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HYDROLOGIC SERIES CHARACTERISTICS ANALYSIS OF THE MAJOR RIVERS AROUND THE TAKLIMAKAN DESERT

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ABSTRACT: This paper firstly analyses the hydrologic characteristics of the major rivers around the Taklimakan Desert with the method of mathematical statistics. Secondly, structure features of annual runoff series of these rivers are discussed both in time domain and in frequency domain with the method of time series analysis. From the analysis, it can be learnt that the nature quantity of water in the rivers in this area is generally steady and the annual runoff series of rivers is mostly independent stationary random sequence. Therefore, this paper can provide scientific basis for runoff variation law research and reasonal exploitation and utilization of water resource in this area.
KEY WORDS: hydrologic characteristics, time series, rivers around the Taklimakan Desert

I. INTRODUCTION

Located in the middle part of Tarim Basin, with an area of 33.76×10^4 km^2, the Taklimakan Desert is in the hinterland of Eurasia. Blocked by the high mountains around, vapour of ocean can hardly reach the desert. Apart from this, as the desert is in the sinking compensation area of the ascensional air current above the Qinghai-Xizang Plateau, its precipitation is rare and the evaporation capacity is intense all the year round. All these contribute to the formations of the typical dry desert climate. The aridity index of the desert and the around region is as high as more than 50, which makes it extremely arid in our country. Hence it is not difficult to understand that the water resources there have become the foundation of both mankind subsistence and its production and development. The quantity and quality of water resources have a direct restriction on mankind production activities as well as the protection of eco-environment. With the petreoleum exploitation in Tarim Basin and the development of industrial and agricultural production, the demand of water resources will still increase. Thus it is important to examine the hydrologic characteristics and runoff variation law. It can not only promote the development of national economy and petreoleum exploitation but also help preserve the eco-environment there. The water resources in the Taklimakan Desert and the around region are com-

posed of surface water resources and groundwater resources, while the groundwater resources are mostly come out of surface water resources, so that the characteristics of surface water resources and their variation laws will produce a much greater impact on those of water resources. That is the reason why it should be analysed in particular. Most surface water comes from the rivers which flow into the desert and the around region. Originating from high-middle mountains around Tarim Basin and flowing through the margin of the basin, at last these inland rivers disappeared in the desert. The water quantity of these rivers is mainly supplied by precipitation of the mountain area and melting water of glaciers. The rivers are generally divided into two different runoff-zones according to the mountain pass. The zone above the pass is the main supplying area of the rivers. The zone below the pass is runoff-disappearing area, where water quantity decreases gradually along the river and at last rivers disappear in the desert. This paper focuses on the analysis of the hydrologic characteristics and runoff variation law of the major rivers flowing into the Taklimakan Desert, on the basis of which, the structure features of annual runoff series of rivers is further discussed, so as to probe into its variation law.

II. THE HYDROLOGIC CHARACTERISTICS OF THE MAJOR RIVERS AROUND THE DESERT

Around the Taklimakan Desert, i. e. in Tarim Basin, there are about 144 rivers having water all the year around. Originating from the middle-low mountains, however, most of them belong to small river systems which are short-coursed and small-discharged. Annual runoff amount of 106 rivers of them is less than 1.0×10^8 m^3, making up 5.4% of the total amount. There are only 8 rivers yet whose annual runoff amount is more than 10×10^8 m^3, making up 64% of the total. Another 7 rivers, their annual runoff amount is between 5×10^8 m^3 and 10×10^8 m^3, which makes up 13% of the total amount. In the northern part of the desert, some above-mentioned rivers formed the Bosten Lake, Weigan River and Aksu River systems. They belong to the Tarim River basin. In the southern part, other rivers formed the Yarkant River, Hotan River, Keriya River and Qarqan River systems, which are all independent small river systems. The water quantity of these river systems constitutes the surface water resources of the Taklimakan Desert and the area around. Among them, flowing into the desert, with large water quantity, seven typical rivers are to be examined. They are: the Kaidu River, Weigan River, Aksu River, Yarkant River, Hotan River, Keriya River and Qarqan River. The annual runoff amounts of the first five rivers are all more than 15×10^8 m^3. The rest two are both more than 5×10^8 m^3. The first three rivers originate from the Tianshan Mountains, and lie in the north of the desert. The last four originate from the Kunlun Mountains and lie in the south. After out of the mountain pass, these river water is partly diverted to the oases for agricultural irrigation. Surplus water will flow into the desert. At present, because of the development of the industrial and agricultural production, the diverted water quantity for irrigation and other uses has been increased continuously, so that little water can continue flowing into the desert.

The Tarim River in the northern part of the desert is a discharging river. It starts from Xiaoxiake in the east, where is the confluence of Aksu River, Yarkant River and Hotan River and ends in Taitema Lake in the west, gathering many rivers halfway. Its water quantity and hydrologic characteristic is determined by that of those joining rivers (Table 1).

The rivers around the Taklimakan Desert are typical inland rivers. The supply of river water mostly comes from the precipitation and the melting water of glaciers. And the latter occupies considerably large proportion, which causes interannual runoff change of all rivers in Tarim Basin relatively small and the discharge of rivers steady. But the distribution of discharge within a year is uneven in proportion to the air temperature. Owing to the large water quantity, the rivers are likely to be in flood in summer, while in spring and winter, the water quantity is small, which results in irrigation water shortage. As far as the distribution of water quantity is concerned, rivers with abundant water quantity mostly lie in the north of the desert, and rivers in the southeast part are of poor water quantity. In addition, the annual runoff change and the change of the rivers within a year in the north are smaller than that of the rivers in the south, and the water quantity is steadier. As a result, in the whole Tarim Basin, it is in the north where there are more surface water resources, but it is also in the north where surface water is diverted for agricultural use in large amounts. Consequently, great harm has been done to the desert in the lower reaches of the Tarim River. And things are becoming even worse.

Table 1 Hydrologic characteristics the major rivers around of the Taklimakan Desert

Rivers	Stations	Area of basin (km^2)	Series length (year)	Annual runoff (10^8 m^3)	Coefficients of variation (CV)	Seasonal distribution (median year)			
						Spring	Summer	Autumn	Winter
Kaidu	Dashankou	19022	32	32.97	0.15	22.5	45.7	21.3	10.5
Weigan	Qianfodong	16784	34	22.78	0.19	14.4	48.2	22.3	15.1
Aksu	Xidaqiao	43123	36	62.27	0.16	9.3	57.3	21.0	12.5
Yarkant	Kaqung	50248	34	64.42	0.17	6.8	68.5	18.6	6.1
Hotan	(2 tributaries)	34558	31	44.38	0.20	7.4	76.5	11.9	4.2
Keriya	Nunumaimai	7358	31	7.07	0.17	10.6	70.1	12.4	6.9
Qarqan	Qiemo	26822	31	5.09	0.22	20.3	47.7	23.3	9.2

III. TIME SERIES CHARACTERISTICS ANALYSIS OF THE RIVERS AROUND THE DESERT

We have analysed preliminarily the hydrologic characteristics of seven typical rivers around the Taklimakan Desert in the above part. We now make the further analysis of hydrologic series characteristics and inner structures of these rivers, using the random process theory and method. It mainly concerns tendency analysis, self-correlation analysis and period analysis of

annual runoff series of the rivers.

From the above analysis of the runoff process of each river, it can be seen that there is no obvious sudden change as well as upward and downward tendency in the annual runoff series variation of the rivers around the Taklimakan Desert. It can be further testified by 3-year and 5-year sliding average curves of the annual runoff series (Cheng, 1986, Gao, 1990) . Regression test of linear tendency again proves the non-existence of obvious tendency term.

The study of the self-correlation of the annual runoff series can help analyse the self-dependent degree and the characteristics of changing with the increase of time interval(time lag) in the time domain. Accordingly, the independence of hydrologic series can be examined. On the other hand, through the comparison between the self-correlation diagram of these samples and the known theoretical self-correlation diagram of the random process model, we can decide the best estimation model according to their similarity degree. From the hydrologic data of the rivers for more than 30 years, we are able to calculate each step length self-correlation coefficient of annual runoff series of each river. The calculation indicates that annual interdependent degree of each river is generally low . The self - correlation coefficients are all below 0 . 4 . From the self - correlation diagram of each river (Fig . 1) , we can see that none of the points of the

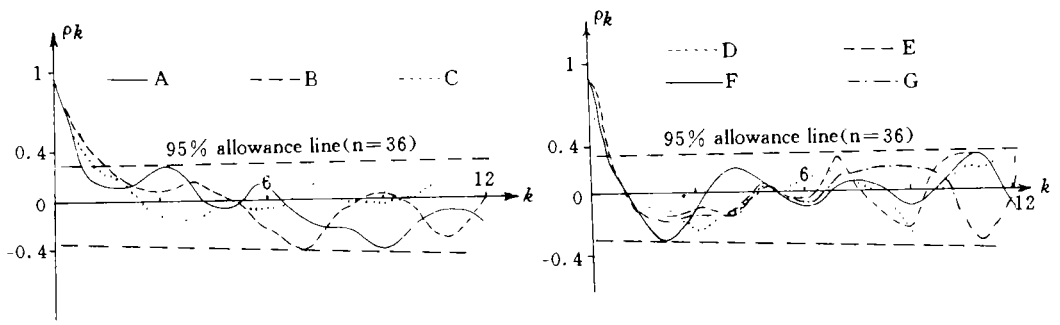

Fig. 1 Self-correlation diagram of annual runoff of rivers around the Taklimakan Desert

A: Weigan River, b: Aksu River, c: Kaidu River,

D: Yarkant River, E: Hotan River, F: Keriya River, G: Qarqan River

self-correlation coefficient are beyond the independent random series allowance line, of which the confidence level is 95%. Therefore the annual runoff series of every major river in the area is believed to be the independent random series. The formation of this feature is mainly due to the supply characteristic of rivers and the surface geographic characteristic of catchment area. Most rivers in this area are supplied by the precipitation and the melting water of glaciers, which mainly come from the catchment area before the mountain pass in the mountain area where most bedrocks are uncovered and the vegetation is in poor condition. Consequently, the water storage adjustment capacity in the catchment area is very limited. On the other hand, to a great extent, the annual runoff quantity of rivers is affected by the amount of precipitation and the melting water of glaciers every year, rather than the supply in another year. Thus the runoff series of each major river in Tarim Basin is the pure random series which is independent

from year to year.

The above is the independent characteristic analysis of the annual runoff in time domain. Next is the further analysis of inner structure of runoff series in frequency domain. As is known to all, a hydrologic series can be regarded as a regular vibration phenomenon, as well as a group of resonant waves composed of sine waves and cosine waves with various frequency. It can even be expressed by Fourier series. In addition, variance linear spectal and variance spectal density can be used to investigate resonant waves and their corresponding frequencies which contribute a lot to the series formation, and then to proceed to delimit the possible variation period of the hydrologic series so as to reflect the inner variation characteristic of the hydrologic series in frequency domain (Ding, 1988).

According to the actual runoff data of the major rivers in the area, we can calculate the variance density value of different frequencies of each typical river and draw a variance density diagram of each river (Fig. 2). The diagram shows that no rivers in the researched area has high and abrupt peak value, in other words, there is no resonant wave component which contributes greatly to hydrologic series, that is to say, there is no obvious periodic components. The diagram also shows that the variance density curve of each river has independent random series features, that is, fluctuating up and down along the horizontal axis whose numerical value is 2. Because no variance density values of each river's annual runoff surpasses the independent random series variance density value with allowance line of 95% confidence level, we can prove once more that the rivers in Tarim Basin can be regarded as independent stationary random sequence and there is no obvious variation in the annual runoff series.

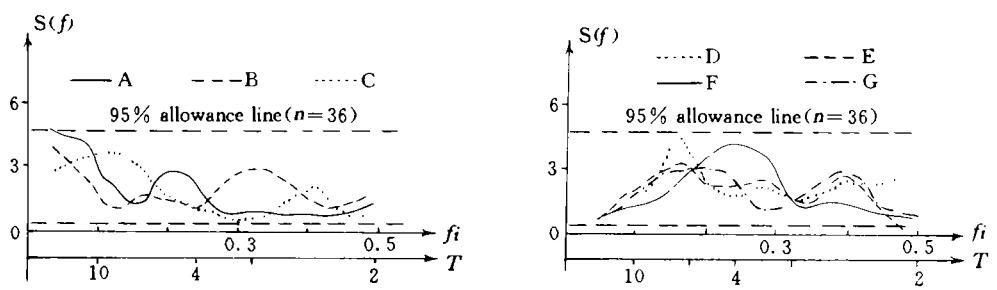

Fig. 2 Variance density diagram of annual runoff of rivers around the Taklimakan Desert

A: Aksu River, b: Weigan River, c: Kaidu River,

D: Yarkant River, E: Hotan River, F: Keriya River, G: Qarqan River

IV. CONCLUSIONS

From runoff time series analysis of the major rivers in the aspects of both time domain and frequency domain, we can draw a conclusion that annual runoff series of rivers are the independent random series in Tarim Basin. For recent tens of years, the natural quantity in the whole Tarim Basin is generally stable. At present, however, water quantity of the rivers flowing into

the desert is decreasing; the vegetation of the desert is retrograding; and the eco-environment is worsening. All these are caused by man-made factors. With the population increasing in the basin, demand for water, land and energy is also increasing. Many new oases appear because of the development of agricultural cultivation, which leads to the increasing of diversion amount, thus transferred water quantity is reducing. In order to exploit natural resources, recover petroleum in a large scale, develop economy and protect eco-environment in this area, it is advisable to utilize water resources in the whole basin more reasonably and concentrate our efforts on economizing on water. Since most diverted water in the basin is used for agricultural irrigation, we should economize on irrigation water. While on the other hand, we should pay attention to vegetation protection where water is in demand and try our best to keep the balance of ecology. Moreover, we should try to tap hard new water resources and achieve the co-use of surface water and groundwater. To sum up, the utilization of water resources in the whole basin should aim at the greatest economic and social benefit and be beneficial to the balance of ecology and environment protection as well.

With the method of mathematical statistics and time series, according to the actual hydrologic data, we have examined the hydrologic characteristics and the inner structure characteristics of the annual runoff series. Through the investigation of the characteristics and variation laws of surface water resources of rivers in Tarim Basin, we mean to provide the analysis and calculation basis for water resources optimization, as well as a decision-making basis for further exploitation of water resources in this area. The study in this paper is only a preliminary one. In some aspects, further studies are needed.

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