A Study on the Relation between the Variation of the Precipitation in Eastern Jianghuai Watershed and Sediment Transport in Chihe River Valley*

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Abstract: Rainfall resource is very important to the development of society and economy, especially to eastern Jianghuai watershed which is now facing serious challenge of water shortage. Based on the observational records covering the period from 1957 to 1999, the characteristics of precipitation changing over eastern Jianghuai watershed and its connection to sediment discharge in Chihe river valley were studied using tendency analysis and correlation analysis .Results shows that the rainfall in this area had a declining tendency in Spring at a rate of –21.2mm/10a, Annual and Summer precipitation was increasing at the rate of 10.6mm/10a and 14.8mm/10a. The gray correlation analysis shows that sediment discharge correlates most closely with runoffs and the frequency of the rainstorm with a daily precipitation of 50mm—100mm, on the second place, with the rainfall and the frequency of the rainstorm of a daily precipitation no less than 100mm; and thirdly with the number of rainy days. In addition, the paper suggests the major countermeasures and methods for controlling of soil and water losses in this area.

Keywords: eastern Jianghuai watershed, Chihe River, rainfall, sediment discharge, correlation grade

1 Introduction

Jianghuai Watershed, located in the central part of Anhui Province, stretches as long as 500kms from east to west, including in its borders 7 cities and counties, namely, Lu'an, Changfeng, Feidong, Feixi, Dingyuan, Fengyang and Mingguang.As connected with Yangtze River, a prime water route in China, and Huaihe River, it is endowed with transport facilities, which has contributed to its leading role in the rural reform of China. Shouldering the responsibility for the production of grain, oil, cotton, meat, egg, mild, and vegetable in Anhui, this area has been playing an important role in the social and economic development of the whole province. Eastern Jianghuai Watershed, to be specific, refers to 3 cities (or counties), i.e., Dingyuan , Fengyang and Mingguang .The natural environment of this area determines that it should suffer from a severe shortage of water resources. With a varying precipitation, this area has been frequently attacked by droughts. What is even worse, its landform predetermines that it is not suitable for the construction of large-scale reservoirs, so it is all too easy to lose the surface runoff. Therefore, it is quite meaningful to conduct a study on the natural variation of the precipitation of Jianghuai Watershed and its relation with the sediment transport in Chihe valley. its findings will encourage rational exploitation of water resources, help to prevent and control water loss and soil erosion, and promote the formulation of the plan for social and economic development.

This paper, based on the data of the monthly average precipitation in Dingyuan, Fengyang and Mingguang from 1957 to 1999, attempts to analyze the variation of the precipitation resources in eastern Jianghuai Watershed during the past 43 years and to predict the tendency of this variation .Meanwhile, in order to analyze the rainfall runoff factors and the features of the sediment in Chihe Valley, which is

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situated in Mingguang City, results of the survey concerning silt-carrying runoff in this area from 1990 to 2000 has been employed and further analyzed to see if there is any correlation between the rainfall runoff factors and the sediment. The results show that these two closely correlate with each other.

2 The general situation of the area under research

Most part of eastern Jianghuai Watershed has an altitude of 50m—100m. Over 50% of its total is covered with hills and earth hummocks, with a small amount of low mountains, plain and water scattering in the rest part. Moreover, the parent material of this area is rather complex. Various local rocks can be classified into 8 groups, 3 kinds of crystallined rocks: granite, andesite, basalt, argillaceous rock, purple sandstone and carbonatite, etc.. This area interspersed with purple soil and black calcareous soil, the zonal soil is dominated by yellow-brown earth.

The climate of this region is featured as a transition from the typical climate of Northern China to that of Southern China. On average, the temperature reaches 15.2℃ annually, 1℃—2.3℃ in January and 28℃ in July. While the highest temperature of a year amounts to 41℃, the lowest one is only –20 ℃. The annual precipitation ranges from 900mm to 1100mm, about 65% of which can be accounted by the rainfall in flood period, i.e., from May to September. The area's climate is especially prominent for its variability of precipitation and vulnerability to drought.

Chihe River, a 182km-long tributary of Huaihe River, Originate in Changfeng County, Anhui Province, flowing into Nushan Lake via Dingyuan and Northern Mingguang, Mingguang Hydrologic station established in 1935 and lying in longitude 117º59′ east, latitude 32º47′ north, controls the upper and middle reaches of Chihe River, an area of 3 501km^2. Chihe Valley, mainly hilly terrain, surges up and down like waves. This, however, boosts soil erosion. According to the most recent investigation conducted by the satellite remote sensing in 2000, 7.98% of the total area of eastern Jianghuai Watershed has suffered from a loss of water and soil erosion, 76.5% of the erosion is in a light level, 23.15% in a medium level.

3 Variation of precipitation in eastern jianghuai watershed

According to the data of precipitation in the past 43 years, on average, the annual precipitation of this region amounts to 922.62mm, among which 211.79mm is in Spring, 453.35mm in Summer, 176.62mm in Autumn, and 80.86mm in Winter. Obviously, in this area, it is mainly in summer, especially from June to August, that it rains, while spring follows suit. Rainfall in these two seasons accounts for 72.1% the total amount of precipitation of this year. After analyzing the data of the monthly average rainfall obtained by 3 hydrologic stations, i.e., those in Dingyuan, Fengyang and Mingguang, from 1957 to 1999, the anomaly percentage curve of the annual rainfall and those of the Spring and the Summer have been worked out (Fig. 1). If the anomaly percentage 20% is taken as a criterion in judging whether the rainfall is abundant or not in the past 43 years, there are 12 summers which can be considered as being rich in rainfall, while 15 others experienced a shortage of rainfall. The results correspond to the severe floods or droughts occurring in that area. The summers when the highest anomaly percentages of rainfall have been achieved are respectively in 1991 (The anomaly percentage reaches (92%), 1972 (75%), 1965 (61%), 1987 (52%), 1963 (37%) and 1980 (37%). On the contrary, the anomaly percentage of rainfall declined to the lowest points in the summers of the following 6 years: 1966 (–66%), 1959 (–56%), 1978 (–52%), 1994 (–46%), 1992 (–42%) and 1988 (–40%).

In terms of the anomaly percentage of rainfall in spring, there are 12 years in which the percentage is above 20%, and another 16 years with a percentage below 20%. Thus, it can be said that in spring it is more likely to have a rainfall below the normal level, that is, the anomaly percentage of rainfall ran up to 91%, while in the same period of 1984 came the lowest –61%. In terms of the total amount of annual precipitation, there are 6 years that have a higher anomaly percentage of rainfall than 20%, i.e., 1991 (70%), 1972 (32%), 1987 (31%), 1993 (23%), 1974 (21%) and 1964 (21%), whereas the anomaly percentage of the rainfall does not come to 20% in another 9 years, i.e., 1966 (–41%), 1978 (–31%), 1976 (–29%), 1994 (–26%), 1992 (–25%), 1999 (–24%), 1961 (–23%) and 1995 (–22%).

From the above statistics, it can be found that 2 of the 6 highest rainfalls, together with 4 out of the 9 lowest rainfalls appear in 1990s. In this sense, the annual rainfalls of eastern Jianghuai Watershed, with an even higher variability, have tended to decline since 1990. In the same way, the rainfalls of spring and summer also show certain tendency while varying by stages.

Moreover, accumulated anomaly percentage curve (Fig.2) has also been worked out so that the way in which the annual rainfall and that of spring and summer tend to vary in a long period of time can be figured out. As Fig.2 indicates, in the past 43 years, it is obvious that the precipitation has undergone variation by stages. Spring rainfall has achieved a high variability, with a declining tendency from the end of 1970s to the end of 1980s. Then from 1990 onwards, it has been showing a rising tendency. As regards the summers precipitation, an increasing amount of rainfall has been obtained from the end of 1980s to the beginning of 1990s. After that, however, the rainfall has been declining. In general, the annual precipitation has varied in accordance with that of summer; that is, in the middle and later part of 1990s, the rainfall has been inclined to decrease. But with a view to the whole picture of the rainfall in the past 43 years, an increase has been shown in annual rainfall and that of summer, while the spring rainfall has mainly shown a tendency of decline. According to linear regression fit, the variability of rainfall are respectively 14.8mm/10a in summer, 10.6mm/10a annually and –21.2mm/10a in spring.

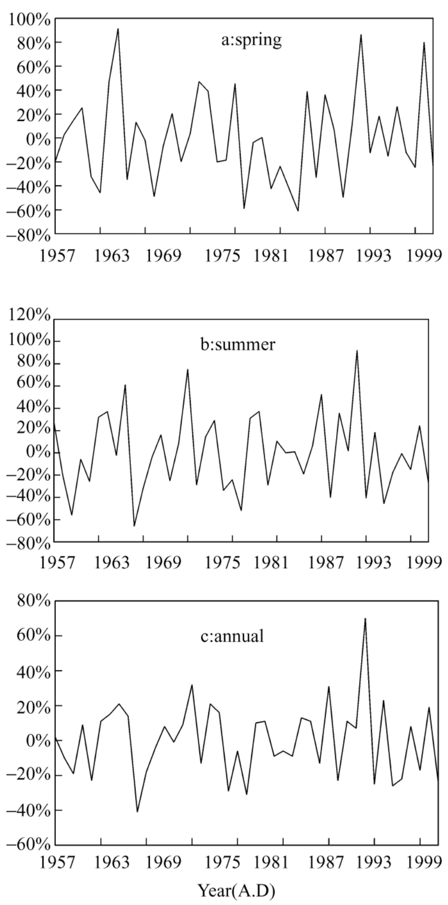

Fig.1 Anomaly percentage of precipitation over eastern Jianghuai watershed

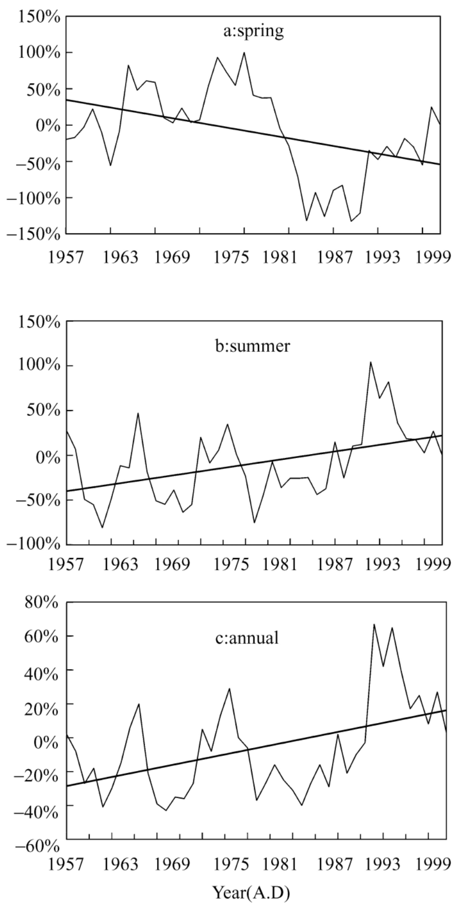

Fig.2 Accumulated anomaly percentage and trend curve for spring(a),summer(b)and annual(c)rainfall

4 Features of the rainfall, the flood and the sediment in chihe valley

4.1 Features of rainfall and floods

According to the statistics on the average rainfall from 1957 to 1999, in eastern Jianghuai Watershed, 49.14% of the annual precipitation comes in summer(from June to August), While that of the flood period (from May to September) amounts to 66.51% of the annual rainfall. Moreover, during flood period it is much likely to have rainstorms. From the later part of March till the beginning of November, rainstorms can be available. On an average scale, rainstorms would be available from the middle part of June to the middle part of August. The number of the days with downpour varies from year to year, 12 days in 1991, while only 1 day in 1978.

According to the data of the precipitation from 1990 to 2000, provided by Mingguang Hydrologic Station of Chihe Valley, in 1990s there are 32 days whose rainfall reached 50mm—100mm per day, and 5 days with daily precipitation above 100mm, that is, July 6,1999 (167.2mm), August 3,1990 (164.4mm), July 6,1991 (161.1mm), June 21,1993 (114.0mm) and July 2,1998 (107.2mm). What is more, the storm flow is closely related to the flood discharge in Chihe Valley. For instance, immediately after a strong downpour on July 6,1981, followed on July 9th the largest flood discharge in history so far, one of 2,160m^3/s, which is 5 times larger than the average flow of the rest of the years in 1990s. Another example lies in the fact that, the largest daily flood discharge following the rainstorm on July 2nd , 1998, is almost twice as large as the average flow of 1993. With hills and earth hummocks surging in eastern Jianghuai Watershed, a long-time strong rainstorm is bound to scour the bare rock on the dip and even wash away the thin slope wash or saprolite, aggravating the soil erosion and further sterilizing the soil on the hill and hummocks.

4.2 Features of sediment

After analyzing the data from 1990 to 2000, it could be found that the largest sediment discharge of a year and that of the flood season tend to be influenced by rainstorms and floods. in 1991, the annual amount of sediment transport, amounting to 2,160,000t and 1.8 times as large as the average of the rest 10 years, reached the peak of the 11 years. Moreover, 99% of the sediment discharge of this year; that is, 2,133,900t, can be ascribed to the sediment transport in flood period; There are still other years when a large sediment discharge has been achieved, such as 1998, 1993 and 1990. According to the statistics conducted during the 11 years (1990—2000), on average, the sediment discharge of flood period accounts for 74.18% of that whole year, while water discharge of flood period takes 54% of the annual one, and rainfall in flood period 48%. Conclusions can be drawn from this rainfalls and floods in flood period are correlated with the sediment discharge .

According to the data, the average silt content of Chihe River comes to 0.91kg/m^3. The highest silt content, reaching 2.18kg/m^3 in 1991, tends to be achieved during the flood period every year. Furthermore, over 80% of the top silt content appears in June and July, and that of August and September follows suit. All these indicate that the water-erosion effects exerted by the rainfall runoff factors in flood period have led to a large amount of silt.

4.3 Gray correlation analysis of the sediment discharge and the rainfall runoff factors in Chihe Valley

According to the data provided by Mingguang Hydrologic Station, a table concerning the monthly distribution of the sediment discharge , the precipitation and the runoff of Chihe Valley in the past 20 years (1980—2000) has been worked out (Table 1). Based on these figures obtained from observation, gray correlation analysis, which was proposed by Zhang Wei and Gu Chaolin in The Model System of Urban and Regional Plan, was conducted to the sediment discharge and various rainfall runoff factors in Chihe Valley (Table 2). The results calculated in Table 2 indicates that, the sediment discharge correlates most closely with runoffs and frequency of the rainstorm with a daily precipitation of 50mm—100mm; on the second place, with the rainfall and the frequency of the rainstorm of a daily precipitation no less than 100mm; and thirdly with the number of rainy days.

The above findings well correspond to the reality of eastern Jianghuai Watershed. Owing to this area’s undulating land forms, poor incrusting substance and its lack most of the rainfall, instead of being totally absorbed and stored by the soil, should most probably become surface runoff, resulting in the loss of water and soil erosion. In this sense, it can be said that the sediment discharge correlates most closely with the runoff and the rainstorm with a daily precipitation of 50mm—100mm which appears more frequently than that with a daily precipitation no less than 100mm. From a long run, the former will contribute more to soil erosion than the latter. Admittedly, not all the rainfall leads to surface runoff and soil erosion. Thus, the weakest correlation has been found between the sediment discharge and the number of rainy days.

Table 1 Monthly distribution of mean annual sediment discharge and rainfall-runoff factors

Factor	Sediment discharge (t)	Rainfall (mm)	Runoff (10^8m^3)	Rainstorm (50mm—100mm) (frequency)	Rainstorm (⩾100mm) (frequency)	Rainy days (d)
January	0	36.4	0.17	0	0	7
February	0	43.8	0.30	0	0	7
March	0	88.5	0.83	1	0	11
April	8.01	64.7	0.45	3	0	8
May	5.02	92.8	0.28	3	0	9
June	32.75	147.3	1.36	7	1	11
July	33.16	167.9	2.28	6	3	10
August	18.05	150.9	0.88	10	1	11
September	7.80	58.3	0.36	2	0	8
October	3.90	53.3	0.34	0	0	7
November	6.25	46.8	0.38	0	0	7
December	0.11	18.0	0.13	0	0	4
Mean annual	115.05	968.7	7.76	32	5	100

Table 2 Correlation grade between sediment discharge and rainfall-runoff factors

Sediment discharge	Rainfall	Runoff	Rainstorm(50mm—100mm)	Rainstorm (⩾100mm)	Rainy days
1	0.55	0.60	0.57	0.55	0.41

5 Conclusion

(1) According to the monthly average precipitation from 1957 to 1999, the precipitation of eastern Jianghuai Watershed has a high variability. If 20% is set as the criterion in judging whether the rainfall is anomaly or not, in those 43 years, 62.8% of spring rainfall, 65.1% of summer rainfall and 34.9% of annual rainfall will be considered anomaly. Those seasons or years having anomaly precipitation, 55%—60% lack of water and 40%—45% abundant in water, suffer mostly from drought rather than flood.

(2) Periodicity features in the variation of precipitation. Rainfall variability reaches its peak every spring and has been keeping on increasing since 1990s. With respect to the long-term varying process in the past 43 years, the anomaly percentage of spring rainfall was declining, whereas that of the summer and annual rainfall rising. This shows that the precipitation decreased in spring while increasing in summer and in the whole year.

(3) As shown in the gray correlation analysis of the sediment discharge and the rainfall runoff factors in Chihe Valley from 1990 to 2000, runoff and the rainstorm with a daily precipitation of 50mm—100mm have been identified as the main factors affecting the sediment discharge . Therefore, it is of great importance to extend the incrusting substance on the surface of earth, especially in flood period. Rather than maintain the tradition of planting along the slope, bench terrace should be promoted. In addition, water conservancy project and plantation should be encouraged so as to effectively retard the surface runoff and prevent rainfall from deteriorating the earth’s surface. Only in this way, can the

precious water and soil resources be preserved.

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