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The Chemical Erosion in River Basins of Georgia

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A B S T R A C T

Soil erosion events in the river basins of Georgia are quite intense in both the middle and upper reaches of the western and eastern Georgian rivers, with soil leaching 10-33 t/ha per year. Especially with high denudation, 0.8-1.0 mm annually are characterized by watersheds of western Georgia: Kodori, Enguri, Mananga, Techuri, Rioni, Kvirila, Adjaristskali and Satsikhuri watersheds. From the rivers of western Georgia - the river.i Kodori (Vil. Latha - 6.60 t/ha), Enguri (Vil. Dizi - 6.30 t/ha), Rioni (Vil. Khidikari - 6.10 t/ha, Vil. Namokhani - 6.50 t/ha). From the rivers of western Georgia - the river Kvirila (Zestafoni - 6.90 t/ha) and Adjaristskali (Khulo - 6.50 t/ha), solid runoff module exceeds the permissible amount of erosion. The watersheds of the Southern Georgian Rivers basin are characterized by minimal denudation that varies from 0.01 to 0.08 mm per year. This denudation of the watersheds of the rivers of southern Georgia can be termed "geological erosion". Ionic runoff accounts for 15-88% of total runoff. Ionian runoff in sediments in southern Georgia exceeds sedimentary runoff, which is not observed in river basins of other regions of Georgia.

Key words: Soil erosion, Watersheds, Sedimentary runoff, Suspended sediments, Chemical runoff, Arable soils.

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Introduction

There is no data on assessing the intensity of manifestations of soil erosion processes in various natural conditions in Georgia, which would at least partially cover a significant part of the country's territory. There are only fragmented experimental data that describe the identification and intensity of the development of erosion phenomena. The above materials that have accumulated in soil-erosion data describe the identification of erosion processes on agricultural land in both Western and Eastern foothill-hilly [1,2] and mountain-forest zones [1-7]. Data There were, of course, on the amount of chemical elements dissolved in water, but no quantitative analysis of soil erosive events has been carried out so far and therefore no regularity has been established for the conditions in Georgia.

Objects and research methods

Based on hydrological data, the intensity and spatial variability of erosion processes in the main catchment areas of the Georgian rivers were analyzed. To solve this problem, we used the mean long-term data of runoff and turbidity of river waters. The amount of runoff and suspended sediment was determined with actual data on observations of the turbidity of river waters

[8.9], and for rivers and tributaries that have not been studied in this respect, according to the dependences are given in [10]. According to the above dependencies and according to the data on the mean annual discharge of water, it is possible to determine the average annual discharge of suspended sediment in rivers, in kg/s.

The average annual runoff of suspended soil particles that enters river water from one hectare of arable land located in its catchment basin is calculated taking into account the fact that as a result of erosion only 15-20% of the total washed out from the slopes of the soil enters river water [11, 12].

In the foothill-hilly and low-mountain zone of Georgia it was experimentally established that only 17-20% of the total mass of washed away soil particles from the arable land located on the slopes as a result of erosion processes [5]. Therefore, for the conditions of Georgia, as a mountainous country, one should take a 20% level of getting into the river waters washed away from the sloping arable land of soil particles.

Chemical runoff data from river catchments were taken from the bulletins of the Hydrometeorological Department of Georgia [13].

The results obtained and their discussion

As the area of arable soils increases, especially in the foothill and mid-mountain zones, the area of eroded soils increases. In Western Georgia, the area of arable land is 2.5 times less than in Eastern Georgia. Nearly 34% (63.0 thousand ha) of arable land is eroded to varying degrees in Western Georgia, and 29.0% (142.7 thousand ha) in eastern Georgia. Across Georgia, the area of weakly eroded arable land is 110.5 thousand ha (16.4%), medium eroded - 74.4 thousand ha (11.0%) and highly eroded - 20.8 thousand ha (3.1%) (Table 1).

Table 1. *The area of eroded arable soils of Georgia*

Administrative division of Georgia	Total arable land		Including eroded						Sum	
			Weak		Average		Heavy			
	thous. ha	%	thous. ha	%	thous. ha	%	thous. ha	%	thous. ha	%
Regions of Western Georgia	141,9	100	24,0	16,9	15,5	10,9	6,1	4,3	45,6	32,1
Abkhazian A.R.	36,1	100	3,7	10,2	5,3	14,7	3,1	8,6	12,1	33,5
Adjara A.R.	8,8	100	2,7	30,7	2,5	28,4	0,1	1,1	5,3	60,2
Total in Western Georgia	186,8	100	30,4	16,3	23,3	12,5	9,3	5,0	63,0	33,8
Regions of Eastern Georgia	467,7	100	74,6	15,9	45,0	9,6	9,8	2,1	129,4	27,6
South Ossetian A.Region.	18,7	100	5,5	29,4	6,1	32,6	1,7	9,1	13,3	71,1
Total in Eastern Georgia	486,4	100	80,1	16,5	51,1	10,5	11,5	2,4	142,7	29,4
Total in Georgia	673,2	100	110,5	16,4	74,4	11,0	20,8	3,1	205,7	30,5

Wind erosion is developed in Eastern and Southern Georgia, where the area of arable land susceptible to wind erosion is 102.5 thousand ha, i.e. 21.1% of the total area of arable soils in Eastern Georgia. The modulus of runoff from the river catchment in Western Georgia exceeds the permissible soil erosion limit only in the basins of the Kodori River (at 4,90 t. - 6.60 t/ha), Inguri (at Dizi - 6.30 t/ha), Rioni (near the village of Khidikari - 6.10 t/ha; near the village of Namokhvani - 6.50 t/ha), Kvirila (near the town of Zestafoni - 6.90 t/ha) and Adjaristskali (near the village of Khulo - 6.50 t/ha). The drainage basins of the Chakvistskali rivers (near the village of Khala - 0.92 t/ha), Machakhelistskali (near the village of Sindieti - 0.80 t/ha), in Western Georgia are the minimum washout module; in the catchment basins of the Paravani rivers (near the village of Khertvisi - 0.21 t/ha), Kobliani (near the village of

Mlache - 0.72 t/ha), Tana (near the village of Ateni - 0.37 t/ha), Ksani (at the village of Korinta - 0.76 t/ha), Ktsia-Khrami (at the village of Yedikilisa - 0.52 t/ha, before flowing into the Kura river, at the Red Bridge - 0.30 t/ha), Beyukchay (above the village of Beshtasheni - 0.51 t/ha), Dzhudzhiani (near the village of Trialeti - 0.41 t/ha), Shavtskarstskali (near the village of Kizil-Ajlo - 0.21 t/ha) and Bolnisi (near the village of Samcevrisi - 0.70 t/ha) in Eastern Georgia. The minimum washout modulus in river basins was recorded in the catchment of the river Ktsia-Khrami, in the vicinity the village of Chatakhi is 0.11 t/ha per year. In the remaining river basins of Georgia, the erosion modulus is much lower than the permissible limit, soil erosion rate. In Western Georgia, this is explained by the high percentage of forest land cover in the river basin, which varies from 37 (the basins of the Natanebi and Tekhuri rivers) to 64 percent (the basins of the Supsa and Dzirula).

In Eastern Georgia, the drainage basins of the South Georgia rivers (allocated within the limits of Eastern Georgia) are distinguished by the minimum soil washout modulus, especially the river basins. Dzhudzhiani (0,14 t/ha), Shavtskarstskali and Potskhov (0.21 t/ha). The minimum washout modulus in river basins was recorded in the catchment of the river Ktsiya-Khrami, in the vicinity of the village of Chatakhi - 0.11 t/ha per year. In the remaining river basins of Georgia, the erosion modulus is much lower than the permissible limit, soil erosion rate. In Western Georgia, this is explained by the high percentage of forest land cover in the river basin, which varies from 37 (the basins of the Natanebi and Tekhuri rivers) to 64 percent (the basins of the Supsa and Dzirula).

In Eastern Georgia, the drainage basins of the South Georgia rivers (allocated within the limits of Eastern Georgia) are distinguished by the minimum soil washout modulus, especially within the river basins. of rivers Dzhudzhiani (0,14 t/ha), Shavtskarstskali and Potskhov (0.21 t/ha). As already noted, 17–20% of the total soil particles washed away from arable lands fall into Georgian river waters. Based on this, in the river basins of river Bzyb real flushing of soil with arable land varies from 10 to 23 tons per hectare per year, which in the river basin. Kodori is increasing to 33 t/ha per year. In the upper part of the river basin. Inguri, in Region of Upper Svaneti and in the river basin. of Managa, flushing soil from arable land is 20-31 t/ha per year. In the lower reaches of the river. Inguri, flushing soil from arable land is reduced by 2-3 times and amounts to 11 t/ha per year. Erosion processes on arable lands occur with much lower intensity in the catchment basin of the largest river in Western Georgia - the Rioni, with tributaries of the rivers Tskhenistskali, Kvirila, Dzirula, Tekhuri - where soil erosion varies from 6 to 34 t/ha per year. The maximum content of suspended particles in water of the river of Kvirila is associated with intense erosion of the yields of manganese readily soluble rock layers. In the coastal part of Adjara, as well as in Guria, erosion activity is minimal and varies rom 5 to 13 t/ha per year. In the mountains of Adjara in the lower and middle parts of the river basin of Adjaristskali, the intensity of soil erosion on arable land does not exceed 12 t/ha per year. In the upper part of the basin of the same river, the intensity of soil erosion on arable land increases 2,7 times and amounts to 30-34 t/ha per year.

In the basins of some rivers of the southern slope of the Caucasus Mountain Range, soil loss from arable lands varies from 17 to 31 t/ha per year (the Didi Liakhvi, Aragvi rivers near the village of Chinti, (Village Pasanauri), and in the basins of a number of rivers, soil runoff from arable land is only 4-9 t/ha per year (basins of the Ksani river, Tetri Aragvi). In the catchment basins of the rivers of southern Georgia (the Ktsia-Khrami, Dzhudzhiani, Shavtskarostskali, Bolnisi rivers) the minimum soil wash-off from arable land is observed, which varies from 0.55 to 3.50 t/ha per year. The above level of soil loss during erosion is 1.1 - 7.3 times less than the permissible norm.

In the catchment basins of the rivers of Kakheti - Rivers Iori and Alazani, the flushing of the soil from arable land is 10-21 t/ha per year, which is 2,5-5,0 times higher than the permissible flushing of the soil.

It should be noted that within Georgia, on the arable lands of drainage basins, with the exception of drainage basins of South Georgia, only in drainage basins of several rivers in Western Georgia – River of Machakhelistskali (4.0 t/ha), in Eastern Georgia – River of Kobliani (3.60 t/ha), river of Tana (1.85 t / ha), river of Ksani (3.80 t/ha), soil erosion is less than or equal to the recommended soil erosion during the development of erosion processes.

Table 2. *Display of erosion processes in the main river catchments of Georgia*

River-Point	Catch-ment area km^2	Discharge		Module of the wash out soil from the catchment area t/ha	Module of the Ionic Dis-charge t/ha	Total denudation of the basin		Washout of soil from the arable land of catch-ment basin t/ha
		Weighted sediment thousand t.	Ionic thousand t.			t/ha	mm/ year	
Bzib-v. Lower Betega	507	100	103	1.97	2.04	203	0.4	9.85
Bzib- Pitsunda bridge	1510	710	476	4.76	3.15	1186	0.9	23.50
Gumiﬆa-Above Sukhumi Hydroelectric Power Station	114	25	19	2.20	1.67	44	0.5	11.0
Kelasuri-v. Bagmarani	214	70	42	3.20	1.96	112	0.6	16.00
Kodori – v. Lata	1420	880	240	6.60	1.69	1120	1.0	33.00
Kodori – v. Varcha	2020	461	341	4.90	1.69	802	0.8	24.50
Enguri - v. Khaishi	2780	1200	486	4.10	1.75	1686	0.7	20.50
Enguri - v. Darcheli	3640	790	699	2.20	1.92	1489	0.5	11.00
Rioni - v. Oni	1060	250	272	2.40	2.57	522	0.6	12.00
Rioni - v. Sakochakidze	13300	5600	2846	4.50	2.14	8446	0.8	22.50
Kvirila - Zeﬆafoni	2490	1700	416	6.90	1.67	2116	1.0	34.5
Dzirula - v. Tseva	1190	200	134	1.70	1.13	334	0.3	8.5
Chkherimela- ﬆ. Kharagauli	398	76	56	1.90	1.40	132	0.4	9.50
Tskeniﬆskhali-v. Khidi	1950	510	524	2.60	2.69	1034	0.6	13.00
Tekhuri - v. Nakalaqevi	558	230	184	4.10	3.30	414	0.9	20.50
Sufsa - v. Khidmagala	1100	180	143	1.70	1.30	323	0.4	8.50
Gubazeuli - v. Khidmagala	337	88	29	2.60	0.86	117	0.4	13.00
Natanebi - v. Natanebi	469	80	56	1.70	1.20	64	0.3	8.50
Kintrishi - v. Kohi	191	20	33	1.00	1.75	53	0.3	5.00
Machakheliﬆskali-v. Sindieti	362	29	20	0.80	0.56	49	0.1	4.00
Ajariﬆskali - v. Khulo	251	15	30	6.00	1.20	45	0.8	30.00
Ajariﬆskali - v. Keda	1360	340	178	2.50	1.31	518	0.5	12.50
Paravani - v. Khertvisi	2350	50	92	0.21	0.39	142	0.07	1.05
Potskovi - v. Skhvilisi	1730	280	121	1.60	0.70	401	0.02	8.00
Kobliani - v. Mlashe	468	34	32	0.72	0.69	66	0.1	3.60
Big. Liakhvi - v. Kehvi	924	460	195	4.90	2.11	655	0.8	24.50
Small Liakhvi - v. Vanati	422	74	29	1.80	0.70	103	0.3	9.00
Tana - v. Ateni	283	11	17	0.37	0.62	28	0.1	1.85
Ksani - v. Korinta	461	120	63	0.76	1.36	183	0.2	3.80
White Aragvi - v. Mleta	107	20	36	1.90	3.33	56	0.6	9.50

White Aragvi - v. Pasanauri	335	120	103	6.30	3.07	223	1.1	31.50
Black Aragvi- near the mouth	235	100	57	4.40	2.42	157	0.8	22.00
Pshavis Aragvi-v. Magaroskari	736	260	110	3.50	1.49	370	0.6	17.50
Algeti - v. Partskhisi	359	72	43	2.00	1.21	115	0.4	10.00
Ktsiya-Khrami-v. Edikilisa	544	28	25	0.52	0.46	53	0.1	2.60
Ktsia-Khrami-v. Chatakhi	1420	15	23	0.11	0.16	38	0.01	0.55
Ktsia-Khrami-v. Red bridge	8260	250	917	0.30	1.11	1167	0.01	1.50
Beyukchay-above v.Bestasheni	184	9.4	9	0.51	47	18.4	0.01	2.55
Djujiani-v. Trialeti	126	1.8	6	0.14	0.49	7.8	0.07	0.70
Shavtskarostskali-v. Kizil-Ajlo	328	6.8	15	0.21	0.46	21.8	0.08	1.05
Bolnisi - v. Samtsevrisi	292	21	21	0.70	0.72	42	0.01	3.50
Iori - v. Lelovani	494	100	76	2.00	1.54	176	0.4	10,00
Alazani - v. Chiaura	4530	1900	575	4.10	1.27	2475	0.6	20.50

It is well known that chemical depletion plays an important role in soil formation, which is reflected in the soil profile of certain chemical elements by its movement, interference and accumulation in the lower horizon. Most of the chemicals in the soil and in the depletion zone are flows into the river in the form of lateral runoff. The study revealed that the ionic flow modulus of the river is not known. The Kodori and Enguri basin Module of the Ionic Discharge is up to 2 t / ha. Especially high ionic runoff is the river Tskhenistskali and the river Supsa (Chokhatauri) basin, where ionic runoff reaches 3 t / ha (Fig. 1).

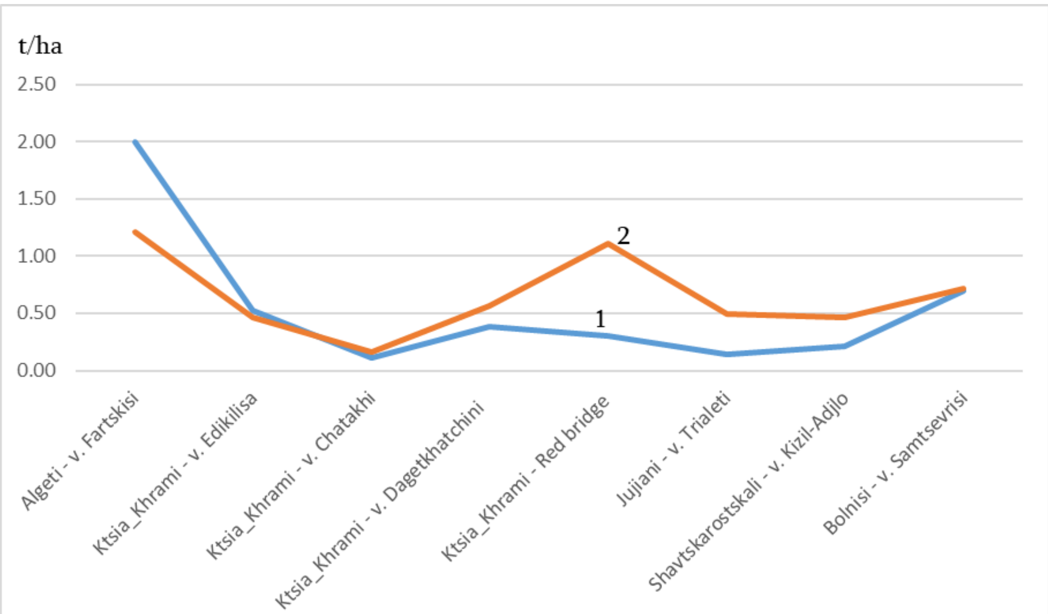

Fig. 1. *Distribution of the annual sediment runoff modulus (1) and ion runoff modulus (2) in the river basins of Western Georgia*

The situation is different in the rivers of southern Georgia. The study found that sediment runoff in all the rivers in the region. The quantity is less than 0,50 t / ha. It is noteworthy that here,

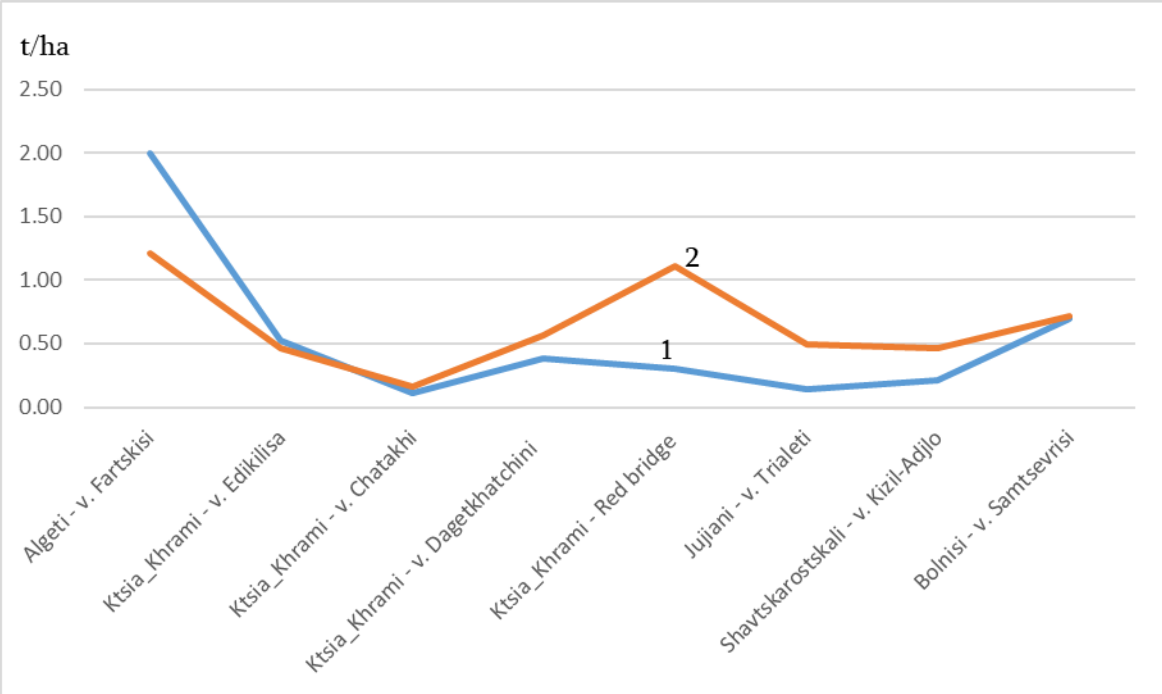

Fig. 2. *The amount of sediment runoff.*

Sedimentary and ionic runoff in both the western and eastern Georgian rivers is much higher than ionic runoff is twice as high in the southern Georgian rivers. Ionian runoff in sediments in southern Georgia exceeds sedimentary runoff, which is not observed in river basins of other regions of Georgia.

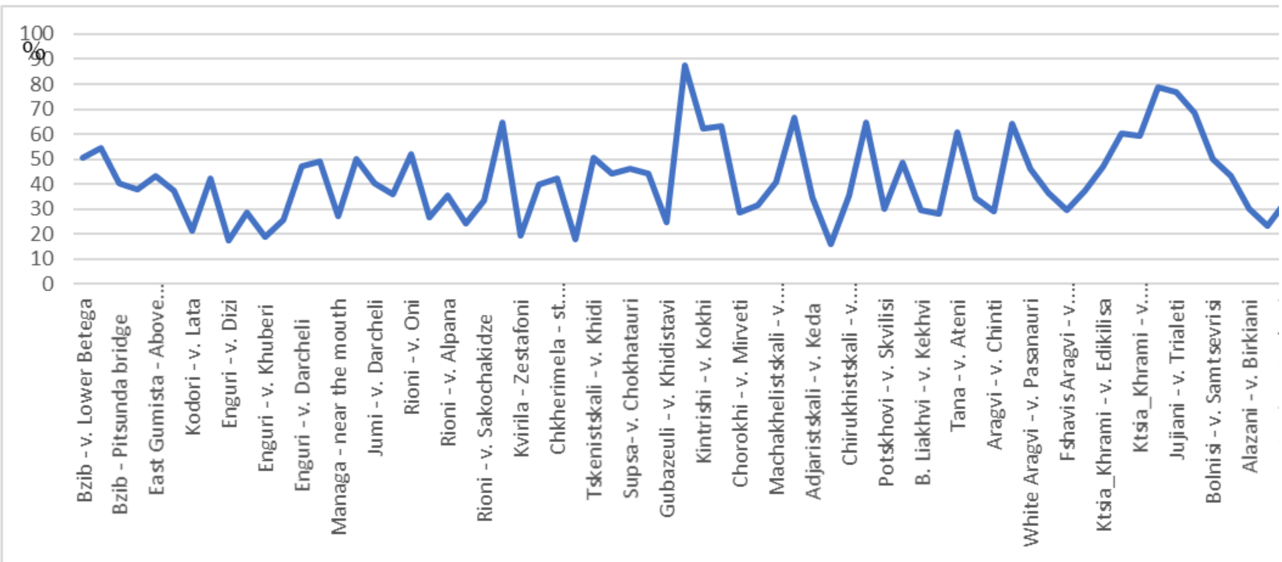

Fig. 3. *Distribution of the annual sediment runoff modulus (1) and ion runoff modulus (2) in the river basins of Eastern Georgia*

The largest ionic runoff from the river basins of Eastern Georgia is distinguished by the river of Aragvi basin, where ionic flow exceeds 3 t/ha (Fig. 3). Here the minimum ionic runoff is observed in the river of Ktsia-Khrami Basin (Vill. Chattakhi).

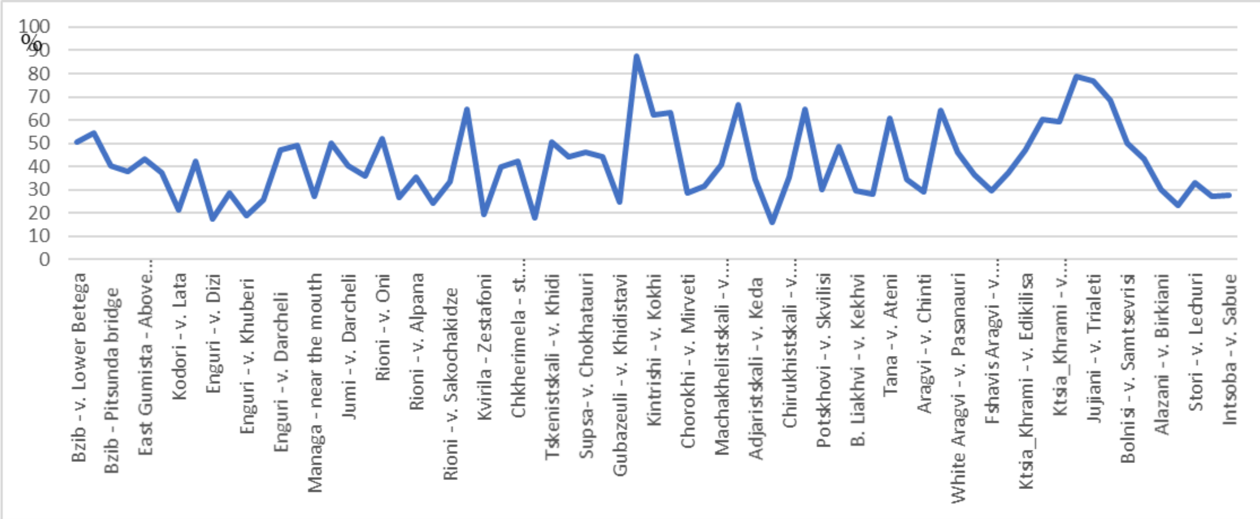

Fig. 4. % Ratio of the module of the ion drain to the modules flushing from the pool

The study found that ionic runoff from the river basins of Georgia varied from 20 to 88% (Fig. 4). It follows that only 50% of the total consolidated runoff from the river basins of Georgia is accounted for during erosion studies. The river Ionic runoff in the Kodori and Enguri basins accounts for 20-50% of the total consolidated runoff from river basin, 20-65% in Rioni river Basin. Ionic runoff in the Guria-Adjara river basins reaches a maximum value - up to 90%. In the Shida Kartli rivers and Aragvi basins the ionic fluxes change up to 30-60%. The ionic runoff ratio is particularly high in the South Georgia rivers, where it reaches up to 80%, however, the solid runoff module is not high in the % of ion runoff - $R^2 = 0.454$, but can be used for spatial distribution of ion runoff in the rivers basin, to determine the regularity (Fig. 5). If we know the number of solid runoff modules, then the logarithmic formula can be used to determine the % content of ion runoff.

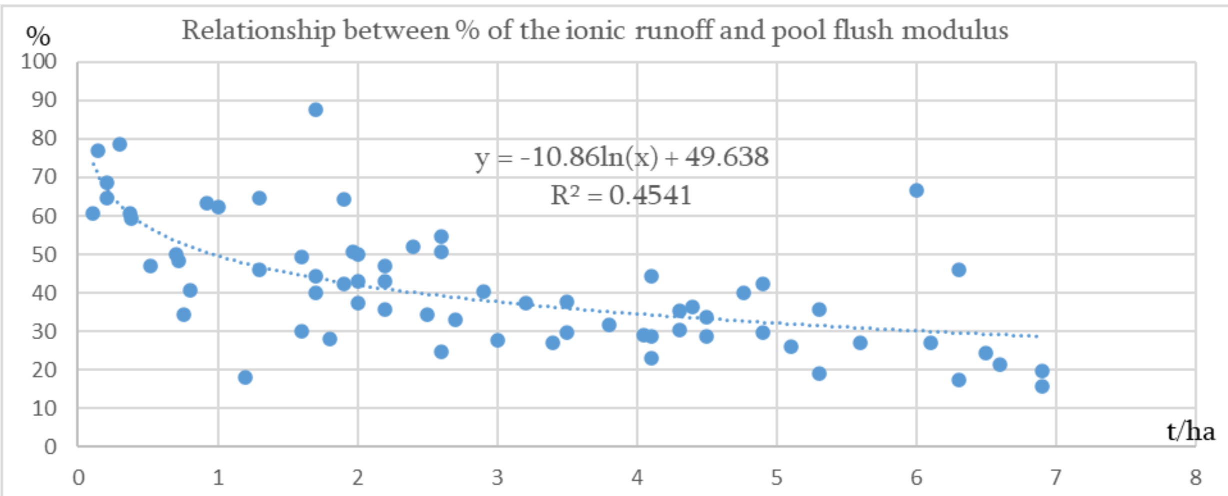

Fig. 5. *Relationship between % of the ionic runoff and pool flush modulus*

Conclusion

The area of the agricultural zone (up to 1800 m above sea level) of Georgia is 51,789.5 km^2, i.e. 74% of the total territory.

The maximum amount of cultivated land in Western Georgia is 28-40%, and in Eastern Georgia 29-33% of the total catchment area of rivers.

Eroded arable land is 205.7 thousand ha, i.e. 30.5% of the total area of arable land, including Weak - 110.5 thousand hectares (16.4%), Average - 74.4 thousand hectares (11.0%) and Heavy eroded lands - 20.8 thousand ha (3.1%).

The average annual flushing with arable land in the catchment areas of Western Georgia is an average of 17.40 t/year, i.e. exceeds the permissible rate of erosion by 4 times. In the river basins of Eastern Georgia - 10.46 t/year per year, which is 2.5 times more than the permissible norm for erosion. Much less than the permissible limit of soil erosion is washed off per year, from arable land in southern Georgia - 3.08 tons per year. It has been found that high ionic flow is observed in the river of Tskhenistskali and the river of Supsa (Chokhatauri) basin, where ionic runoff reaches 3 t/ha.

Ionian runoff in sediments in southern Georgia exceeds sedimentary runoff, which is not observed in river basins of other regions of Georgia.

Ionic runoff from river basins in Georgia varies from 20 to 88 % of the total pool flush modulus.

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