Mongolian Journal of Biological Sciences 2006 Vol. 4(2): 75-78

[Short Communication]

Scientific Approaches and Methods in the Investigation of the Formation and Stability of Hydromorphic Natural Complexes of the Irtysh River Valley System (The Kazakhstan Part)

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Abstract

The current geo-environmental situation of the Irtysh River valley system is connected with the high degree of control of the river drainage, which affects the functioning of its entire ecosystem and determines some morphological features of its channel. In the present work, the methodological approaches in the study of formation of the valley's hydromorphic natural complexes are discussed, and the results of studies on the channel processes in the middle course of the Irtysh River are given.

Key words: Valley, floodplain, hydromorphic complex, river Irtysh, Kazakhstan

Introduction

According to the concept of ecological safety of the Republic of Kazakhstan for 2006-2015, "The ecological safety is considered a component of the national safety and is an obligatory condition of the sustainable development, and it acts as a basis for preservation of natural systems and maintenance of the corresponding quality of the environment". The concept also concerns water resources of Kazakhstan, as it refers to the category of countries with a deficiency of water resources. Currently, the valley of the Irtysh River is undergoing significant anthropogenic loading, and consequently the solution of problems concerning the stabilization of hydromorphic landscapes have huge national-economic values, and is one of the serious regional problems of the republic.

The formation of the valley paragenic hydromorphic landscape complex is largely predetermined in many respects by the geologic-geomorphological and hydrological factors, and inherently reflects the features of ancient paragenesis and modern functioning of the basin geo-system.

It is well known that the river channel is considered a stable system under the influence of the stream as the result of washout or rock deposition, and it does not cause any serious change in the river runway. Usually the river itself creates the natural form of the channel, which is characterized by some stability and corresponds to the least resistance of the water stream. So, while creating bends, the river stops their development as soon as the radius of their curvature reaches the optimum size of the given stream. A big congestion of deposits in the channel creates resistance to the current, and the river deviates or breaks into sleeves, losing its stability.

The river Irtysh is one of the largest trans-boundary waterways in Kazakhstan. The sources of the river are locate, in a glacier of the Mongol Altai Mountains in China, whence it flows in a northwesterly direction, crosses the frontier between China and Kazakhstan and flows into Lake Zaisan below Bukhtarma water basin. After Lake Zaisan the Irtysh River proceeds through the western part of the Russian Altai Mountains and the lowland of Western Siberia and flows into the river Ob'.

In the territory of Pavlodar oblast' the section of the middle watercourse is about 720 km long. The water area at the boundaries of the area (N50°36' and E79°30') consists of 276200 square km.

The valley landscape of the river Irtysh is represented by channels, terraces and floodplain. The area of the floodplain occupies 371 square km, and is characterized by high soil and humidifying freshet. The valley of the Irtysh is situated within the limits of a large platform structure – the Irtysh syneclise of the Western Siberian epipalaeozoic plate - and is characterized by a considerable complexity of structural-geomorphological

http://dx.doi.org/10.22353/mjbs.2006.04.19

composition. The big variety of geomorphological types in the valley relief has been caused by a long history of its geological development. The character and rates of the newest tectonic movements as well as anthropogenic activity rendered a strong influence on the geomorphological shape of the valley.

The river Irtysh crosses the territory of Pavlodar from the south to the north, where its modern floodplain valley makes a continuous strip of 1-15 km on the left bank, and up to 4-6 km on the right bank. The channel of the river within and below the city only covers the valley slopes for short distances.

The bases for the present work are references, archives, maps and mapping satellite photographs, and field data of the author. Comparison of plans of the river Irtysh based on research data from 1901-1904, navigating and pilot-age cards, air photography made by hydro-geologic investigation in 1957, and also the study of the newest satellite photographs of the valley, shows that on a number of sites, the river has strongly developed in width and has deepened some new channels, and the old channel has sometimes appeared strongly constrained by shallows, spits and midpoints.

The relative stability of the channels is defined in the form of settlement factors (indexes) referred to by Lohtin's number (1948), updated by Velikanov (1958). The index reflecting the stability of the channel in the current cross-section direction was developed by Dzjankhen based on Altunin's hydromorphological dependence (Altunin, 1958). The index reflecting the intensity of horizontal deformations, considered a morphological parameter of the channel, was developed by Glushkov (1961). There are a number of factors that can characterize the integrated stability of the channel, for example, the factor of erosion-morphometric stability by Karasev (1975), and also the coefficient of stability by Makkaveev (1955).

Results and Discussion

The results of my research revealed that within the boundaries of Pavlodar city the river has become distanced from the slopes of the valley, where we observed only redound of earlier deposits and a local increase or reduction of firm material. The non-uniformity of the firm material on different sites of the river affects channel deformations in various ways.

The result of anthropogenic activity in the river valley is the infringement of the geoecological skeleton that involves the degradation of grasslands and fish communities, development of water-erosive processes within the river valley, decrease in the recreational value of nature conservation objects etc. The current ecological situation within the Kazakhstan part of the Irtysh requires the development of scientifically-proven bases of conservation management of the valley's natural-economic system.

On the basis of calculations of stability factors, the stability of the channel on the observable site of the river Irtysh has shown intensive channel deformations. The Irtysh is characterized by a wandering river channel: Kc = 6.4. The range of values of the cross-section stability index were between 0.9 and 2.1, i.e. the higher is A value, the lower is the intensity of horizontal deformations. The river Irtysh, within Pavlodar area, has the greatest range of values. The range of values of the stability factor by Lohtinov are W>15; in the Irtysh this factor mismatches stability (W=2.35). The calculation result allows the conclusion that the channel of the river Irtysh is comparatively stable under anthropogenic loading.

Deformation of the river Irtysh is influenced by the display of transported deposits carried by the stream in the form of washout, carry and deposit of material. The channel of the river meanders strongly through the whole valley. The presence of plenty of islands in the channel, dead channels and lakes in the floodplain determine the typical features of deformation of the river bed and the mode of river deposits. Non-uniformity of the deposit distribution along the river is basically explained by the change in morphology of the valley and channel, leading to varying intensity of channel formation (meandering in the floodplain, widening and narrowing of sections, formation of the channel etc.). In the years when river waters abound there is a general increase in channel erosion activity, leading to an increase of deposit drain owing to sedimentation in the low and wide flooded plains. In shallow water years, when the floodplain is filled only occasionally and the river just runs in the channel, the loss of deposit drain is little.

The feed by deposits due to the stream undermining valley slopes replenishes the drain of the river as the general extent of sites on which

the river is "pressed" to the slopes of the valley is about half the entire length of the river Irtysh within the limits of Pavlodar area. Deformations of the channel in the reaches and shallows become greater, judging by the presence in many sites of large ground deposits in the channel (pebbles). Fine deposits are carried by the river in suspension and their deposits are not too developed. Near the Pavlodar city the river Irtysh widens considerably, and the slopes have a less limiting influence on the development of the meandering process. Also the channel of the river becomes twisted.

On the site of the investigated area where the river appears "pressed" to the valley slopes, meanders of the channel are scarce and it is sometimes almost rectilinear. For example, near the city Pavlodar the channel follows the outlines of the valley slope precisely (Karasev, 1975). During the development of meanders there is sometimes a tearing away of parts of convex banks due to floodplain washout by the stream because of a high level of water.

As a result of the economic activities in the river Irtysh valley, water-economic conditions have become complicated and led to a certain change. One of the widespread and most intensive anthropogenic loading on the river Irtysh since the mid 20th century is dredging for maintenance and improvement of waterways. The channel of Irtysh River within the Pavlodar city area is characterized by relative mobility, with periodic vertical deformations of shallows by 1-2 meters and it recedes from the banks by some meters a year. These deformations correspond to the average indexes of stability. So near to the city Pavlodar the parameter G was equal to 17.1; the complex index F – 0.15; Cs – 6.4 and A – 33.8.

Comparison of these values testifies that despite extensive dredging the stability of the channel changes, but insignificantly. A sharp change of stability of the channel is possible under the control of water drain. The large water basins of Bukhtarma and Shulba regulate the drain of the river over the long-term by water-power engineering, and can also lead to a change in morphological characteristics of the Irtysh River channel, in particular to the rectifying of the channels. The calculations have shown that the Irtysh river channel within the territory of the Pavlodar city is relatively stable.

Establishing the factors influencing the stability of the channel of the Irtysh within the city of Pavlodar leads to the following conclusion: the channel is influenced both by spontaneous (natural) and anthropogenic factors. In accordance with the conducted research, the influence rendered on the intensity of erosive ability is shown by natural influences, i.e. large deposits, pitch, current speed, and water regime. Anthropogenic components influencing the stability of the river channel involve hydroelectric power stations, water transport, dredging, and water supply, which lead in their turn to a change in morphological characteristics of the river channel, in particular to rectifying the channel.

We made the calculation of stability of the channel to anthropogenic loading: the range of values of the stability factor by Lohtin (1948) makes W>15, i.e. the channel is motionless. Within the vicinity of city Pavlodar, this index is 5 times lower than the former (W=2.35), and it in its turn mismatches the stability of the channel and shows the small mobility of the channel.

For calculation of stability of the channel we used a criterion which allows the assumption that the channel is washed away, and so is relatively stable because of the high parameter of the factor of ground deposits that participate in the movement together with water. This calculation has been confirmed by a differential curve of the granule-metric of ground deposits within the area Pavlodar city, and it shows that deposits in a suspension occupy the greatest area, and this shows the high degree of channel erosion.

There are more than 1000 lakes in the Irtysh River valley. The majority of them are saline and self-sedimentary lakes and have round superficial hollows. The group of lakes in the northern part of the Pavlodar region is in the forest-steppe zone with a warm and comparatively humid climate. The second group of lakes located in the steppe zone, both on the left and right sides of the Irtysh valley, are in an area with a warm and insufficiently damp climate. The third group of lakes is located in a forest zone of the Kazakh low hills, with a warm and sufficiently humid climate. The fourth group of lakes can be found in the inundated parts of the Irtysh, with an original microclimate, transitive from steppe to forest-steppe zone. Close underground waters (0.2-1.0 m) have a special significance in the formation of the microclimate and the feed of inundated lakes.

Territorially, the lakes of the Irtysh river valley can be divided into the following groups:

a. Pavlodar group, represented by small reservoirs (Moyldy, Jalauly, Big and Small Tavoljan, Chungur, Usun-sor, Balkyldak).

b. Lebyazhye group, whose lakes are scattered over the vast area and are at a significant distance from each other (Maraldy, Chagalinkoye, Anarcha, Goloye, Naked, Bi and Small Yamyshevskoye etc.). In the self-sedimentary lakes of the left bank of the Irtysh table salt is accumulated.

c. Ekibastuz group of basically self-sedimentary lakes (Jaman-Tuz, Ekibastuz, Atybai, Ansar-sor, Big and Small Kalkaman, Kener-Tuz, Karasor). Some sites of the floodplain are boggy, abounding in numerous girths, horns, branches and freshwater lakes.

According to the degree of development and character of relief forms, the channel of the river is broken into a set of islands and sandy spits, separate horns, branches, gullies-hollows and girths, which are not connected with the river surface drain and feed the whole flood plain with subsoil waters.

Our studies conducted during the strip survey have shown that modern landscape conditions in the reservoirs of the investigated lakes were formed under the influence of many factors. The leading factors in the formation and development of lakes are the integrated geographical factors: relief, climate and drain. In each lake-like reservoir, there are physical, chemical and biological processes whose joint action defines its regime. The intensity and direction of these processes is in their turn determined by the influence of geographical conditions, under which the lakes exist. Another prominent feature of the lakes is their accumulation of an overwhelming number of suspended particles, fractional load and dissolved elements, products of wind deposits appearing during the drain, and also the material arising in the lake as a result of the vital functions of water organisms and interaction of the water body with the hollow.

The analysis of modern satellite images has shown that the degree of bending and branching of the river, promoting the formation of inundated lakes, has the highest value in the vicinity of Pavlodar city, where the factors on average were 1.2 and 1.95 respectively, and increase with reduction of the river slope. Also this research allowed us to offer a genetic classification of the inundated lakes distributed in the valley of the Irtysh river, which are confined the following classification types: endogenous, class: hydrogenic, subclass: erosion-accumulative (river), sort: lakes inundated, lakes of terraces above the flood plain; kind: lake-channels, lakes-girths.

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Хураангуй

Иртыш мөрний нуга, татмын геоэкологийн асуудал нь үндсэндээ голын гольдрол, урсгалын хяналт, зохицуулалтаас ихээхэн хамааралтай болсон бөгөөд энэ нь тус голын сав газрын экосистемийн үйл ажиллагаа, геоморфологийн хэв шинж зэрэгт тодорхой өөрчлөлтийг бий болгосон нь илрэв. Энэхүү өгүүлэлд Иртыш мөрний нугын гидроморф шинж бүрэлдэн бий болох онцлогийг судлах арга зүйн асуудал болон уг голын дунд хэсгийн урсгалын шинж төлвийг судалсан дүнг нэгтгэн оруулсан болно.

Received: 16 June 2007
Accepted: 30 January 2008