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The role of anthropogenic factors in changing the water regime of the Ertis river flow in the territories of the People's Republic of China and the Republic of Kazakhstan

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ABSTRACT:In this study, to assess the anthropogenic impact on the within-year runoff distribution (WYRD) of the Irtysh River (hereinafter Ertis), the results of flow characteristics for different periods of economic activity in the territory of the People's Republic of China and the Republic of Kazakhstan were evaluated and analyzed. To quantify the impact of the Chinese side on the water regime of the r. Ertis, the data of a gauging station located on the border between Kazakhstan and China were used.
In modern conditions, economic activity has reached such a scale that it began to influence not only the quality of natural waters, but also their regime and the total water resources of large river basins and regions. This is caused the need to assess their changes under the influence of human activities.
A significant change in the within-year runoff distribution of the river Ertis under the influence of economic activity on the territory of the basin, located in the PRC and RK was revealed. In the Chinese part of the basin, there is currently no possibility of deep inter-annual flow regulation and only affects seasonal uneven flow. In the middle years of water regulation of flow in the territory of the PRC is observed in the period from April to October.

KEYWORDS: Within-year runoff distribution, Catchment area, inflow, flood, river runoff, water regime, reservoir.

I. INTRODUCTION

The Ertis River originates in China on the western slopes of the Mongolian Altai and before the confluence of the lake Zaisan is called Kara Ertis. Further, Ertis crosses Kazakhstan, flows through Russia and flows into the Ob river. The total length of Ertis is 4280 km, of which 618 km flow through China, 1698 km - Kazakhstan and 1964 km - Russia. The average height of the basin is about 2000 m. The catchment area to the Kazakhstan border is 58800 km2, the total area of the basin is 1643 thousand km2 [1-5].
By the nature of the terrain, the basin of the river Ertis can be divided into two parts - mountain and plain. In the zone of the basin there are mountain systems of Altai, Sauyr-Tarbagatai, Zhongaria and Tien Shan (Figure 1)..

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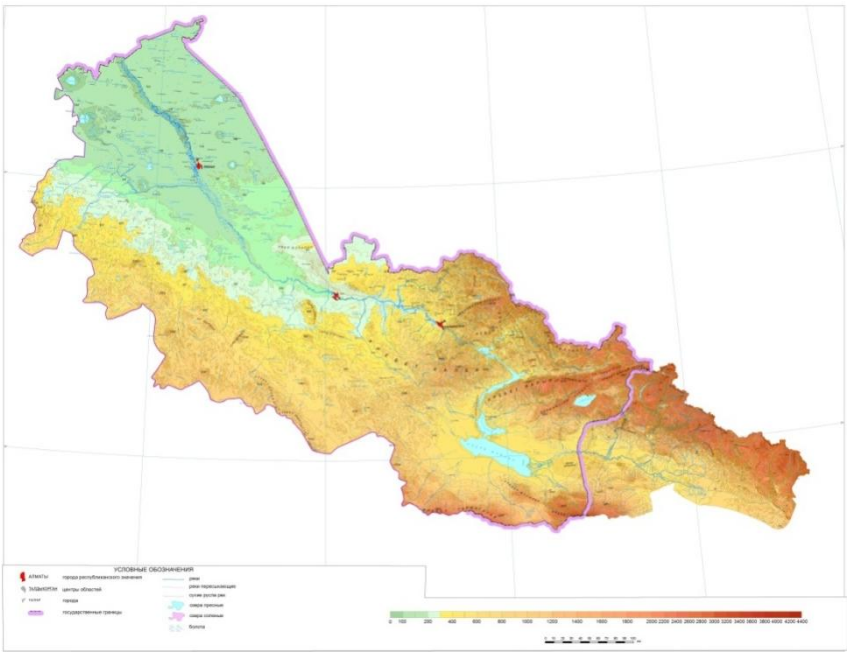

Fig. 1. Map of the scheme of the Kazakh-Chinese part of the Ertis river basin

Identification of the role of anthropogenic factors in changing the within-year runoff distribution of the Ertisriver is no less importance, in some cases, the nature of use, and more important scientific and applied importance for the economy. For a number of objective reasons, over the last decades in Kazakhstan, more attention was paid to the issues of annual runoff, maximum water discharges, as paramountly important characteristics in assessing the resource potential of rivers and the main threats that emanate from them. Effective management of resources and floods in most cases is possible only if the river network is regulated by one or another method and technical measures, which requires fairly accurate information of the runoff regime as a whole. The within-year runoff distribution of the rivers of Kazakhstan with rare exceptions was fully considered only in the 1960s and 1970s and these parameters still serve as the main reference point for water management activities.

Establishment of regularities of the within-year runoff distribution of rivers, calendar periods, seasons and within seasons has an important scientific and practical significance, as it is based on the planning of the use of water resources for various water management purposes. First of all, the distribution of runoff depends on changes in precipitation and air temperature during the year. In addition to climate, the distribution of the flow is influenced by other physico-geographical factors that express the natural regulation of the runoff in the basin.

The distribution of the runoff in a year can significantly change as a result of human economic activity: the construction of ponds, reservoirs, the arrangement of forest shelter belts, and the carrying out of agrotechnical measures. The WYRD for any point of the river does not remain constant, it varies from year to year, and moreover very significantly.

II. METHODOLOGY OF RESEARCH

Geographical and statistical methods of calculation for two periods have been carried out to assess the trends in the monthly expenditure of the Ertis river water: from the beginning of observations to 1969 and from 1970-2012.

Geographical methods of investigation include the method of geographical interpolation on the distribution maps of flow characteristics and the method of hydrological analogy [6].

Also, in the study, a method of comparative analysis of runoff characteristics for different periods of economic activity was used to determine the anthropogenic impact on the WYRD of the rivers in the region under research.

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III. RESULTS AND DISCUSSION

At present the natural regime of the Ertisriver and many other rivers of the basin is distorted by the regulating influence of the reservoirs, and economic activity in the catchment.The total of reservoirs and ponds in the East Kazakhstan region is more than 80, from which 9 reservoirs have capacity more than 10 million m^3. In the Pavlodar region, 7 hydrosystems with reservoirs are included in the complex "Canal of K. Satpayev ».

Regulation of a drain of the Ertis River is carried out by three reservoirs: Buktyrma (Wuseful = 30 810 million m^3), Ust-Kamenogorsk (Wuseful = 35,0 million m^3) and Shulbinsk (Wuseful = 1 470 million m^3). These reservoirs have a complex purpose. The Buktyrma reservoir from the Zhaysanlake carries out long-term and unlimited daily regulation, being the main regulator of the cascade, controlling almost 70% of a drain of a river basin (Figure 2). The flow of the Ertis in range of the Shulbinsky reservoir, after creating Bukhtyrma reservoir is mainly determined by the regime of releases from Bukhtyrma lateral inflow between. In the basin of Ertis there are 17 reservoirs with a general useful capacity of 32,63 km^3 and also ponds with a total useful capacity of 0,55 km^3.

The source of the Ertisriver is on the southern slopes of Altai in the territory of the People's Republic of China. The length of the Kara Ertis river (so it is called before the confluence of lake Zhaisan) to the border with Kazakhstan - 672 km, in the territory of Kazakhstan it flows into the lake Zhaisan which area is 1800 km^2.

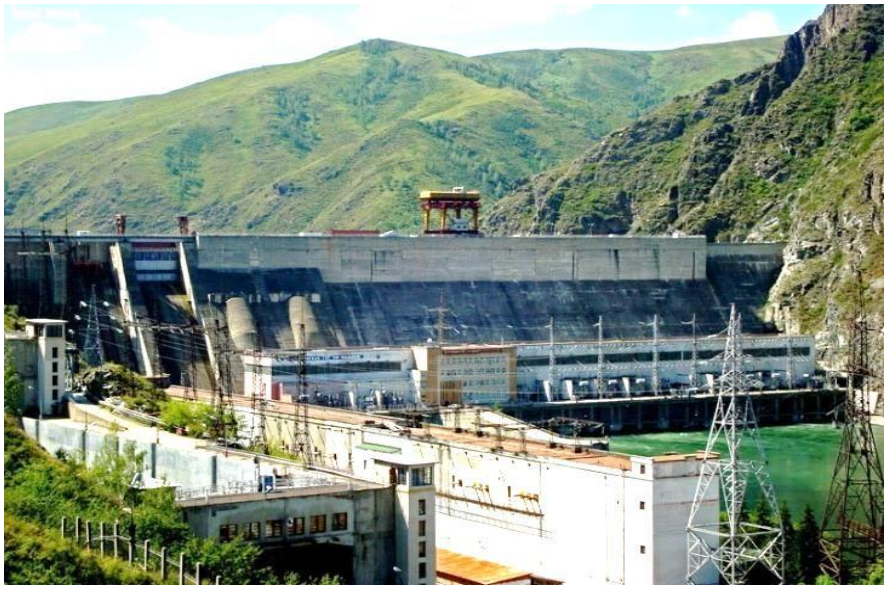

Fig 2.Bukhtyrma HPS on the Ertisriver

In table 1 shows the statistical data of reservoirs in the basin of the Ertisriver in the territory of Kazakhstan, the total number of which is 77 units.

Total water consumption in the basin on the territory of Kazakhstan in 1990 amounted to 2 763,0 million m^3. There is a tendency of their increase (from 1990 to 2010) which in 2009 and 2010 amounted to 4,967.0 million m^3 and 5,123.0 million m^3 respectively [7].

Change of a drain of the Ertisriver on a hydropost of the village of Boran considers influence of anthropogenic activity on the Ertis river in the territory of the People's Republic of China (headwaters of the Ertis river).

Table 1. Statistical data of reservoirs in the basin of the Ertisriver

Country	Volume of the reservoir	Total	Total amount ($10^6 m^3$)	Adjustable volume ($10^6 m^3$)
Republic of Kazakhstan	Volume $\geq 10^6 m^3$	16	53019.17	32 553.54
	Volume$< 10^6 m^3$	61	47.3	-
	Total:	77	53066.47	32553.54

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According to the analysis of uniformity of hydrological ranks of a drain of the river Kara Ertis at the village of Boran and on hydroelectric power stations on the main rivers in the Chinese part of the pool economic activity in the territory of the People's Republic of China up to the 1995th years was insignificant at the level of the accuracy of hydrological measurements and calculations. A natural number of monthly expenses of water flow of the Ertisriver at the village of Boran from 1996 for 2010 are restored depending on total expenses of the main inflows of the river in the territory of the People's Republic of China (rivers Kuertis, Kayyrty, Kyran, Burshyn, Kaba). Correlation between them high, coefficients make 0,8-0,9.

To determine the impact of anthropogenic activities on the river flow. Kara Ertis in the territory of the PRC calculated the difference between the natural and actually observed runoff at the cross-section of the river. Kara Ertis - the village of Boran, averaged over the period 1996-2010 (Figure 3). The results showed that the observed runoff in comparison with the natural (reconstructed) runoff in winter is longer, and in the warmer season, less. This is explained by the work of numerous small hydropower plants in the cold season, and the withdrawal of water for irrigation during the growing season.

By results of the analysis of a drain in an alignment of a hydropost of the village of Boran on the Ertis River, from April to October the observed drain in comparison with the natural (restored) drain decreases up to 125 m^3/s. Such reduction of a river drain is connected with a water intake via channels a penalty Ertis-Karamai (despite the name, the channel has a second branch in Urumchi). With the introduction of the channel "Kara Ertis - Karamay" into operation, the Chinese side began to carry out an annual intake of water from the Ertis river. According to different official and informal data this size is from 450 to 800 million m^3 a year. Although, according to independent experts, the capacity of the channel before separating into two branches is about 3.0 km^3 per year. So, according to our estimates, a drain of Kara Ertis river on border between Republic of Kazakhstan and People's Republic of China is reduced from 1990th years till present from 402 to 2 440 million m^3 a year.

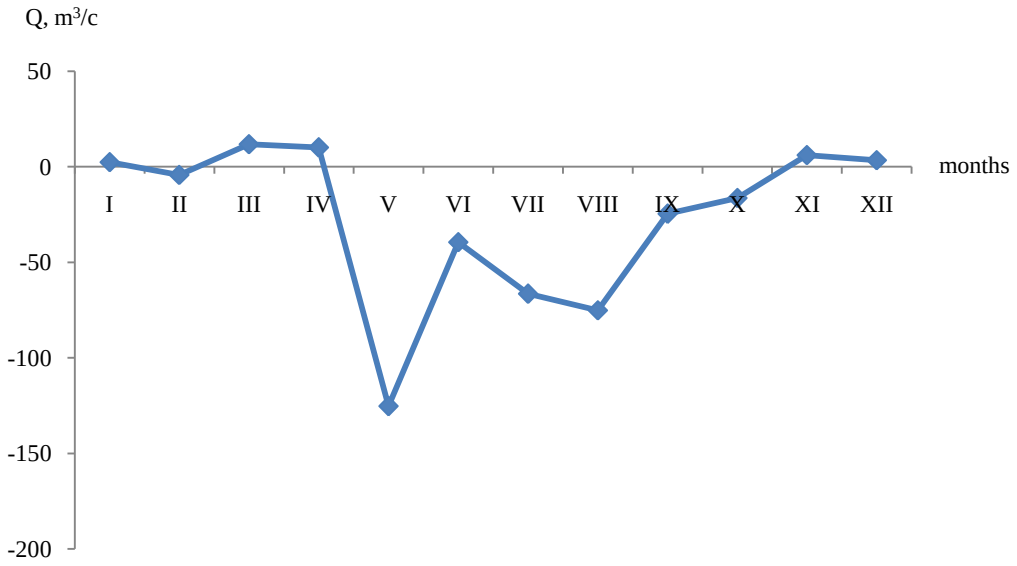

Fig 3. Change of a drain in a year as a result of anthropogenic activity in the territory of the People's Republic of China (river. Kara Ertis - the village of Boran.)

In the territory of the RK, the Buktyrma reservoir, which carries out deep regulation of the flow, and, accordingly, the intra-annual distribution of runoff of the river, almost uniformly throughout the year, have a significant influence on the runoff of the Ertis river. Anthropogenic changes in the intra-annual distribution of runoff of the tributaries of the river are insignificant.

In an average water year there is a significant decrease in the volume of the spring flood. Such reduction of a river drain is explained by a water intake in spring and summer time in Buktyrma of a reservoir and also evaporation from an additional surface of the water. [8].

In winter months increase in a river drain makes 152-297%, in april and october of 13 and 31%.

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Decrease in a drain in shallow year from april to july s in the range 6-73%. Increase in a drain during the modern period takes place from january to march for 25-28%, from august to december of 12-196%. In a year abounding in water the river drain – hydroelectric power station Ust-Kamenogorsk from may to august in comparison with the conditional and natural period has decreased by the Ertis river within 8-57%. Increase in a drain during the modern period for 97-150% is observed in winter months, for 18-53% – in autumn months and for 8-104% – in spring months (march, april). Thus, in the territory of Kazakhstan the Ertis River drain in a year is completely redistributed.

IV CONCLUSION

In the territory of Kazakhstan the river drain Ertis in a year is completely redistributed. According to estimates, a drain from the territory of China (on a hydropost of river. Kara Ertis – the village of Boran) is reduced from 1990th years till present from 12,7 m^3/s to 77,4 m^3/s or from 402 to 2 440 million m^3 a year. It is connected with commissioning of reservoirs, irrigation canals, hydroelectric power station, also large channel Kara Ertis – Karamay on the Chinese part of the pool. Because of anthropogenic activity on the Chinese part of the Ertisriver on an alignment of river Kara Ertis – the village of Boran a n observed drain in comparison with a natural drain in winter time is more, and in warm season it is less. Besides, on the Ertis River drain considerable impact is exerted to Buktyrma by reservoirs which carry out deep regulation of a drain of the river and according to river intra-annual distribution of runoff almost uniform during the whole year. In the middle year of water, there is a significant decrease in the volume of spring flood (up to 67%). In the winter months, the increase in river drain is 152-297%, in april and october 13 and 31%. Decrease in a drain in shallow year from april to july makes 6-73%. Increase in a drain during the modern period takes place from january to march for 25-28% and from august to december of 12-196%.

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