APPROACHES TO THE ASSESSMENT OF THE CHANNEL FORM COMPLEXES (ON THE EXAMPLE OF THE UPPER DNIEPER CATCHMENT)

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Abstract: The article presents an approach to the assessment of the stability of the channel form complexes taking into account the different factors and characteristics of the channel process within their borders. The middle rivers of the upper Dnieper catchment are selected as example. The stability of the complexes it is proposed to evaluate the morphological and morphodynamical change of the channel, installed by different years' geoimages within the borders of macromeanders. The types of channel dynamics are defined, the method of macromeanders' sustainability scored is developed. The relationship between channel sustainability and the lithological structure and the geometrical features of the valley is substantiated.

Keywords: channel complex forms, channel deformation, channel sustainability, geoimages, macromeanders, upper Dnieper Basin

Introduction:

Relief sustainability, in the most general form, can be expressed in two ways:

- the ratio of the factors affecting the geomorphological processes
- characteristics of their intensity

Link relief factors and processes are probabilistic and thus represent the relative independence of the ways to assess its sustainability.

The comparison of the results obtained by different methods allows an overview of the entire territory and local peculiarities of the dynamics, defined by a combination of factors.

In assessing the sustainability of rivers, both approaches have been applied through ratio of channel-forming factors and speed channel deformations.

The speed and direction of deformations are unequal within the boundaries of current, relevant complexes of river bed forms, depending on the local combinations of factors. Complexes of channel forms are considered as a natural combination of meanders, linear sections and branches, reflecting the specific channel process on long stretches of the current. Probably the complexes form a hierarchical system, but

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the principles of their selection and classification are not developed.

The unequal conditions of occurrence and characteristics of the channel process involve a specific way of assessing the sustainability of the channel complex forms.

Such an approach to assessing the sustainability appears to be promising, nonetheless, there is a poorly developed direction of the fluvial geomorphology, whose development is connected with the prospects of the forecast of the dynamics of the river bed extended segments (Hooke 2007).

Materials and methods:

The evaluation methods and indicators for the channel's sustainability developed in the General form are mainly used for certain channel forms with relatively homogeneous conditions of the channel processes. The use of the same indicators for the sustainability assessment of the larger forms is limited by different conditions, speed and direction of deformations within their borders. The calculation of the average values of the indicators for larger river bed forms allows taking into account only the quantitative characteristics of the changes, but does not affect the high specificity of the channel's process.

The same values of sustainability can correspond to major forms with relatively homogeneous morphology and dynamical structure, combined in a single complex of stable and rapidly changing flow segments.

Therefore, the changes reflect sustainability, either the dynamics of the main process in the framework of a certain type of interaction of a stream and river channels, or restructuring dynamical features of the flow segment.

The methods for assessing the sustainability of large forms, these should dwell on constancy of morphology and dynamical features of channel process as a specific indicator sensitive to long-term dynamics of factors.

The duration of the period, during which the value of sustainability within the selected approach may be considered constant, depends on the characteristic time of the development of forms of a different order.

Considering local segments, the separate forms have transformed merely over a few years, unlike complexes which have formed over decades and centuries.

Defining the time interval for which the calculated values of the channel sustainability are true, discussed in the review work, but are not implemented in any specific models.

We developed an approach to the definition of the stability of the major forms of the river bed for the period from the mid-nineteenth to the beginning of XXI century concerning the changes in morphology and morphodynamic type.

The main objects are selected from the middle of the river basins of the upper Dnieper - Sudost, Snov, Bolva (tributaries of Desna), Iput (tributary of Sozh) with relatively homogeneous climatic characteristics of the catchment territory and a variety of geological and geomorphological conditions proper to the channel process.

Snov River flows intersects the fluvial glacial plain and occupies the southwestern part of the Bryansk region (Russian Federation) and the North-Eastern part of the Chernigov region (Ukraine). The catchment area is 8,700 km^2. The valleys feature a smooth curve form, with wide, flat low floodplains, gradually turning into interfluve surfaces. The height of the floodplain above the water edge does not exceed 1-2 m, its width in the lower sites reaching up to 4.0 km. The meandering channel type prevails 55 % of the channel's length. The braided type (37 %) is widely distributed in the middle reaches, and the relatively straight type (8 % of length) in the upper reach.

The valley of Sudost river shares the right Bank elevated plains, folded from the surface of the loess - like loam with high erosive partition and left side moraine fluvial glacial plains, folded by sands. The catchment area is 5,850 km^2. The floodplains are wide, prevailing the meandering channel type (74 % of the river's length). Single straights and braid segments are, respectively, 18 % and 8 %. The floodplain average height is 3 m.

The Bolva basin is divided into three parts, with differing physical and geographical conditions. The upper reaches of the river cross the hill-moraine plain in the middle part of the basin located on the alluvial fluvial glacial plains, folded by sands. In some places the surface of the plain is complicated by the moraine hills. In the lower reaches of the river pool gentle sandy hills have elevated from the plain on the bedrock of middle erosive partition. The catchment area is 2,324 km^2. The floodplain wide channel is mainly meandering (83 %), with straight segments with lengths up to several kilometers (17 %). The floodplain's height is up to 4 m, while in many sites it is composed of sands and cemented by iron hydroxide.

Iput river basin is located on the fluvio-glacial plains. The terrain is dominated by sections of flat plains with terraces, folded by fluvial-glacial and alluvial sands and sandy loams, separated by erosive forms. The characteristic features of the valley are structurally due to the asymmetric structure, the alternation of tectonically favoured areas of different channel type. The catchment area is 10,900 km^2. The meandering type of channel prevails 61 % of the river's length. At the local structural-conditioned reaches, the straight (11 %) and braided (28 %) type are distributed. The height of the scarps of the floodplain coast varies from 0.5 to 6 m, typical of areas with a height of 2-4 m (Rybal'sky et al. 2007).

The evaluation of the sustainability of the river bed performed within the boundaries of macromeanders' major bends, complicated the forms of the lesser order – curves separating those sites of branched or linear channels. The emergence of the macro bend determined structural-morphological features of the valley and the dynamics of the flow in the postglacial era by increased water availability.

The choice of the macromeanders as key objects is due to the following reasons. First, these large channel forms are clearly recognized on maps of different time and space images; secondly, they are relatively resistant in space in connection with the peculiarities of the origin; in the third place, the direction of their dynamics is a factor in the development of river bed forms of lower rank. The location of model objects is shown in Fig. 1 (Annexes).

Results and discussion:

The stability of the channel is assessed in comparison with geoimages for intervals: the middle of the XIX century, the decade of the 30s of the XX century, the 30s to 80s of the XX century, the 80s of XX century – the beginning of the XXI century, through the determination of the direction and rate of configuration change. The interval limits are determined by the time of the creation of maps and satellite imaging. The information about the configuration of the channel in the XIX century are obtained from the military topographic maps of scale 1:126000, created under the leadership of Schubert (the state of the area in the 60s of the XIX century). The source of information about the state of the channel in the twentieth century topographic maps of scale 1:100000 (state of the area at 1928-1931 and 1988-1992). This approach is used for major rivers, but relatively little is designed for small and medium ones (Yang et al. 1999; Mario et al. 2005; Takagi et al. 2007).

The method of evaluation of the channel's stability in the macromeander borders includes two stages. At the first stage**,** a variety of morphological and morphodynamic changes were systematized and summarized in several characteristic types.

The morphological changes are divided into groups: complexity, simplification, stability configuration. The morphodynamic changes are of two types: the change of morphology while maintaining a morphodynamic channel type, as well as the change of morphology and morphodynamic type. The characteristic types of the dynamics are presented by Tab. 1.

Table no. 1 Types of the channel dynamics in the macromeanders borders

Direction of changes in the morphology	Changes in morphology with morphodynamical stability	Change of morphology and morphodynamic type
The complication	Development of the complex, bends, increasing the number of braid (furcation) channel, reducing a length of straight line segments	Change of straight channel by meandering or braided
Simplification	the Increase in the number of segment gentle bends, decrease channel bifurcation, increasing the length of a straight line segments	Change of meandering or braided channel by straight line segments
Stability	Opposite changes within macro-meanders without changes in the ratio of the lengths of segments with different configurations	Opposite changes within macro-meanders without changes in the ratio of the lengths of segments with different morphodynamic type

There is a slight probability that some types of dynamics occured throughout several decades from the first century, for it seems to be the least probable change of the morphodynamic channel type on the whole macromeander, as it involves substantial alteration factors of the channel process.

In addition to these types, the variant of the stable existence of the channel is possible without any noticeable change in the configuration. Simplification and complication of the configuration in combination with a change in the morphodynamic channel type indicate the ongoing dynamics of the most important factors of the channel process. The stability configuration, as a rule, highlights the auto-oscillatory dynamics of valley-channel complexes without significant changes in the conditions of channel processes.

The second stage includes scoring types of dynamics and their combinations as an integral indicator of sustainability. Configuration of the reaches with maximum resistance has not changed during the entire period of time. On reaches with less resistance prevail morphological changes, but morphodynamic type of the channel process is maintained. On segments with minimal resistance combined morphological and morphodynamic changes (Tab. 2)

Table no. 2 The principle of macromeander sustainability scoring

Points	Change of morphodynamic type	Change in channel morphology
3	morphodynamic type is maintained throughout the all reach	Configuration remains stable
2	morphodynamic type is changed in some parts of the macro-meanders	Configuration becomes more complicated or simplified within one of the macromeander arm
1	morphodynamic type is changed more over the channel	Configuration becomes more complicated or simplified throughout of macromeander arm

The information on channel sustainability indicators is shown in Tab. 3. Ordinal numbers of objects correspond to their numbering on Fig. 1 (Annexes). In columns 2-3 are presented the results of the scoring of morphological and morphodynamic changes**;** in column 4, the values of the integral index.

Table no. 3 The sustainability indicators of the channel in the macromeander borders

R	NM	MDT	CM	S
Bolva	1	3	2	5
	2	3	1	4
	3	2	1	3
	4	3	1	4
	5	2	1	3
	6	2	2	4
Sudost	1	3	1	4
	2	3	1	4
	3	3	2	5
	4	2	1	3
	5	2	1	3
	6	3	3	6
	7	2	1	3
	8	2	1	3
	9	3	1	4
Snov	1	2	1	3
	2	2	2	4
	3	3	2	5
	4	3	2	5
	5	3	1	4
	6	2	1	3
	7	2	1	3
	8	2	1	3
	9	2	2	4
	10	3	2	5
	11	3	1	4
Iput	1	3	1	4
	2	3	3	6
	3	3	3	6
	4	2	3	5
	5	1	1	2
	6	3	2	5
	7	2	2	4
	8	3	2	5
	9	2	2	4
	10	3	3	6

Legend: R-river; NM-number of macromeanders (by Fig. 1); MDT-change of morpho dynamical types (points); CM-change of channel morphology (points); S-stability (points).

In the spatial distribution of sustainability there are two patterns: a relatively small resistance of medium reach and non-periodical loose alternations of its value in other areas, which are in good agreement with the theory of the channel process. The first pattern is explained by the maximum values of the energy flux of the secondary reaches (Chalov 2008). The second is connected with the influence of local conditions - various lithological structure of the segments and the mutual disposition of the geometrical axis of the macromeanders and the axis of the valley.

At the level of individual channel forms there has been established that the flow has maximum erosion ability if the orientation of the shore slope angle is 45 degrees. The smaller or larger values of the relatively greater impact are given by the strength properties of grounds. The peculiarities of interaction between flow and channel are saved, probably at the level of macromeanders.

The most significant changes occur if the macromeanders set at an angle of 30 to 60 degrees to the axis of the valley, in other cases, the channel stability of the riverbed significantly more.

Conclusions:

The stability of the channel is assessed at the level of large form macromeander peculiarities of their long-term dynamics. Conversion of the river bed is discussed through the configuration changes and morphodynamic type. The values of sustainability are determined by the degree of morphological and morphodynamic transformation expressed in score. In the framework of the approach chosen, the stability of the rivers in the basin of the upper Dnieper changes downstream, depending on the homogeneity of geological and geomorphological structure of the territory. In relatively homogeneous conditions of the development of river bed deformations, the least steady is the middle reach of the channel

Rezumat:

ABORDĂRI ÎN EVALUAREA COMPLEXELOR FORMAȚIUNI DE CANAL (PE EXEMPLUL BAZINULUI NIPRULUI SUPERIOR)

Articolul prezintă o abordare privind evaluarea stabilității complexelor formațiuni de canal, luând în considerare diferitele elemente și caracteristici ale procesului de canal în cadrul malurilor. Au fost selectate ca model râurile de dimensiuni medii din bazinul superior al Niprului. Stabilitatea complexelor are ca scop evaluarea schimbărilor morfologice și morfodinamice ale canalului, survenite în geoimaginile din diferiți ani în interiorul malurilor macromeandrelor. Sunt definite tipurile de dinamică a canalului și dezvoltată metoda de înregistrare a durabilității macromeandrelor. Principalele cauze posibile ale distribuției spațiale a stabilității canalului sunt argumentate. Este demonstrată relația sustenabilă dintre structura litologică și caracteristicile geometrice ale văii.

Annexes:

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Figure no. 1 Distribution of key object – macromeanders in the upper Dnieper catchment.