Analysis the Hydrological Situation of the Influx Runoff Series for Poyang Lake

LIU Xiao-zhi 1,2, a, LI Rong-fang *2, , QING Da-youn 1, JIANG Yun-zhong 1

1China Institute of Water Resources and Hydropower Research, Beijing 100038, China
2Jiangxi Provincial Institute of Water Sciences, Nanchang, 330029, China

Abstract

According to historical observed data for the runoff into the Poyang Lake, the analysis of runoff into the Poyang Lake about 50 years was conducted. The results showed that the five rivers runoff for the influx into the Poyang Lake, were decreased since 2002, and the runoff decline phenomenon like this has appeared in the 60's and 80's. About the runoff annual distribution, the uneven distribution was detected. The sum of the monthly runoff from April to July account for 46%~69% about the entire year, and in the dry season, the sum of the monthly runoff from October to next year January only account for 12%~23%. About the each monthly runoff series of the five rivers from 1956 to 2008, it was observed that during the flood season the dispersion coefficient of the series is small, and in the non-flood season the dispersion coefficient of the series is bigger. It illuminated that the monthly runoff series were changer in the non-flood than the flood season and the increased human activities may be the major factor.

Keywords: climate change, human activities, runoff

In recent years, with the global climate change and human activities exacerbate the effects of uneven spatial and temporal distribution of water resources is increasing. In the south wet area, the phenomenon was the main factors which constrained to local economic development. Hydrological analysis of the runoff situation is the foundation of the optimal water resources allocation and ecological water management. In Poyang Lake region, there are rich about natural resources and biodiversity, on the other hand its Hydrological analysis is complex. The Poyang region is lake with high water level, while with the low water level, the Poyang region is a trench area. The phenomenon mostly depends on the influx runoff. The hydrological analysis of influx runoff will help to understand the water cycle laws and characteristics of water resources. All of this will contribute to the rational development and utilization of water resource for the Poyang Lake.

Overview
Poyang Lake Basin is located at latitude 24° 29'14" ~ 30° 04'41", longitude 113° 34'36" to 118° 28'58"", and the area is about 162,200 km². The site is in a typical East Asian monsoon region with mild climate, abundant rainfall. The mean annual precipitation is about 1700 mm and mean annual evaporation from a free water surface is 800 ~ 1 200 mm.

The Poyang Lake Basin is on the Middle and Lower Yangtze River and has 5 sub-catchments from east to west (Fig.1), named Raohe River, Xinjiang River, Fuhe River, Ganjiang River, Xiushui River. Each sub-catchment has corresponding river. The sum of the influx Poyang Lake about 5 rivers is a major component of the lake influx, and the proportion is about 82% of the whole. The runoff of the 5 rivers is estimated by the runoff control hydrological stations adjacent the Poyang Lake(Fig. 1). The runoff, sub-catchment area, and other statistics characteristics of the 5 rivers is showed on the table 1.

![Figure 1 Distribution of the 5 rivers and hydrological stations](image)

| River name    | Hydrologic station | Catchment's area (km²) | River length (km) | Annual runoff (10⁸ m³) |
|---------------|--------------------|------------------------|-------------------|------------------------|
| Ganjiang River| Waizhou            | 80948                  | 751               | 678.9                  |
| Fuhe River    | Lijiadu            | 15811                  | 349               | 126.2                  |
| Xinjiang River| Meigang            | 15535                  | 312               | 177.5                  |
| Raohe River   | Hushan             | 6374                   | 313               | 70.8                   |
|               | Dufengken          | 5013                   | 250               | 46.2                   |
| Xiushui River | Qiujin             | 9914                   |                   | 88.4                   |
|               | Wanjiabu           | 3548                   | 148               | 35.2                   |
The Ganjiang River is the largest river for the 5 river in the catchment’s area with the catchment’s area 80948km², and accounted for 59% of the whole. The average yearly runoff is estimated to be 678.9×10⁸ m³ between 1956 and 2000. With the other rivers runoff descending order, the Xinjiang River (177.5×10⁸ m³), Fuhe River (126.2×10⁸ m³), Xiushui River (123.6×10⁸ m³), and Raohe River (117×10⁸ m³) has variability of runoff.

The yearly runoff changes of the 5 rivers during the last 50 years

The runoff analysis of the 5 rivers in the different ages. The rapid increase of human population, the expansion of cultivated land, the development and expansion of irrigation practices and the construction of reservoirs can affect the yearly runoff during the 1956~2008. With the different ages, the average yearly runoff of the 5 rivers tends to fluctuate from period to period (table 2).

| River name   | Ganjiang River | Fuhe River | Xinjiang River | Raohe River | Xiushui River |
|--------------|----------------|------------|----------------|-------------|---------------|
| Hydrologic station | Waizhou | Lijiadu | Meigang | Hushan | Dufengken | Qiujin | Wanjiabu |
| 1956~1959    | 580           | 128        | 149       | 65         | 46          | 69     | 28      |
| 1960~1969    | 616           | 118        | 158       | 59         | 35          | 72     | 29      |
| The average runoff in different years | 1970~1979 | 709       | 127       | 180        | 73          | 47     | 91      | 36      |
| 1980~1989    | 658           | 126        | 171       | 67         | 46          | 84     | 34      |
| 1990~1999    | 773           | 135        | 214       | 91         | 60          | 112    | 45      |
| 2000~2008    | 659           | 105        | 161       | 57         | 34          | 76     | 29      |
| Average 1956~2000 | 679     | 126        | 178       | 71         | 46          | 88     | 35      |

According as the ages, the time series about 1956~2008 are divided into 6 stages. The runoff has shown an abundant and dry trend with fluctuations. From the historical process, in the 50s’, 80’ and starting in the 21st century, the runoff of most of the rivers are relatively dry, and in the 70s’ and 90s’ the runoff relatively abundant. Since the beginning of this century, compared to the average for many years the runoff of the 5 rivers are reduced. The runoff decrease of maximum is the Raohe River, and the runoff reduction is 26×10⁸ m³, proportion about 22.2%. Followed by the Fuhe River, the runoff reduction is 21×10⁸ m³, proportion about 16.7%. The runoff decrease of minimum is the Xinjiang River, with runoff reduction 17×10⁸ m³, proportion about 9%. From the river runoff anomaly map in different periods (Fig. 2), the reduction phenomenon is obvious, and the amount of the runoff reduction is about 20×10⁸ m³.

Figure 2 The runoff anomaly map of the 5 rivers in different periods
The high and low runoff cycles analysis of the 5 rivers. In recent years, with the climate change and the impact of human activities, the runoff of the 5 river, has reduced. Compared with the average for many years, the value of the runoff reduction from 2002 to 2008 year is about 4.3% ~ 22.1%. The runoff of the Raohe River drastically decreased about 22.1%, while the ruption of the Ganjiang Rivera is relatively small. The high and low runoff cycles can analyze from the difference accumulation curve which the difference between the each yearly runoff and the series average yearly runoff is accumulated.

Figure 3 shows from the 1956 to 2008, the difference runoff accumulation curve of the 5 rivers into the Poyan Lake. It can be seen from the figure, there are three time rang which is 1962~1968,1984~1991 years and 2002~2008 years, have been continuing decline duration about 7,8 and 7 years. From the duration of the dry and the average the runoff value, the dry state of the phase about the 1962~1968 is more serious than of the phase about the 2002~2008, so it is hard to say that the phenomena of the runoff reduction in recent years is outside the high and low runoff cycles.

Monthly runoff changes of the 5 rivers

The annual runoff distribution of the 5 rivers. The annual runoff distribution of the 5 rivers is uneven (Table 3). The runoff summation during the flood phase is the larger proportion of total annual runoff, about the 63%~79%. In the flood phase, during the maximum of 4 consecutive months which are Apr., May, Jun. and Jul., the sum of the runoff accounts for the year 47~70%. In the 5 rivers, the maximum runoff summation belongs to the Raohe River while the minimum runoff summation belongs to the
Xiushui River. In the dry phase, during the minimum of 4 consecutive months which are Jan., Oct., Nov. and Dec., the sum of the runoff accounts for the year $12 \sim 23\%$. The minimum runoff summation belongs to the Xinjiang River, which the proportion is only about $12\%$.

Figure 4 shows the monthly runoff comparison about the 5 rivers. The Ganjiang River runoff was significantly higher than on other rivers, with the runoff distribution hump narrow. The phenomenon indicates the flood phase of Ganjiang River runoff alternates with periods of the dry, with the rapid increase of flood runoff and the quickly decline of dry runoff.

| River name     | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|----------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ganjiang River | 3\% | 4\% | 9\% | 14\%| 17\%| 18\%| 10\%| 7\% | 6\% | 4\% | 4\% | 3\% |
| Fuhe River     | 3\% | 5\% | 10\%| 15\%| 18\%| 21\%| 10\%| 4\% | 3\% | 3\% | 3\% | 3\% |
| Xinjiang River | 3\% | 5\% | 10\%| 15\%| 17\%| 22\%| 10\%| 5\% | 4\% | 3\% | 3\% | 3\% |
| Raohe River    | 2\% | 4\% | 9\% | 15\%| 18\%| 22\%| 15\%| 6\% | 3\% | 2\% | 2\% | 2\% |
| Xiushui River  | 6\% | 5\% | 8\% | 10\%| 12\%| 12\%| 13\%| 9\% | 7\% | 5\% | 6\% | 6\% |

**Figure 4: The Chart of annual runoff distribution about the 5 rivers**

**Monthly runoff changes from 1956 to 2008 year.** The Dispersion coefficient is the ratio between the standard deviation the average value of data series. The parameter reflects the difference size between data and the average level. The greater the dispersion coefficient is, the more scattered data distribution is. On the contrary, the smaller the dispersion coefficient, indicated that the distribution of data around the average concentration.

Figure 5 shows the changes of the dispersion coefficient about the monthly runoff series from 1956 to 2008 year. It can be seen from the figure that in April the river runoff dispersion coefficient is on the minimum value about 0.45. The phenomenon suggests that the variety of April runoff of the 5 rivers is weak from 1956 to 2008 year series. From July to December, the data points of the dispersion coefficient about the 5 rivers are scattered. In the 5 rivers, the value of coefficient about the Raohe River, Fuhe River and Xinjiang River are relatively bigger, while about Ganjiang River and Xiushui River are smaller. This phenomenon may be caused by the construction of water conservancy project, the regulation and storage of the reservoirs, water runoff process and water runoff trends.
Conclusions

The Poyang Lake have abundance water resources and rich biodiversity gave birth with the special climate and geographical conditions. In recent years, with the climate change and the impact of human activities, the runoff of the 5 river, has reduced. Compared with the average for many years, the value of the runoff reduction from 2002 to 2008 year is about 9.6% ~ 22.2%. The runoff of the Raohe River drastically decreased about 22.1%, while the ruction of the Ganjiang River is relatively small. there are three time rang which is 1962~1968,1984~1991 years and 2002~2008 years, have been continuing decline duration about 7.8 and 7 years.

About the each monthly runoff series of the five rivers from 1956 to 2008, it was observed that during the flood season the dispersion coefficient of the series is small, and in the non-flood season the dispersion coefficient of the series is bigger. It illuminated that the monthly runoff series were changer in the non-flood than the flood season and the increased human activities may be the major factor.

Acknowledgments

We are grateful to the research grants from Research Project of China Institute of Water Resources and Hydropower Research (Found1046) and the China National Eleventh Five-Year Plan Technology Support Program Fund (2008BAB29B08).

The Corresponding author of this paper is LI Rong-fang, Email: lrf@jxsl.gov.cn

References

[1] China Institute of Water Resources and Hydropower Research. Key technology about the construction of the Poyang Lake ecology water control pivot[R]. 2010.9

[2] Jiangxi Provincial Water Resources Department. Investigation and evaluation about the development and utilization of Jiangxi Province water resources [R]. 2008.3

[3] Jiangxi Provincial Institute of Water Sciences. The research about effect of Poyang Lake and "Five Rivers" water after application of the Three Gorges Project [R]. 2009.12
[4] Xie Dong-ming, Yang Yan, Deng Hong-bing, Fang Yu, Fan zhe-wen. A Study on the Hydrological Characters in the Five River-catchments in Jinangxi Province. Acta Agriculturae Universitatis Jinagxiensis, 2009, 31(2): 364-369

[5] Wang Feng, Wu Dunyin, Li Rongfang. Analysis on flood disaster characteristics in Lake Poyang region. Journal of Lake Sciences, 2008, 20(4): 500-506

[6] Guo Hua, Jiang Tong. Trend analysis of flood peak/dry season flowrate in Poyang Lake Basin. Journal of natural disasters, 2008, 17(3): 75-80