Assessment of speed of the recent floodplain alluvium accumulation in basins of minor rivers of the East of the Russian Plain

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Abstract. The indicator of intensity of erosive and accumulative processes in basins of minor rivers is forming of the recent floodplain deposits. Studying of width and age of deposits has been held since 70-80th of the XX century. Three methods are used in studying of the recent floodplain accumulation. They estimate influence of natural and anthropogenic factors on speed of floodplain deposits accumulation in basins of minor rivers in various landscape conditions. Floodplain deposits do not grow in forest landscapes with minimum anthropogenic impact. In comparison with natural conditions speed of floodplain deposits accumulation in reclaimed landscapes of forest-steppe and steppe zones increases in 1-2 times (in average until 21-22 mm per year).
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Introduction

From geomorphological prospective studying of erosive and accumulative processes in river basins is important [1]. Changes in landscape and climate conditions in many respects determine within-year variability of a river drain of minor rivers and influences intensity of erosive and accumulative processes. Unevenness of a river drain also affects the speed of accumulation of the recent alluvium on flood land [2, 3].

Land invasion by humans was expressed in expansion of land drainage and decrease in drought flow up to complete drying of many minor rivers of steppe, forest-steppe and even south forest zone. Some researches tack it with extermination of natural vegetation and ploughing lands. Consequently, filtration characteristics of soils worsened, land drainage increased and ground-water flow decreased [4-7].

Other authors think that the main reason of changing in the drain regime is natural and anthropogenically determined climate changes [8] and lithological and geomorphological conditions [9].

The authors of this paper uphold the first point of view. They have made an attempt to assess intensity of alluvium accumulation on flood land during the last hundreds of years.

Material and research methodology

Forming of floodplain soil is connected with the process of accumulation of floodplain alluvium. Stabilization of accumulation or essential slow-up of alluvium deposits are fixed in differentiated floodplain soils. Accumulation of weak material, brought by water flows to floodplains and forming of "superimposed" floodplain or floodplain deposits increase with changes of erosive and accumulative processes in basins and valleys of rivers.

Width of floodplain deposits is accepted for the indicator of accumulation of the recent floodplain alluvium. It is the horizon of alluvium, which lies on concealed well-formed upper hydromorphic soil.

Studying of floodplain sections have been held during expeditionary researches since 1974 till present in 81 river basins of the Volga-Kama region. The area of studying was 400 thousand km^2. In total 197 floodplain sections were studied.

To get quantitative data on age, speed and amounts of a material accumulated on a floodplain they used a number of methods.

The first method is based on studying of a floodplain structure and determination of width and relevant age of the recent floodplain deposit. Characteristics of youth of the recent floodplain deposit are:

1. Thin-bedded alternation of sandy, sandy-loam, clay-loam and clay sediment;
2. Occurrence on well-formed concealed alluvium soil;
3. The concealed soils, observed on denudation of floodplain terraces, often transform into the recent soils of slopes and watersheds;
4. It is often possible to observe the following: old trees have root collars on humus horizon (where they have come up), but the bottom of a trunk is covered with floodplain deposits of different width;

5. Debris of red brick, modern ware and house utensils, well-remained wood (stubs, trunks, etc.) can be found in depth of floodplain deposits, especially in river basins, where the forest vegetation was destroyed and its place was taken by arable lands.

These data quite unambiguously testify that accumulation of floodplain deposits happened during agrarian reclamation period.

The gist of the second method is that they laid alignments from land-marks on the previously surveyed site to study dynamics of floodplain sedimentation. Land-marks are metal rod stocks with a diameter of 3-5 mm, 20-30 cm long which were rammed into a soil apace with a surface or partly remained over a surface. Rod stocks were laid across and along a floodplain, and also on a grid of the particular area. Frequency of an arrangement of land-marks on alignments was defined by width of the floodplain. In total they laid 36 alignments with 989 land-marks on the studied territory. Annually they took width reading of the accumulated material according to the land-marks. The average width of this material taking into account its volume weight allows to calculate the mass of the deposits accumulated within the year [10, 11].

The third method is based on studying of absolute age and accumulation speed of floodplain deposits based on the basis of radio-carbon dating [2, 11]. The method provided age definition for the concealed soil and floodplain deposits. The concealed soil serves as the land-mark fixing stages of change in the sediments accumulation regime on flood plains of the rivers. In total 10 age-specific boundaries of concealed soils and six – of floodplain deposits were studied.

Comparison of the results received by these methods showed their good fit to each other.

Research results

In 9 of 197 studied sections floodplain deposits were not allocated. Floodplain soils here lay in well-formed floodplain alluvium, which is underlied with channel alluvium. The example is a floodplain section of a minor right feeder of the Vyatka river – Vishkil river in the northern taiga, where floodplain alluvium, characterised by the clearly seen alternation of clay-loam and sands, overlaps sandy, sandy-loam and clay-loam channel alluvium. Mature floodplain soil with humus and accumulative and illuvial horizons tops the floodplain unit. It is possible to see similar sections of a floodplain unit in other rivers with high level of forest coverage and small reclamation: Moloma river (a right feeder of Vyatka river), Yaran river (a right feeder of Pizhma river), headwaters of Kazanka river (a left feeder of Volga river), headwaters of Kirzyat (a left feeder of Sura river), etc.

Field researches have been made since 1983 till present. They cover different landscape zones where width of floodplain deposits on studied sections varied from 0 to 400 cm (table 1).

Table 1. Width of floodplain deposits in different landscape zones (cm)

Landscape zones	Maximum	Minimum	Average
Forest	328.0	0	66.5
Forest-steppe	400.0	0	91.3
Steppe	210.0	14	76.7

Minimum width of floodplain deposits confined to river basins in forest landscapes. The natural and anthropogenic factors influencing speed of floodplain deposits accumulation were considered. The role of each factor was estimated by methods of mathematical statistics: correlative analysis and single-factor analysis of variance.

Calculation of partial coefficients of correlation of some factors revealed that after an exception of influence of the proportion of ploughed land the connection between a forest coverage and width of floodplain deposits is characterized by a coefficient of correlation – 0.66 (table 2).

Table 2. Coefficients of correlation (r) between width of floodplain deposits and the separate factors influencing it

Factors	R	Nature of connection
Forest coverage	- 0.66	Rectilinear
Proportion of ploughed land	0.72	Curvilinear
Average slope	0.22	Rectilinear
Roughness	- 0.37	-"-
Flood altitude	0.36	-"-
Flood basin	0.34	-"-

When excluding forest coverage the coefficient of correlation between the proportion of ploughed land and width of floodplain deposits becomes doubtful and equals only 0.34. All this allows claiming that accumulation of floodplain deposits first of all reacts to changes of character of a fluid drain, which changes in deforested basins even without increase of the proportion of ploughed land. Increase in flow of solid matter, caused by ploughing of lands, probably is not the leading factor of intensive accumulation of the recent floodplain alluvium.

Other analysed factors play the supported role. For example, the closest connection appears between width of floodplain deposits and horizontal

roughness. Even after excluding some other factors the coefficient of correlation is not more than +0.42.

For the analysis of variance we took floodplain basin, average slope of basin, horizontal roughness, flood altitude, forest coverage and proportion of ploughing lands, which was considered as an index of the basin's development. Power of influence of separate factors (h2) and its confidence according to Fisher's ratio test (F) are specified in the table 3.

Table 3. Results of the single-factor analysis of variance

Factors	Coefficient of determination, h2	F	Confidence level, %
Forest coverage	0.69	11.9	99
Proportion of ploughed lands	0.48	4.5	99.9
Average slope	0.19	0.1	< 95
Roughness	0.34	0.3	< 95
Flood altitude	0.53	4.8	99
Flood basin	0.24	1.3	< 95

Results of the analysis of variance show that the two closely connected factors have the greatest impact on accumulation of floodplain deposits – forest coverage and proportion of ploughed lands. Deforestation and ploughing lands promote rapid enhancing of a flood drain, flood duration reduction and volume of ground-water flow. As a result amplitude of water level variation within the year increases. These changes lead to multiple increases in flow of solid matter on deforested areas and intensification of floodplain deposits accumulation (table 4).

Table 4. Average characteristics of fluid and solid drains of minor rivers of Central Volga area with various proportions of ploughing basins

Ploughing lands, %	Number of considered basins	Volume of a flood drain (% of an annual drain)	Amplitude of water level variation within the year, cm	Flood duration, Days	Minimum fluid flow rate for 30 days of summer period, l/sec·km²	Suspended sediments flow rate, t/km²· year
0-19	2	48	166	31	No data	No data
20-39	3	55	252	29	1.84	28
40-59	8	51	294	30	1.71	96
60-79	11	67	417	28	1.00	193
80-100	4	64	304	29	0.76	234

Therefore, the closest correlative connection is established between width of floodplain deposits and basin reclamation indexes.

As water level variation within the year is the prime cause of facies division of alluvium on channel and floodplain facies, intensification of floodplain deposits is in accord with increasing of flood level. This is testified by the results of the analysis of variance (table 3) and data on specific rivers: Nurminka river, a feeder of Vyatka river and Morkvashinka river, a feeder of Volga river. They are situated in a forest zone; surface of basins consists of Upper Permian clay and carbonaceous deposits. Forest coverage of Nurminka river basin is 2%, of Morkvashinka river is 40%. Average level of flood on Nurminka reaches 168 cm, and an average width of floodplain deposits is 68 cm, the same indexes for Morshanka river constitute 112 cm and 40 cm respectively.

The radio-carbon method revealed that the speed of alluvium accumulation in- situ is comparable on all floodplain sections. Accumulation speed for the last 6-2 thousand years in the Volga region was in average not more than 6-7 mm/year. This speed for the last 1000 years in some river basins with maximum anthropogenic impact has increased and according to the data of the recent stationary supervision it reached 21–22 mm/year. Age of the recent floodplain deposits is within 700-30 years.

The data of stationary supervision of speed of floodplain deposits accumulation with a help of land-marks for the last three decades show that the more reclaimed land the higher speed of floodplain deposits accumulation. In rivers with forest coverage close to 100%, superimposed floodplains were not found.

Conclusion

The quantitative account and assessment of floodplain accumulation of products of basin erosion is a necessary condition for study of erosive and accumulative balance of river basins with different types of land use for landscape and territorial planning.

Summary

The quantitative indices received by different methods give a chance to trace communication of the recent accumulation of floodplain alluvium in valleys of minor rivers with factors of forest coverage and reclamation of basins.

Intensive accumulation of the recent floodplain deposits on floodplain and partly on low terrace above floodplain of minor rivers is a consequence of basins development.

Width of floodplain deposits serves as a good cumulative index of transformation of natural potential of river basins, an index of the recent conditions of river system functioning. They are specific not only for the East of the Russian Plain, this conclusion was made by Matveev for Oka river, by Jadson for rivers in Italy, by J. Kost for rivers on the East of the USA and by Shushansky for rivers in Poland [2, 12, 13].

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