dark chestnut soils	Zone 2 Chestnut soils	Zone 3 Light chestnut soils
No grazing	77.10 ± 1.30	76.00 ± 1.09	75.03 ± 0.43
Weak grazing	71.20 ± 0.21	71.89 ± 1.05	67.50 ± 0.72
Moderate grazing	63.83 ± 0.24	65.57 ± 0.42	64.91 ± 1.10
Intensive grazing	60.57 ± 0.89	54.82 ± 0.50	53.06 ± 1.31

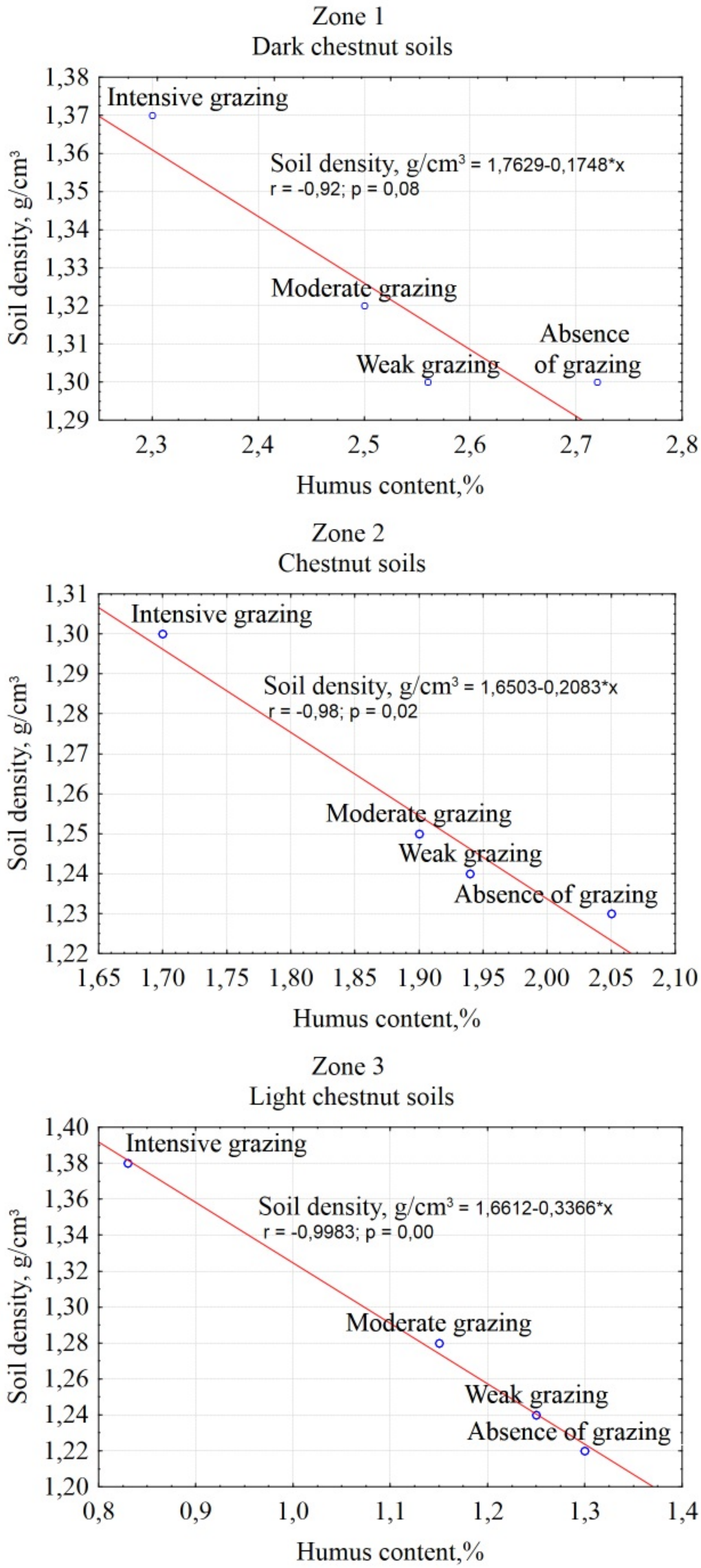

Figure 2. *The density of chestnut soil types in the pastures of Western Kazakhstan, depending on the grazing technology, in the 0 – 30 cm soil layer*