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# Silt Charge of Water in the River Sluch: Dynamics on Length and in Time

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ABSTRACT

Change silt charge of water in the rivers can negatively be reflected in throughout the rivers beds, stability of coast, change of river structures, disappearance of boggy places, etc. In work questions of variability silt charge waters in the river Sluch in time and on length of the river are considered. It is revealed that in time average and maximal silt charge waters decrease. While on length of the river change silt charge waters is shown not precisely, similar on some increase silt charge waters to a mouth of the river. The researches led by the factorial analysis and graphic-analytical method on the basis of long-term materials of measurement of charges of water have shown that, on a part of posts average depth of water in the river grows, and on others - cyclically changes with the general tendency to reduction. Average speed in them, accordingly, falls and grows. Stratification of interrelations of a silt charge with other factors on years is observed. The reasons of reduction of a silt charge are: 1) agrarian and forest meliorative actions on a catchments of the river, hydraulic engineering construction; 2) grassy bed of the river; 3) change of a climate that promotes growth of temperature of a surface of soils and grassy bed of the river. In developed natural-climatic conditions expediently application on reservoirs of the antierosion organization of territory of the land tenure including agrarian- forests- meliorative actions that will allow to adjust outflow of a moisture from reservoirs to lower warming up of a surface of the soils, to provide against a high water protection and it will favorably be reflected in manufacture of agricultural production.

## 1. Introduction

Silt charge waters (turbidity) in the rivers is a parameter erosive-accumulative processes and quality of water<sup>[1-10]</sup>. Erosive-accumulative processes represent interaction of the water spreading surfaces and channels during all

hydrographic network: from slopes interill streams up to mouths the large rivers<sup>[4-6,11-13]</sup>. All kinds erosive-accumulative processes are closely interconnected among themselves and define transportation and adjournment of sediments channels of the rivers.

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On length of the rivers and in time silt charge waters in the rivers undergoes changes which economic activities of the person and change of a climate influence<sup>[2,14,15]</sup>. The plowed land and agricultural operation of arable lands have led to an intensification of erosive activity. A conclusion from crop rotations of a part slopes the lands, introduction of antierosion methods of agriculture promoted stabilization of erosive activity on reservoirs of many rivers. Both the high silt charge, and a low silt charge can negatively be reflected in throughput beds the rivers, stability of coast, change of river structures, disappearance of boggy places, etc.<sup>[16]</sup>.

Silt charge waters in the river carry character of dropping of precipitation to major factors of formation or snowmelts, erosive-accumulative processes on a catchments of the river and feature of a water mode of the river<sup>[4,12,13]</sup>. Essential influence on sizes silt charge waters in the rivers also renders waters percent of a forest on a catchments and grassy bed the rivers water vegetation. Changes of a climate lead to dynamics of a vegetative cover that should be reflected in a silt charge of water.

On many rivers communication between charges of water and silt charge waters is traced, however this communication often happens not unequivocal, on rise and recession of water levels curve dependences silt charge waters from charges of water miss<sup>[17]</sup>. Distribution in space silt charge waters the rivers difficultly enough<sup>[18]</sup> also depends on a climatic zone and a relief's of land<sup>[19]</sup>. The top parts of many rivers now sedimentations, however are data on increase in lengths of the rivers on 10%. Probably erosive processes in the top parts, the lengths which have caused increase in the rivers, just also have defined sedimentations those top parts of the rivers. Attempts them to clear away specialized techniques will lead to repeated activation of erosive processes in top parts and to deterioration of water resources.

Silt charge waters as the parameter of its quality is widely applied not only to an estimation of its applicability for household and drinking needs and use in the industry, but also and a fish - economic specifications. Changes in silt charge waters of river water can disrupt complex energy and material relationships between different components and tiers of the ecosystem, change the growth conditions and species composition of aquatic vegetation, reduce the forage base of ichthyofauna, complicate migration and orientation of aquatic organisms in water flow, disrupt their activity or death. Multicellular algae and higher aquatic vegetation of river biocenoses are the most sensitive to changes in silt charge waters. Increased silt charge waters of water significantly reduces the penetration of light and leads to deterioration of photosynthesis of

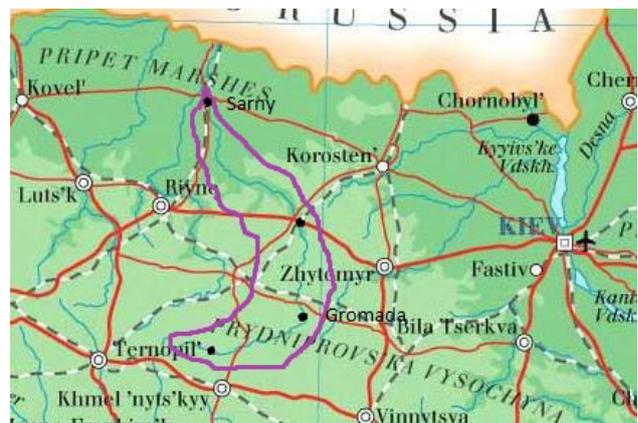
submerged macrophytes. Phytoplankton is quite sensitive to increased silt charge waters. As a result of increasing silt charge waters of river water, the species composition of phytoplankton changes<sup>[20]</sup>.

Studying of change of a silt charge waters in time and space in regions with various physical-geographical conditions allows solving some questions at operation of the rivers in maintenance of the population and the industry qualitative water resources, in navigation to prevent failures on waterways, etc.

The purpose of the present research was to track change of a silt charge of water in the river Sluch on length of the river and in time and to define the cores factors influencing its changes.

The river Sluch is the right inflow of the river Goryn, that, in turn, is inflow of the river Pripyat (the River basin Dnepr, Pool of Black sea) (Figure 1). The river Sluch proceeds partially in a forest-steppe zone and a zone of the mixed forests of Ukraine. As well as other rivers of investigated region, influence of climatic changes and anthropogenous activity tests on itself. The length of the river Sluch makes 451 km, the area of a reservoir 13800 km<sup>2</sup>, the average height of a reservoir of 230 m, percent of a forest on a catchments makes 17% of its territory. In a bed of the river it is located three significant water basins and there is a set of small ponds on its catchments.

River Sluch as well as other rivers of investigated region, influence of climatic changes and anthropogenous activity tests on itself.



**Figure 1.** Arrangement of an investigated catchments of the river Sluch and posts of supervision for silt charge waters (●) on it.

## 2. Materials and Methods

For the analysis materials of long-term supervision of hydrometeorological service of Ukraine on a number of the stationary posts located on different distances from

each other on length of the river Sluch (Table 1) were used. Materials under the measured discharges of water and silt charge waters in hydrometric posts water-measured posts on length of the river Sluch and the generalized materials for separate years, and the long-term period on the same posts are used. Characteristics of posts of supervision and a range of average and maximal silt charge waters in the river on posts for an available period of supervision it is presented in Table 1. To the analysis of materials of supervision were applied, basically, methods of the factorial analysis and graphoanalytical by a method of researches.

### 3. Results

Previous studying of the given territory has shown, that the quantity of dropping out precipitations and temperature of air in considered territory in time increase, grows in time and evaporation from a water table <sup>[2,3]</sup>. Change river waters the rivers of basins of Pripyat <sup>[2,3]</sup> has a different orientation of a course in time: on a greater part of territory river waters the rivers increases, and on smaller - decreases. The discharge of sediments decreases on all catchments of the river Pripyat <sup>[2,3]</sup>.

Materials of supervision show absence of unequivocal communication between a silt charge waters and discharges of water, this communication reminds a loop, on rise of a high water a silt charge above, on recession - below more.

Carried out researches have shown, that as average, and maximal silt charge waters for a year in the river Sluch in

time decreases (Figures 2, 3) while on length of the river change silt charge waters is shown not precisely, similar on some increase silt charge waters in closing створе the city of Sarny. In Figure 4 the course in time of the measured sizes silt charge waters in the river Sluch Sarny which shows is presented, that per 1962-1988 silt charge waters in the river was considerably above than previous and next years. These years on a reservoir of the river, involving active development of marsh files and the boggy lands was spent to agricultural activity earlier not used lands.

The long-term of measurement of charges of water on hydrometric posts hydrometeorological service have shown, that, on a part of posts average depth of water in the river grows, and on others - cyclically changes with the general tendency to reduction (Figure 5). Average speed in them, accordingly, falls and grows (Figure 6).

The increase in depth of water and reduction of speeds of a stream of water promotes deduction of water vegetation in a bed of, that in turn reduces silt charge waters. The increase in depth of water in a bed of in turn defines a raising of basis of erosion of a site of the river (upwards on a channel), that also should promote reduction of erosive processes. Cyclic change of depth of water in a bed of the river on gauge a post for a long time interval, most likely, testifies to passage of the certain stages river bed macroforms on length of a beds rivers.

In the rivers in which feed a soil feed eventually starts to prevail and where within the limits of posts levels of ground waters grow in due course average depths of water in a bed of decrease, and speeds of water grow. In the

**Table 1.** Characteristics of observation posts for silt charge waters in the river Sluch (On materials of the state water cadastre)

The characteristic of a post of supervision	River - observation point for silt charge waters			
	Sluch - Bolshaya Klitna	Sluch -Gromada	Sluch - Novograd-Volynsky	Sluch - Sarny
Distance from the source, km	30	139	252	409
Catchment area, km <sup>2</sup>	232	2480	7460	13300
The period of supervision for silt charge waters, years	1964-1967, 1977-1983	1954-2019	1977-1998	1949-2019
Character bed the rivers	Canal river, straight reach	Twisting, deformed, growing	Moderately twisting, growing	Twisting, deformed
Range of change mid-annual silt charge waters, t/m <sup>3</sup>	3,4-73	1,6-163	3,1-95	13-150
Range of change maximal for a year silt charge waters, t/m <sup>3</sup>	7,6-290	5,0-520	15-360	18-1300
Note	Closed 1983		Open 1974 r.	

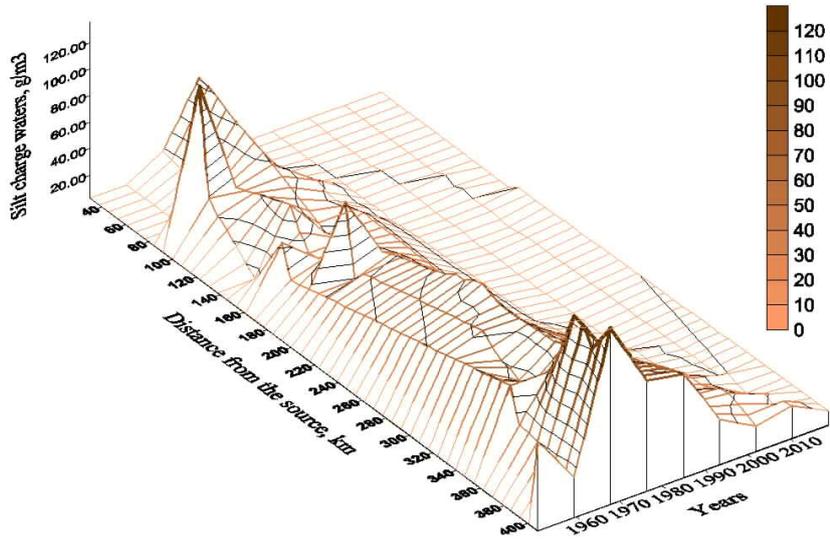


Figure 2. Change average silt charge waters for a year In time and space in the river Sluch

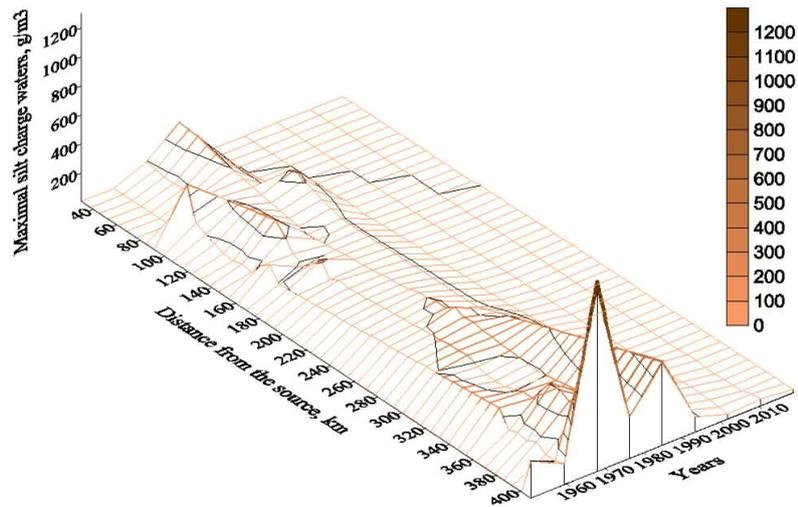


Figure 3. Change maximal silt charge waters for a year In time and space in the river Sluch.

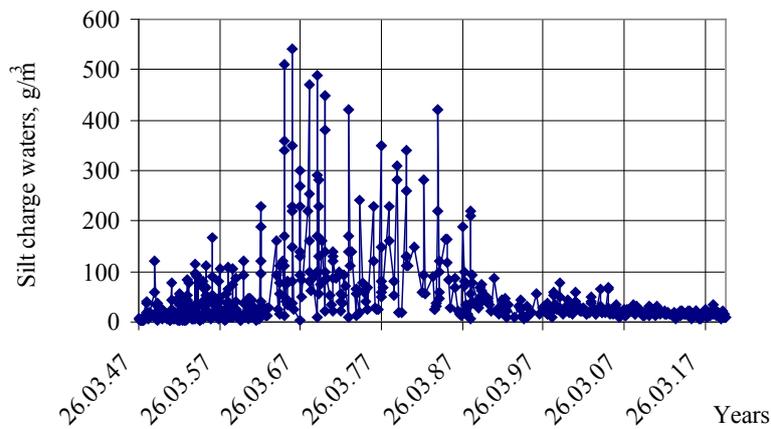


Figure 4. Change measured silt charge waters In time in the river Sluch post Sarny

same place where levels of ground waters decrease and the superficial component of a runoff starts to increase - depths of water in the rivers increase, and speeds decrease. Thus in all cases the silt charge waters decreases<sup>[2,3]</sup>. Similar for work of coastal regulation in beds of the rivers and backwater from beds reservoirs and water basins, water vegetation, etc. in conditions of change of a climate.

On length of beds of the river presence of development of water vegetation is established (Tables 1, 2), however on separate posts (Gromada) it during the separate periods is absent, on post Slych - Sarny - is not observed absolutely. It is established, that in natural conditions grassy bed, as a rule, causes essential increase in hydraulic resistance<sup>[21]</sup>. The vegetation renders braking influence on a stream of

water that can cause afflux water levels and create conditions for sedimentation of the weighed sediments. In work<sup>[22]</sup> also is spoken about periodicity of processes grassy bed, drying shoalinesses leads to time disappearance of vegetation in a bed of and to its occurrence again eventually. In a place with reduction of mean depth of water by a post the Gromada (Figure 5a) decreases also width of the river, i.e. earlier overgrowing shoalinesses appear not flooded by water, and in parts with water of a channel the water vegetation accrues gradually. On post Sarny the increase in depth and speed of water in due course is observed. Therefore the water vegetation is not formed and silt charge waters here appears a little raised on comparison with other posts.

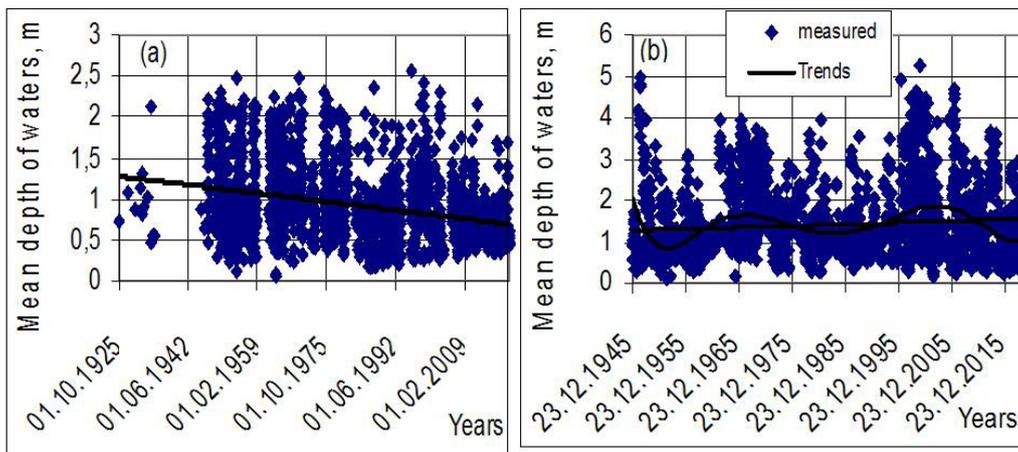


Figure 5. Change in the average depth of water in the hydrometric gauges on the rivers Sluch posts the Gromada (a) and Sarny (b) over a long period of time.

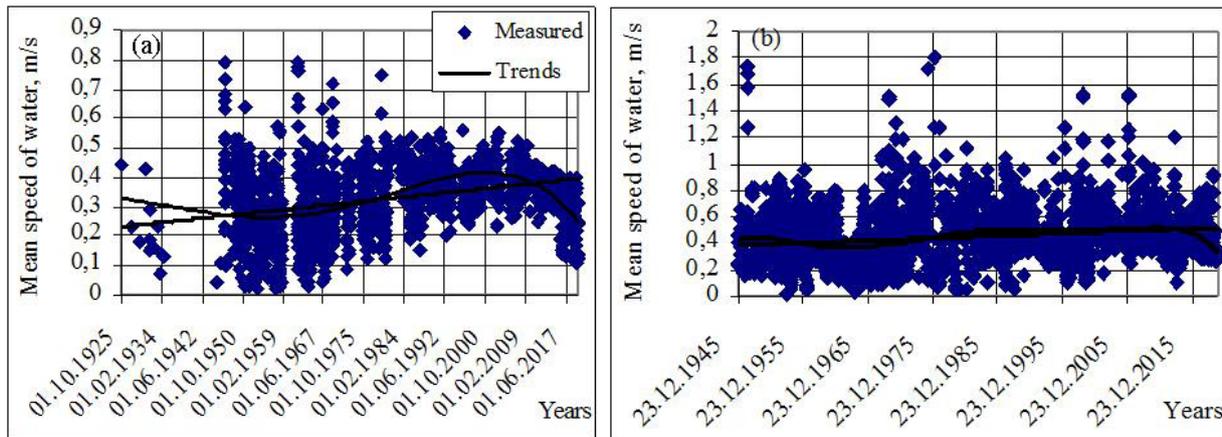


Figure 6. Change in the average speed of water movement in the hydrometric gauges of on the rivers Sluch posts the Gromada (a) and Sarny (b) over a long period of time.

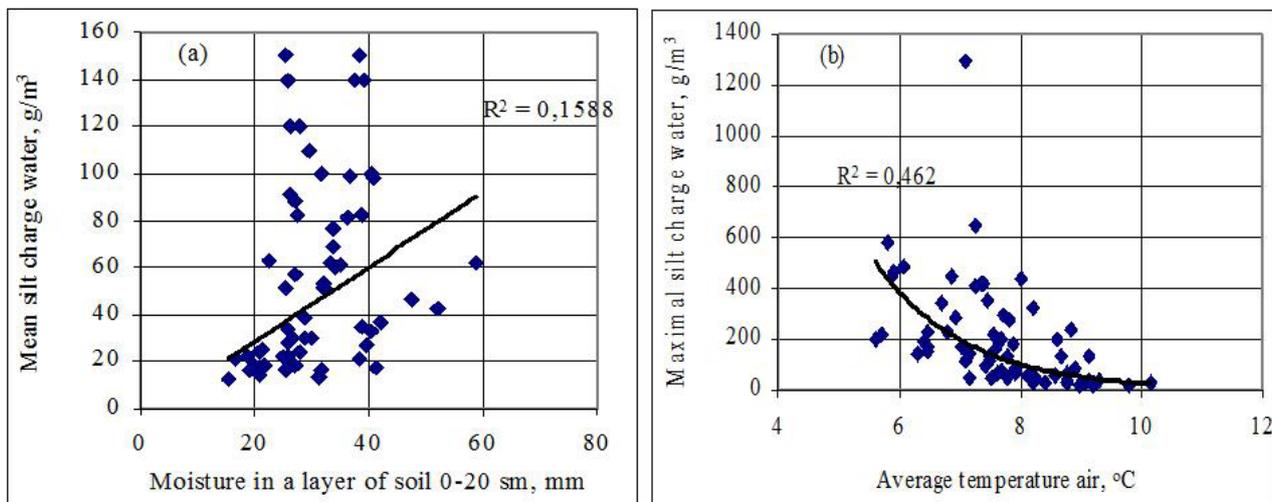
The analysis of influence on mid-annual and maximal silt charge waters has shown waters of physical -geographical factors, that these dependences are ambiguous and often break up for separate factors to groups on years with what prevalence of influence or from factors (Figures 7-9). In Figures 7-8 at number 1 the following of year - 1988, 1990-1993, 1995, 1997, 1998, 2015, 2017, 2019 are grouped; at number 3 - 1956, 1957, 1961, 1964-1968, 1971-1973, 1975, 1979, 1983, 1996; at number 2 - all other years, since 1954 (restriction because of presence of joint supervision). Grouping of years of supervision in separate blocks is defined, first of all, by temperature of air, temperature of a surface of soils and humidity of soils on layers on the average for a year. In Figure 8 precise stratification of data on years for dependence maximal silt charge waters from stocks of a productive moisture in a layer of soils of 0-20 sm is shown. In Figure 9 it is visible,

that this stratification on years shows in one cases greater dependence maximal silt charge waters from mid-annual temperature of air, in other cases - quantities of atmospheric precipitation for a year. In Figure 10 it is visible, that maximal silt charge waters in all range of measurements the interrelation with the maximal temperature of a surface of soils. The more maximal temperature of a surface of soils, the below maximal silt charge waters shows waters on a post the river Sluch - Sarny.

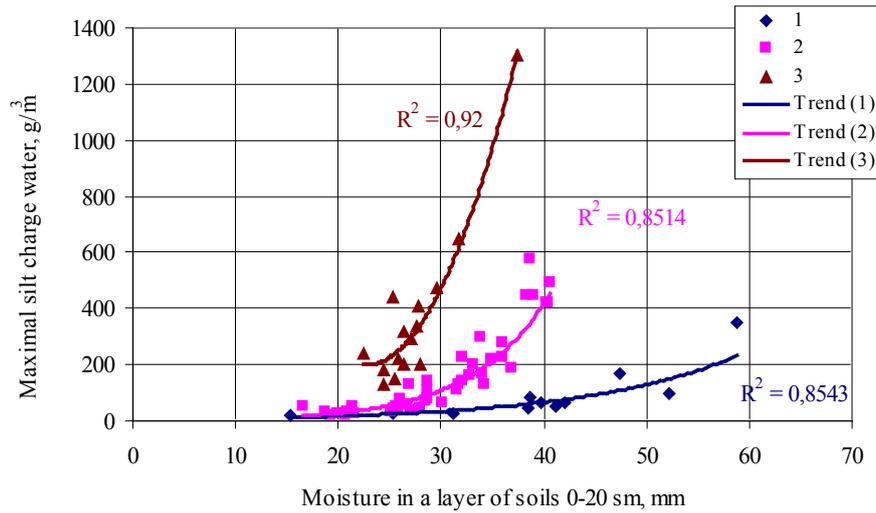
With growth of temperature of water the silt charge waters too decreases, that most likely is connected by that situations at which there is an increase of a silt charge of water in the rivers are observed or during snowmelts (the spring period with low temperatures of air and water) or during loss of precipitations (precipitation have temperature approached at zero of degrees) that promotes cooling of a surface of lands and water in a bed of rivers.

**Table 2.** Dates of the beginning and end of overgrowing of the parts on the rivers Slych (n - the beginning of overgrowing, k - the end of the development of aquatic vegetation, no - not overgrown, empty cell - no information, in the winter months - grass at the bottom)

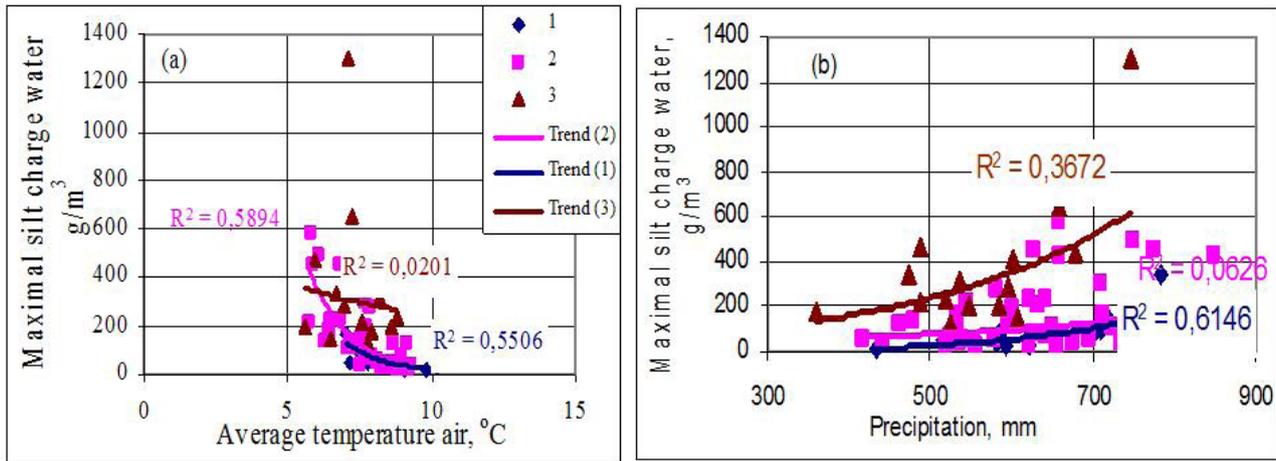
The river - post of observation	Years													
	1950		1970		1980		2000		2015		2017		2019	
	n	k	n	k	n	k	n	k	n	k	n	k	n	k
	Data													
Sluch - Bolshaya Klitna			19.05	27.09	not	not								
Sluch -Gromada	21.05	30.10	15.05	28.09	2.05	4.10	not	not	not	not	1.06	31.12	11.06	3.12
Sluch - Novograd-Volynsky					1.05	7.09	26.05	9.10	29.05	17.10	25.05	10.10	3.07	6.10
Sluch - Sarny	not	not	not	not	not	not	not	not	not	not	not	not	not	not



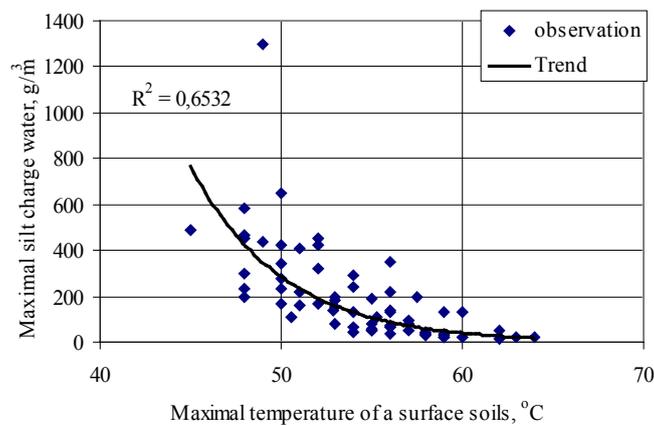
**Figure 7.** Dependence mean for a year silt charge waters in the river Sluch - post Sarny from the productive moisture in a layer of soils of 0-20 sm of a surface of soils for years (a) and maximal for a year silt charge waters from the average for years temperature air (on meteorological station Sarny)(b).



**Figure 8.** Dependence maximal for a year silt charge waters in the river Sluch - post Sarny from the productive moisture in a layer of soils of 0-20 cm of a surface of soils for years (on meteorological station Sarny)



**Figure 9.** Dependence maximal for a year silt charge waters in the river Sluch - post Sarny from the average for a years temperature air (a) and quantities of precipitations for years (b) (on meteorological station Sarny)



**Figure 10.** Dependence maximal for a year silt charge waters in the river Sluch - post Sarny from the maximal temperature of a surface of soils (on meteorological station Sarny).

## 4. Conclusions

Silt charge waters in time in the river Sluch falls. On length of the river both the maximal and average values silt charge waters in rivers changes, the tendency to its growth to a mouth of the river however is observed. Stratification of interrelations of a silt charge with other factors on years of supervision depending on temperature of air, a surface of soils, quantity of precipitations is observed.

Among the reasons of reduction silt charge waters in rivers it is possible to name: 1) agrarian and forests meliorative actions on a catchments of the river, hydraulic engineering construction; 2) grassy bed; 3) change of a climate that promotes growth of temperature of a surface of soils and grassy bed.

In the developed natural - climatic conditions radical measures on regulation of erosive-accumulative processes in the river (clearing bed) cannot be effective neither with ecological nor from the financial point of view. Here it is expedient to spend the control of sources of receipt of sediments over the rivers from catchments and to watch change river waters. Earlier<sup>[18]</sup> by us it was spoken about expediency of application on reservoirs of the antierosion organization of territory of the land tenure including agrarian wood meliorative actions that will allow to adjust outflow of a moisture from reservoirs, to lower warming up of a surface of the lands, to provide against a high water protection and to promote increase of manufacture of agricultural production.

## Conflict of Interest

There is no conflict of interest.

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