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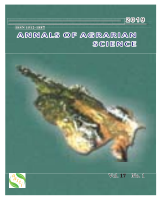

Ecological Assessment of Pastures of Eastern Georgia (Kakheti)

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A B S T R A C T

The article discusses a complex survey conducted in Kakheti pastures. Cinnamonic carbonate and raw carbonate soils are spread in the area of the inner Kakheti pastures. Studied soils with heavy metals (Cd, Cu, Pb, Zn) are not contaminated and do not exceed the maximum permissible concentration (MPC). In case of Arashenda village, the process of erosion and degradation is under the medium risk level. In Gombori and Shakhvetila villages the risk of degradation and erosion is relatively high.

Keywords: Pasture, Heavy Metals, Erosion, Degradation,Visual Research, Overgrazing

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Introduction

Pastures as a resource, has a great importance for the country, in terms of its use, so it is necessary to ensure their sustainable condition. One of the main conditions for the use of pasture is to determine the correct loading, which is defines the amount of livestock on a hectare of pasture, during the period of grazing without reducing its productivity and worsen the vegetation cover [1]. Results are correlated with environmental factors such as: (erosion, soil texture, temperature, evaporation, etc.) [2]. The research was conducted on the above mentioned issues [3].

Anthropogenic factor effects on pasture conditions a lot, pastures close to village populated areas are more eroded and degraded due to excessive grazing than distant pasturelands [4,5].

The study of the deterioration of pasture areas has been conducted in the southern part of Kazakhstan, where the worsen of soil structure is due to improper grazing [6].

Similar long-term surveys have been conducted in Armenia that, it is estimated that, on the pasture it is significantly reduced productivity and modified vegetation cover [7-9].

Several studies have been conducted in Azerbaijan, including for the protection of the grazing territories of pastures that threaten the ecological balance, which is a complex study of soil ecology (study of physical-chemical properties) [10-14].

Food production and their growth has a positive impact on pasture conditions [15]. In Georgia the situation on the pastures and related issues has been studied by many researchers. Among them reviewed the reduction of pasture productivity, their improvement and proper management [16,17].

During the years, the unsystematic, exploitation of natural food plots deterioration of the botanical composition of the vegetation cover, to worsen feed and hay quality also reduces herbage yield and their productivity, contributing to the spread of turf, diseases and erosion processes, and finally environmental pollution. In order to improve existing situation, it is necessary to have optimal loading of livestock and implementation of environmental protection measures on pastures [3].

The bioproductivity of fodder grasses of subalpine hayfields depends on the fertility of soil, the degree of erodibility and herbage thickness [18].

Nowadays, soils of pastures are not sufficiently enriched with mineral or organic fertilizers, soils are contaminated with weed grass, because of the failing of rotational grazing, it has been started the erosion process on pastures [19].

In the soils of Georgia, many studies have been carried out regarding heavy metals by various scientists [20-25].

Soil contamination by heavy metals (Cu, Zn, Pb) is one of the important problems on pastures, regarding the raised issue, the research was conducted in Georgia, in 9 km. radius from village Kazreti, Madneuli mining and processing enterprise, on the milk products of cows. It has been determined that the considerable increasing of Maximum Permissible Concentration (MPC) has been observed in soil, green grass, also in the blood of cows, on these pastures, as well as in milk products (cheese, matsoni) [26].

Erosion process is one of the reasons of degradation of soils of Georgia. Regarding erosion process many studies have been conducted in Georgia by many scientists [27-30].

For assessing the current situation, it is recommended to conduct visual assessment of the soil cover conditions (erosion), heavy metals and evaluation of pastures by visual appraisal.

Objectives and methods

Studies were conducted in Georgia, specified in Kakheti region. The research objects are located in three villages of Gurjaani and Akhmeta municipalities: Arashenda, Cheremi and Koghoto.

Village Arashenda located in the upper drain of the river "Lakbe" at 760 m. height altitude from the sea level. On Arashenda study territory, have been made 10 soil profiles.

Village Cheremi is located on the north-east slope of the Gombori Range, altitude from the sea level is 1000m. The left side of the river Chermiskhevi (Alazani right tributary). In study territory in Cheremi village have been made 10 soil profiles.

Village Koghoto is located on Alazani plain on the right side of the river Alazani at 460 m. from the sea level. In the study area of village Koghoto have been made 5 soil profiles.

According to the selected methodology and research components from 7 research objects have been taken (0-20) (20-40) cm. depth, 14 soil samples. In the raised article, it has been reviewed three objects. The soil samples have been conducted laboratory analyzes regarding the following heavy metals (Cd, Cu, Pb, Zn) content.

Laboratory analyzes of soil samples of pastures have been implemented in Michail Sabashvili Institute of Soil Science, Agrochemistry and Melioration and in the laboratory of ecological agriculture and nature protection;

Analysis of soil samples were performed by the following methods: Soil texture composition was determined by the pipe method; Reaction of soil solution (pH) – in the potential meteoric method in water sampling; hygroscopic water-drying method at 105ºC; Exchangeable bases –trilon B via titre [31]. Mobile N and P content (ISO/TS 14256-1:2003) determination of exchange calcium atomic-absorption spectrometer [32].

Study of common forms of (Cd; Cu; Pb; Zn) according to the Austrian standard (ISO 11466:1995), atomic-absorption methodology (Perkin Elmer 2100) and graphite tube (Perkin Elmer Aanalyst 700) by spectrometer [33].

Soil mapping was created using geoinformation systems (GIS).

For visual assessment of pasture, during the collecting of pasture plot samples, have been used "preferential sampling" and "random sampling" designs. The plots were selected based on the "preferential sampling design" which means, that you can choose the pasture place subjectively, according to certain criteria on the position of your plot. Other sampling methods are random designs; they are usually developed on the basis of satellite images and the selection of plots is done randomly by Geographic Information Systems (GIS) [34,35].

Visual assessment of the pasture, finds out on pasture places 10X10 (In total 100) which is the sample of the demonstration. According to many criteria, there have been created the questionnaire based on the world scientific experience, in the questionnaire it is evaluating existing pasture condition via percentage, such as: erosion tracks; vegetable cover and etc. [35].

Based on information which were collected on pastures, two indicators were created, the first index called susceptibility to erosion (SEI), and the second index is pasture degradation index (PDI).

Susceptibility to erosion (SEI), is clearly shown in the colours of the traffic lights according to the approved methodology [34] during the research, as needed, we have added orange colour, for observing medium risk level signs of degradation, taking into consideration colours above, the layout is following:

Index Range	Risk to Erosion Level	Light
76-100	Low Risk	Green
51-75	Medium Risk	Yellow
26-50	Medium Strong Risk	Orange
0-25	High Risk	Red

Based on calculation indices and by easily expressing, visual appraisal of pastures, evaluating the condition of pastures accordingly.

Results and Analysis

On research territories, in the collected soil profiles have been made soil texture and chemical analyzes (Tab. 1; 2).

Table 1. *Soil Texture*

Objects, profile, N	Horizon, depth (cm)	Fractions, %						
		1-0,25	0,25-0,05	0,05-0,01	0,01-0,005	0,005-0,001	<0,001	<0,01
Arashenda 2	A - 0-5	3	32	17	13	2	33	48
	AB - 5-20	6	24	17	15	6	32	53
	B - 20-40	6	21	25	4	8	36	48
	BC -40-60	8	34	7	8	13	30	51
Arashenda 7	A -0-20	4	42	19	7	12	16	35
	B -20-40	1	29	23	10	14	23	47
	BC -40-60	1	26	21	4	24	24	52
Arashenda 9	AB -0-35	6	23	9	17	18	27	62
	B -35-91	2	11	17	11	32	27	70
	BC_1-91-120	0	33	10	4	30	23	57
Cheremi 3	AB -0-28	0	15	5	17	44	19	80
	BC_1-40	0	16	12	10	24	38	72
	BC_2-40-58	3	27	23	7	18	22	47
	CD -58-80	2	40	10	13	18	17	48
Cheremi 6	AB- 0-20	1	31	12	12	15	20	56
	BC-20-70	1	23	23	5	12	36	53
Cheremi 10	AB- 0-30	10	26	23	9	8	24	41
	BC- 30-60	10	40	6	1	21	22	44
Koghoto 2	A- 0-20	1	16	30	9	15	29	53
	BC- 20-40	0	31	10	13	18	28	59
Koghoto 4	A- 0-20	0	30	12	18	22	18	58
	BC -20-40	0	29	20	18	16	17	51
Koghoto 5	A- 0-20	2	35	23	9	16	15	40
	BC- 20-40	4	38	18	8	22	10	40

Table 2. *Main characteristics*

Objects, profile, N	Horizon, depth (cm)	Hygr. H_2O,%	pH	$CaCO_3$, %	Hu-mus %	Cation exchange capacity, mg/equivalent in 100g. soil			Sum,%	
						Ca^{2+}	Mg^{2+}	Sum. $Ca^{2+}+Mg^{2+}$	Ca	Mg
Arashenda 2	A - 0-5	3.52	8.4	8.18	7.4	20.27	6.76	27.03	75	25
	AB - 5-20	4.38	8.6	10.91	6.3	17.06	5.45	22.51	76	24
	B - 20-40	4.38	8.4	9.09	5.4	24.56	7.5	32.06	77	23
	BC -40-60	4.38	8.5	11.82	2.1	23.87	5.81	29.68	80	20
Arashenda 7	A -0-20	2.67	8.2	21.36	6.8	22.64	10.47	33.11	75	25
	B -20-40	3.73	8.3	23.18	4.5	10.42	7.17	25.59	72	28
	BC -40-60	1.21	8.4	21.36	2.7	16.89	5.64	22.53	75	25
Arashenda 9	AB -0-35	2.88	8.2	15.91	8.3	20.27	6.42	26.69	76	24
	B -35-91	5.71	8.4	22.27	6.8	19.12	5.22	24.34	78	22
	BC-91-120	4.38	8.3	22.73	4.6	17.06	6.14	23.20	73	27
Cheremi 3	AB -0-28	4.38	7.7	2.27	9.4	30.7	6.82	37.52	82	18
	BC_1-40	3.52	8.0	6.82	8.2	27.97	8.19	36.16	77	23
	BC_2-40-58	2.46	8.3	13.18	7.1	23.08	6.36	29.44	78	22
	CD -58-80	2.04	8.4	19.09	6.1	24.09	6.02	30.11	80	20
Cheremi 6	AB- 0-20	3.31	7.9	9.09	9.6	20.95	7.77	28.72	73	27
	BC-20-70	3.31	8.3	22.73	7.1	19.93	7.1	27.03	74	26
Cheremi 10	AB- 0-30	2.04	7.0	0.91	8.1	25.09	5.02	30.11	83	17
	BC- 30-60	2.25	8.3	4.09	6.1	19.4	5.69	25.09	77	23
Koghoto 2	A- 0-20	2.04	8.5	30.45	8.7	16.05	5.03	21.08	76	24
	BC- 20-40	0.81	8.4	29.54	7.4	14.76	4.92	19.68	75	25
Koghoto 4	A- 0-20	5.71	8.4	35.45	7.2	16.34	5.56	21.09	75	25
	BC -20-40	5.42	8.4	36.36	6.5	17.22	6.2	23.42	73	27
Koghoto 5	A- 0-20	12.1	8.3	36.36	8.2	16.39	5.36	21.75	75	25
	BC- 20-40	2.50	8.4	42.27	6.4	14.46	5.17	19.63	74	26

In Arashenda village study territory, for the illustration have been chosen three soil profiles, which belongs to cinnamonic carbonate (prof.2) and raw carbonate (prof.7; 9) soils.

The cinnamonic carbonate soil is characterized by the profile A-AB-B-BC (prof.2). The profile 2 is heavy loam, where the fraction 1-0.25 content is 3-8%, content of fine particles is 30-36%, content of physical clay fraction is between 48-53 % (Tab.1). Higroscopical water fluctuates 3,52-4,38%. The profile is characterised alkaline reactions 8,4-8,6, Ca content is 8,18-11,82%. The humus content in upper horizons is high and reaches 7,4%, but in the depth in lower horizon 2,1%. The soil is saturated exchangeable basis. The sum of exchangeable basis consists 22,51-32,06 mg/equivalent in 100g. Ca predominates 75-80% (Tab. 2)

Raw carbonate soils have the following structure: A-AB-BC (prof. 7; 9), prof. 7 heavy loam, prof.#9 is a light clay, where 1-0.05 mm fractions content 0-6%, the physical clay faction (<0.01 mm) is 35-70%, clay fraction (0,001) is 16-27% (Tab. 1). The higroscopic water varies between 1.21 and 5.71%, its highest rate is observed in the horizon -B.

The profile is characterized with alkaline reaction; pH indicator slightly varies between 8.2-8.4. Content of $CaCO_3$ varies between 15,92-23.18%. The soil is characterized with high and deep content of humus. In horizon A the humus content in consists 6.8-8,3% and in BC-horizon 2.7-4,6%. The soil is saturated with bases. The sum of the exchangeable cations is 22.53-33.11 mg. eqv. in 100g. soil. From exchangeable bases Ca is predominates 72-78% (Tab. 2).

In Cheremi village study territory, have been chosen three soil profiles, which belongs to cinnamonic carbonate (prof. 3; 10) and raw carbonate (prof. 6) soils.

Cinnamonic carbonate soil is characterized by a profile: AB-BC_1-BC_2-CD (prof. 3) and AB-BC (prof.10). Prof. 3 in upper horizons are medium loamy and in lower horizons are heavy clay texture prof. 10 medium loamy texture, where 1-0.25 mm fraction content is 0-10%, content of fine particles is

17-38%, content of physical clay fraction is between 47-80% (Tab.1) The content of higroscopical water is between 2.04-4.38%, pH-7.0-8.4 weakly alkaline and alkaline. Content of $CaCO_3$ varies between 0,91-19.09%. The humus content is high and in the upper horizons consists 8,1-9.4%, in lower horizons 6.1%. The soil is saturated with bases, from exchangeable bases Ca is predominates 77-82% (Tab. 2).

The soil profile 6 is raw carbonate, the profile is characterized: AB-BC, the profile has heavy loam texture, 20-36%, content of clay 20-36%, amount of physical clay fractions 53-56% (Tab.1). The content of higroscopical water is 3,31%, pH- 7.9-8.3 weakly alkaline. Content of $CaCO_3$ varies between 9,09-22,73%, the humus content is high and consists 7,1-9,6%. The soil is saturated with bases, the sum of the exchangeable cations varies 27,03-28,72 mg.eqv. in 100g. soil. from exchangeable bases Ca is more than 73% (Tab. 2).

In Koghoto Village study territory, have been chosen three soil profiles, which belongs to raw carbonate soils. Profiles 2; 4 and 5 characterized with profiles: A-BC.

Profiles 2 and 4, has heavy loam texture, profile 5 has a light loam texture, fine particles' content in three profiles varies between 10-29%, physical clay particles 40-59%. In total, in three soil profiles, the content of higroscopical water varies between 0,81-5.71%. pH-8.3-8.5 is alkaline. Content of $CaCO_3$ varies between29,45-42.27%. The humus content is high and in the upper horizons consists 7,2-8,2%, in lower horizons 6.4-7,4%. The soil is saturated with bases, from exchangeable bases Ca is predominates (73-76%).

These research objects are not contaminated by heavy metals and its contents, as well as the ratio, are absolutely acceptable for each sample in comparison to the limit of permissible concentrations (MPC).

At the same time, in soil samples noted minor changes in heavy metals content. The result of the survey is reflected in Table 3. The data received is comparable with the (MPC) indexes developed by E. Bakradze, Vodianiski, Urushadze and other authors [36].

On natural pasturelands there is no contamination by Pb and Cd in comparison to maximum permissible concentration (MPC) the result is below the critical edge.

In the research samples, the difference of Cu content in the soil layers is approximately 3-5 to 8-10 mg/kg.

Based on literature sources, it is possible to say, that existing difference is natural and therefore, it is defined by the "acceptable" criterion.

In case of Cu and Zn the difference between the depth of upper and lower layers (0-20), (20-40) is insignificant, that means that the content of heavy metals is almost equally distributed.

Supposedly, there is no source of pollution by heavy metals in this area. The concentration obtained is mainly derived from the deep layer of the soil, which can be conditioned by the biogenic factors and vegetation cover.

On the research territory of pastures, there is mentioned 9-10 mg. difference of the content of Zn and Cu, which can be due, to the abundance of natural substances, that come from the rock.

The survey was carried out to verify the condition of natural pastures in order to determine, whether the place is contaminated by heavy metals concentration on intensive grazing pasture territory.

Studied soils are not contaminated with heavy metals (Cd, Cu, Pb, Zn), their content in samples does not exceed so-called maximum permissible concentrations (MPC), accordingly, to this, it is impossible to move it into the food chain and polluted the product.

Based on visual research, in village Arashenda from 55 studied samples, it is visible, that erosion and degradation level of the risk is predominates, this is expressed by "yellow" colour this means medium risk of erosion. Plots of grazing territory of Arashenda village, which is located 700 m. above the sea level, they are more prone to erosion (Fig. 1)

Table 3. *The content of heavy metals (mg/kg).*

Objects	Soil depth, cm	Cu	Zn	Cd	Pb
Arashenda	0-20	39.48	58.94	<1	<5
	20-40	33.33	48.17	<1	<5
Koghoto	0-20	29.52	37.86	<1	<5
	20-40	57.09	53.07	<1	<5
Cheremi	0-20	56.45	53.61	<1	<5
	20-40	58.17	55.16	<1	<5

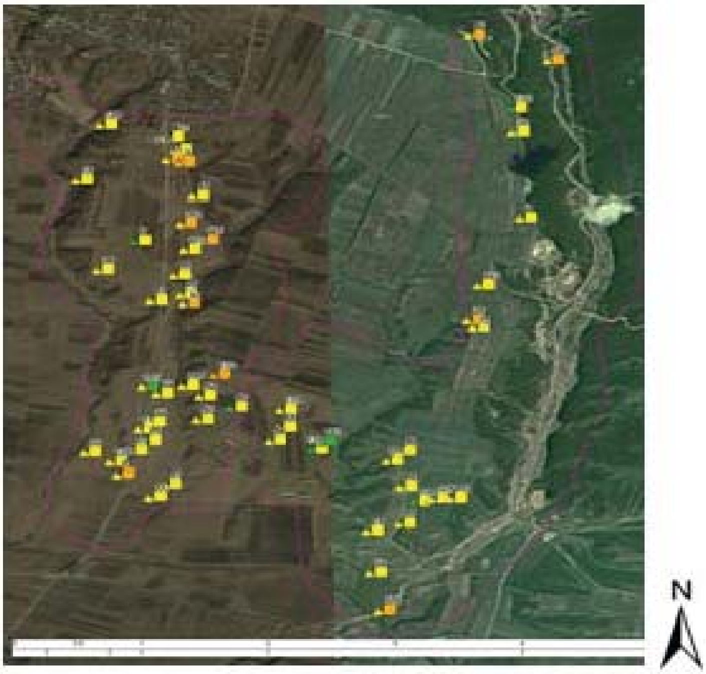


Fig.1 Village Arashenda, four colour map of pastures

Susceptibility to Erosion (SEI)
- Low
- Medium
- Medium strong
- High

Pasture Degradation Index (PDI)
- Low
- Medium
- Medium strong
- High

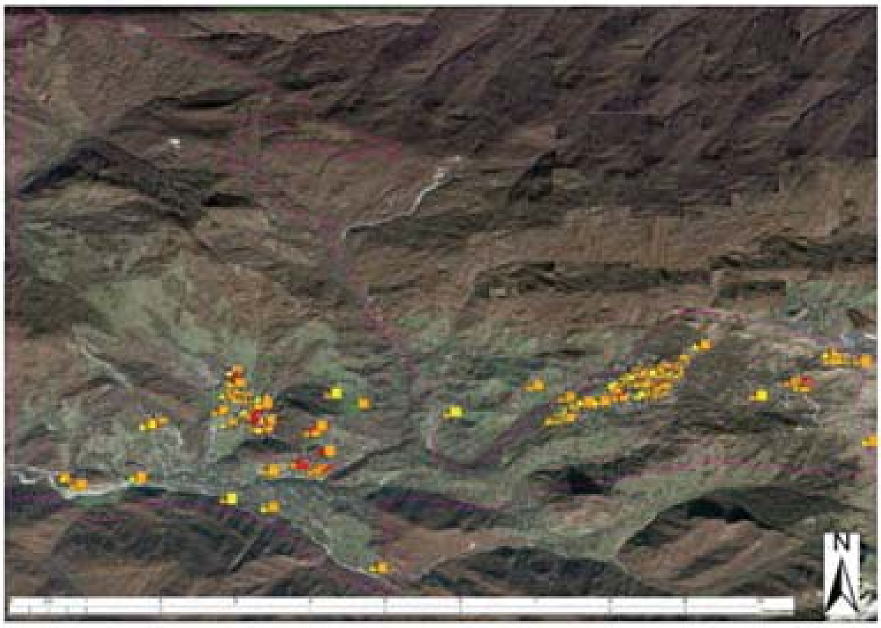


Fig.2 Village Gombori, four colour map of pasture

Susceptibility to Erosion (SEI)
- Low
- Medium
- Medium strong
- High

Pasture Degradation Index (PDI)
- Low
- Medium
- Medium strong
- High

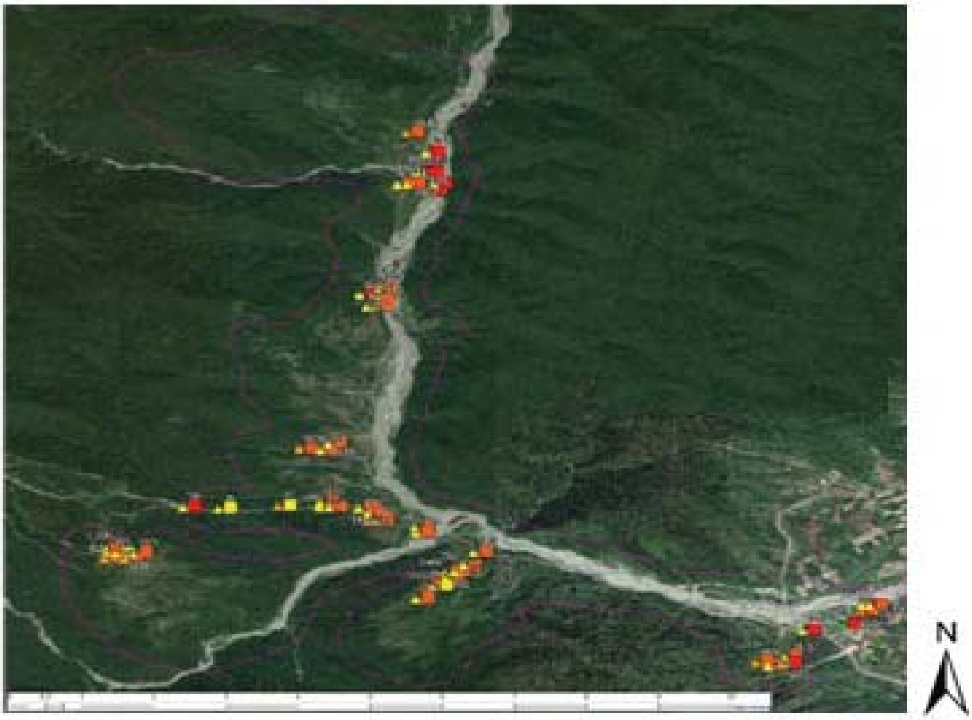
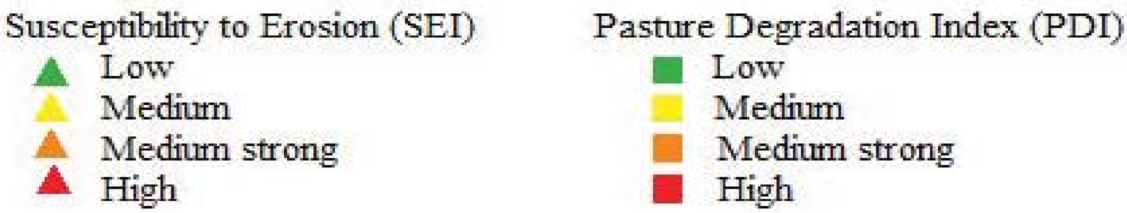


Fig.3 Village Shakhvetila four colour map of pasture



Conclusion

The originality, of this research is that in the framework of the same research, several components have been studied at the same time, as follows: soil cover condition, erosion, contamination by heavy metals and visual assessment of pasture.

In the inner part of Kakheti region, there are distributed raw carbonate and cinnamonic carbonate soils on pastures.

According to soil texture cinnamonic carbonate soils have a heavy clay content. The reaction is alkaline and weakly alkaline, carbonated, high humus content, soils are saturated with bases; From exchangeable bases Ca is predominant.

According to soil texture, raw carbonate soils are mostly heavy and light clays. The reaction is alkaline, carbonated, the humus content is relatively high, deeply humifed, soils are saturated with bases, from exchangeable bases Ca is predominant.

Studied soils are not contaminated by heavy metals (Cd, Cu, Pb, Zn), by the existing concentration on the pastures with heavy metals, it is impossible to contaminate the food product.

In the object of Arashenda dominates, medium level of erosion and degradation processes, thus, increasing the quantity of livestock and pasture using proficiently is very fruitful.

On objects of Gombori and Shakhvetila village pastures erosion and degradation level is relatively high.

For better coordination of Gombori village pastures, it is necessary to determine the quantity of cattle, which are grazed in defined pasture territory, because of protecting rotational grazing rule, according to avoid overgrazing.

In case of Shakhvetila village pastures, the risk of high degradation maybe caused by climate conditions, strict and snowy winter and a frequent rain, which leads to unreachable ways to pastures, in addition, it is mentionable, that the process of reforestation in Shakhvetila and Gombori is a precondition for losing pastures.

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