Journal of Environmental Science International
27(10); 845~851; October 2018

pISSN: 1225-4517 eISSN: 2287-3503
https://doi.org/10.5322/JESI.2018.27.10.845

ORIGINAL ARTICLE

Characteristics of Andong Dam Inflow during Non-rainfall Season

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Abstract

In this study, the runoff characteristics of the non-rainfall period were examined using daily rainfall data from 1977 to 2017 and the data of runoff into the dam. Results showed that, the mean runoff decreases with longer non-rainfall periods in the Andong dam basin. The correlation coefficient between non-rainfall days and average runoff reaches 0.85. The results of the analysis of the runoff characteristics during the non-rainfall period, based on the preceding rainfall of Andong dam are as follows. The runoff characteristics of the entire non-rainfall period, shows that, for a rainfall of 1.0 mm or less, the runoff height was larger than the rainfall size and the base runoff larger. The correlation between the antecedent rainfall and runoff height was reached as high as 0.9864 in the 30 ~ 50 mm interval of the antecedent rainfall period, and this is the interval where the linearity of rainfall and runoff was at its maximum in the Andong dam basin. The correlation between the antecedent rainfall and the runoff height reached 0.92 for rainfalls of 100.0 mm. However, for rainfalls of 100.0 mm greater, the correlation between the antecedent rainfall and runoff height during the rainfall period was 0.64, which is relatively small. In this study, we investigated the runoff characteristics of the rainfall period in the Andong dam watershed. As a result, it was confirmed that the mean runoff decreased with rainfall duration. The linearity was found to be weak for rainfall events greater than 100.0 mm. The results of this study can be used as data for water balance analysis and for formulating a water supply plan to establish water resource management of Andong dam.

Key words : Non-rainfall duration, Andong dam, Runoff ratio

1. Introduction

The flow into the dam is very important in the supply of water resources to downstream areas so it is very important to understand the relationship between precipitation and runoff to provide stable water resources. The assessment of flow in water resources management is a very important consideration in the operation of multi-purpose dams. The assessment of the flow rate is essential in terms of water resources management, such as efficient water distribution and flood control. In particular, the relation between rainfall and runoff in the basin of a multi-purpose dam is related to its storage capacity, and the storage is closely related to its water supply. In the recent climate, the temporal and seasonal distribution of rainfall varies from year to year due to the impact of climate change, which is different from the historical rainfall patterns in Korea. Particular, the intensity of rainfall during heavy rains has increased, and the non-rainfall period when drought occurs has lengthened.

Received 4 October, 2018; **Revised** 22 October, 2018;
Accepted 23 October, 2018
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Generally, the relationship between rainfall and runoff is known to be very close, and is calculated assuming a constant runoff ratio, depending on the characteristic factors of the basin in flood runoff and low flow. In particular, the average outflow rate is about 40% in the case of low flow, but if the characteristics of the basin are fixed constants, the outflow rate may vary according to the non-rainfall period.

Studies to identify the relationship of runoff depending on precipitation have been carried out continuously. In the flood season, there have been many studies on the methods for calculating the appropriate runoff curve index for direct runoff and effective rainfall. There have also been many studies on the simulation on low flow to estimate the irrigation flux during the dry season. However, most modeling studies have focused improving the accuracy of the NRCS-CN (natural resources conservation service-curve number) runoff coefficients to the estimate effective rainfall in flood runoff and increasing the accuracy of model parameters to simulate low flow. In fact, there are only a few studies that have coverd the correlation between inflow to the dam and precipitation. Regarding the estimation of runoff and effective rainfall, there was a study on the effect of a river ecosystem using a hydrologic change index model that quantitatively analyzes the change in the flow rate(Richard et al., 1997).

It quantitatively analyzed hydrological change characteristics of daily flow data for eight multi-purpose dams in Korea (Kang et al., 2015). Using the top model, it analyzed long-term runoff and examined the quantification and applicability of parameters (Cho et al., 2000). To estimate the effective rainfall for long-term runoff analysis, it conducted a study on the estimation of effective rainfall by modifying and applying the SCS (Soil Conservation Service) method which is an effective rainfall calculation method, to long-term runoff analysis. As a result, the regression equation in exponential form was derived, and its suitability was examined (Kim et al., 1989). For the long-term runoff analysis, the GR4J model was improved to examine the applicability of the model to Korea. The influence of the rainfall‐runoff process was reviewed by reflecting the runoff standard reservoir in the soil moisture procedure to the characteristics of the basin(Im et al., 2012). To estimate the flood volume of the ungagged basin, we evaluated the conceptual rainfall runoff model and its application to basin groups, based on the characteristics of the basin characteristic(Chang and Lee., 2015). It has examined the effect of previous rainfall on the stability of slopes by analyzing the characteristics of rainfall penetration in previous rains through a one-dimensional rainfall penetration experiment (Yoon et al., 2015). It has analyzed the temporal correlation and volatility of river flow using a previous rainfall index in mountainous sub-basins and identified the correlation with each factor to review the applicability of the previous rainfall index model for mountain forest sub basin (Jung et al., 2016). Taking into account previous rainfall, it analyzed the runoff characteristics of the Jeju River area. In this analysis, it calculated the runoff ratio for short-term rainfall events and determined the lag time, depending on the existence of heavy rain events, such as typhoons. The analysis showed that the event-specific runoff compared with the annual mean runoff may be different depending on the amount of previous rainfall and rainfall. If annual average runoff ratio is applied to a single heavy rain event, the fluctuation rate of the runoff ratio would be large, depending on the rainfall scale (Yang et al., 2014). For the application of the NRCS effective rainfall calculation method to domestic basins, we studied the method of determining the appropriate number of previous rainfall days and proposed that

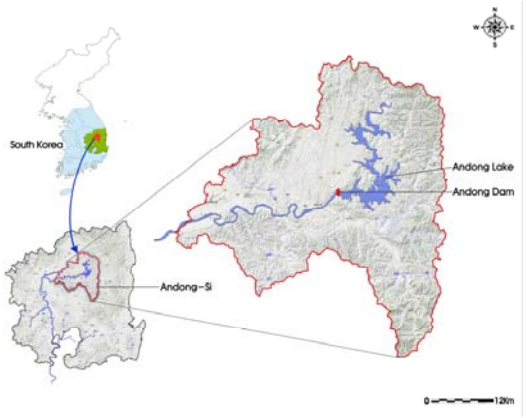

Fig. 1. Location of Andong dam.

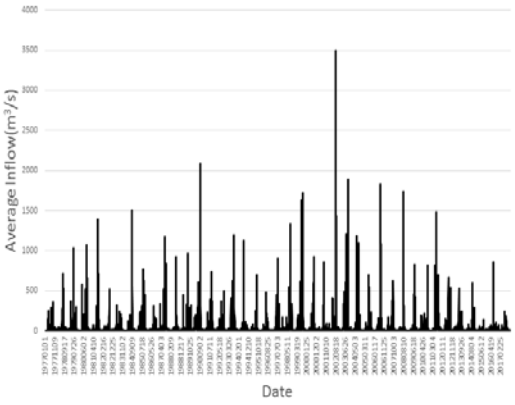

Fig. 2. Andong dam daily inflow (1977-2017).

the application of the previous two-day rainfall was appropriate for the 13 rainfall events, as a result of flood runoff analysis (Lee et al., 2005). A study was conducted to predict the change in soil water storage by analyzing the relation between the soil water storage and the previous precipitation index measured in the forest area for three years (Gawk et al., 2016). To predict the soil moisture, it used exponential and linear precipitation indices to evaluate the previous precipitation index (Saxon and Lenz., 1967). The soil moisture was predicted and evaluated by applying a simple relationship between the previous rainfall index and relative soil moisture data (Zhao et al., 2011).

Therefore, in this study the runoff ratio duration is calculated and compared runoff based on previous rainfall data of the Andong dam.

2. Analysis method

2.1. Basin characteristics

The target area of this study is the Andong dam and the basin area is 1,584 ㎢. In terms of the hydrological soil classification type D was the most distributed, with 76.93 %, of the total area and hydrologic soil type A with good drainage was found to be the least distributed, at 0.78% of the total area. The location of Andong dam is shown in Fig. 1.

2.2. Analysis method

Based on the hydrological information of the dam basin provided by a comprehensive water resource website [www.wamis.go.kr], we collected and analyzed the amount of daily inflow into the Andong dam basin. A total of 40 years of daily data from January 1, 1977 to December 31, 2017 was collected and analyzed.

3. Analysis results

3.1. Analysis of characteristics of non-rainfall periods

An analysis of non-rainfall period days of the Andong dam basin from 1977 to 2017 showed that the most frequent case was a non-rainfall period of 1 day, while non-rainfall periods appeared for up to 45 days.

The analysis showed that the 1-day period was the most frequency with 537 days, followed by the 2-days period and periods of up to 45 days of non-rainfall days occurred.

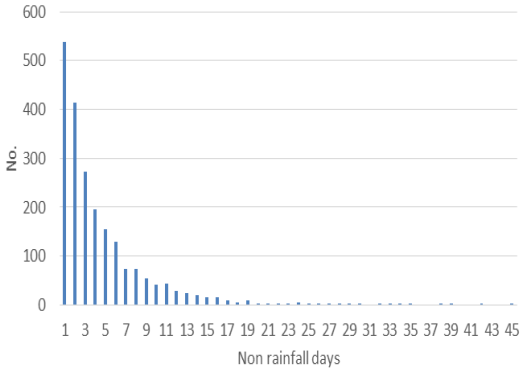

Fig. 3. Graph of non rainfall period days.

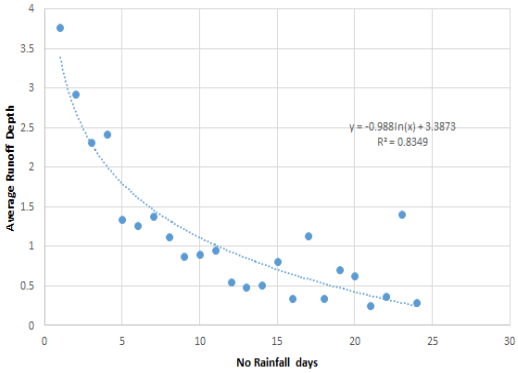

Fig. 4. Average runoff depth for the non-rainfall days.

3.2. Runoff characteristics according to the duration of non-rainfall period

The mean runoff depth based on non-rainfall periods of the Andong dam basin was analyzed, as shown in Table 1. As a result, it was determined that the mean runoff depth tends to decrease with length of non-rainfall period.

This means that as drought continues, the inflow to Andong dam decreases, and as the non-rainfall period increases, the number of inflows to Andong dam decreases, and the inflow to Andong dam decreases. Thus the reservoir function of Andong dam may be deepened. From 1977 to 2017, the runoff depth of the Andong dam basin as a function of non-rainfall period, was analyzed, revealing that the average runoff depth decreases with non-rainfall period days, as shown in Fig. 4. The correlation of mean runoff depth with the non-rainfall period was 0.85.

3.3. Non-rainfall period runoff characteristics of Andong dam basin

The result of the analysis of dependency of the runoff ratio on non-rainfall period from 1977 to 2017 at the Andong dam basin showed that the mean runoff ratio tends to decrease with the non-rainfall period, as shown in Fig. 5.

Table. 1. Average runoff depth for the non-rainfall days

Nonrainfall days	Average runoff depth(mm)	Days
1	3.774	537
2	2.930	415
3	2.312	272
4	2.420	196
5	1.337	154
6	1.270	130
7	1.376	74
8	1.122	73
9	0.877	55
10	0.906	42
11	0.958	44
12	0.551	29
13	0.492	24
14	0.514	20
15	0.811	16
16	0.339	16
17	1.132	9
18	0.349	5
19	0.707	9
20	0.633	4
21	0.259	4
22	0.374	4
23	1.413	3
24	0.288	5

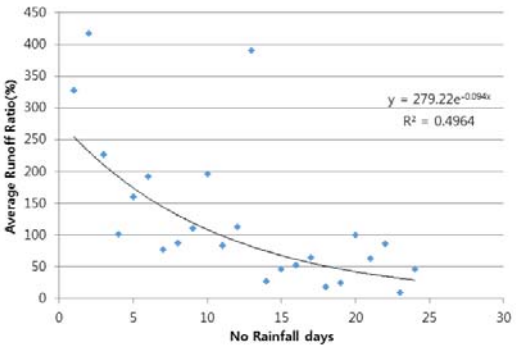

Fig. 5. Average runoff ratio for the non-rainfall days.

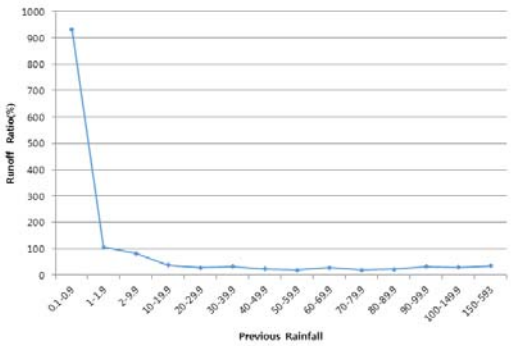

Fig. 6. Average runoff ratio for the previous rainfall.

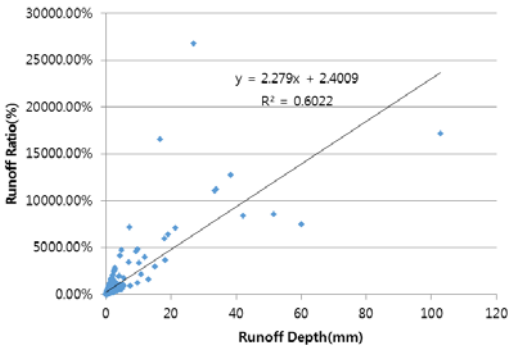

Fig. 7. Average runoff ratio for the previous rainfall (Under 1.0 mm).

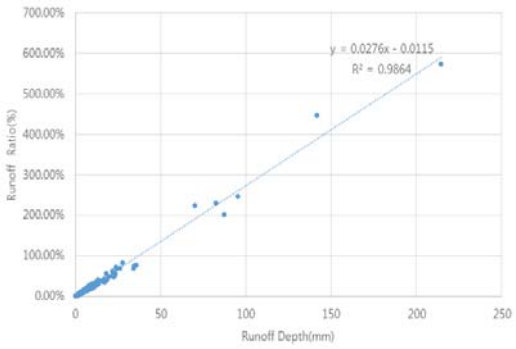

Fig. 8. Average runoff ratio for the previous rainfall (30.0~50.0 mm).

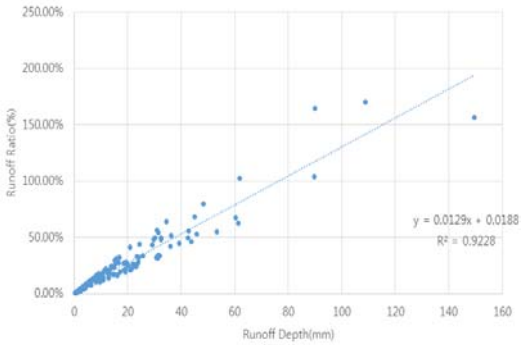

Fig. 9. Average runoff ratio for the previous rainfall (50.0~100.0 mm).

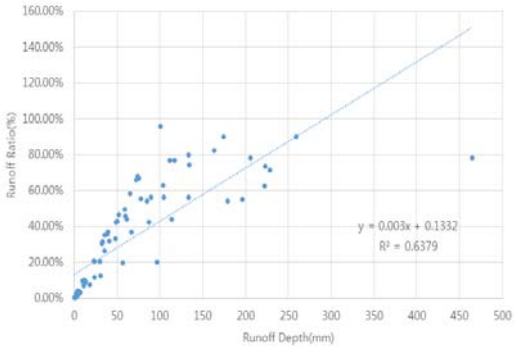

Fig. 10. Average runoff ratio for the previous rainfall (over 100.0 mm).

In this study, the runoff ratio shows the comparison between the previous rainfall and non-rainfall outflow depth. The analysis a smaller the amount of previous rainfall, corresponded to a smaller runoff ratio, as shown in Fig. 6. The runoff ratio was shown to be larger for a previous rainfall of 1.0 mm or less,

which indicates that the rainfall does not significantly affect the increase in runoff and the base flow rate is relatively larger than the rainfall. To analyze the influence of the previous rainfall on the runoff during the non-rainfall period, it also analyzed the dependency of the runoff ratio during the rainfall period on the size of the previous rainfall. As shown in Fig. 7, the correlation between the runoff depth and runoff ratio for previous rainfalls of 1.0 mm or less was 0.60. The reason for the high runoff ratio despite a previous rainfall of 1.0 mm or less was that it was affected by the rainfall before the rainfall occurred. The analysis results of the previous rainfall by interval showed that the interval with the highest correlation between the runoff depth and the runoff ratio is the 30.0～50.0 mm interval, whose correlation between the runoff depth and the runoff ratio was found to be high, 0.9864 as shown in Fig. 8. Fig. 9, shows the 50.0～100.0 mm previous rainfall interval and the correlation between the runoff depth and runoff ratio was found to be high, 0.92. The correlation between the runoff ratio and the runoff depth for a previous rainfall of 100.0 mm or less was found to be 0.64, as shown in Fig. 10. The analysis results of the previous rainfall by interval showed that the increase in a previous rainfall has some effect on the increase in the runoff ratio during the non-rainfall period.

4. Conclusion

In this study, the runoff characteristics of the non-rainfall period were examined using the daily rainfall data from 1977 to 2017 and the data of runoff into the dam. As a result, the following conclusions were obtained. The mean runoff depth was found to decrease with longer non-rainfall period in the Andong dam basin. The correlation coefficient between non-rainfall period and average runoff depth was found to be 0.85.

The results of the analysis of the runoff characteristics during the non-rainfall period based on the previous rainfall of Andong dam are as follows. Considering the runoff characteristics of the entire non-rainfall period, for a downward rainfall of 1.0 mm or less, the runoff depth was larger than the rainfall size, at the downward rainfall of 1.0mm or less, and the base runoff was larger. The correlation between the previous rainfall and the runoff height reached a maximum at 0.9864 for the 30 ~ 50 mm interval of the previous rainfall period, and this is the interval where the linearity of rainfall and runoff is the largest in the Andong dam basin. The correlation between the previous rainfall and runoff depth reached a maximum of 0.92 for the 50.0~100.0 mm interval. However, for rainfalls of 100.0mm or more, the correlation between the previous rainfall and runoff depth during the non-rainfall period was 0.64, which is relatively small. In this study, we investigated the runoff characteristics of the non-rainfall period in the Andong dam watershed. As a result, it was confirmed that the mean runoff decreased as with non-rainfall duration. For rainfalls of 30.0～100.0 mm, the average runoff and linearity during the non-rainfall period was large, and the linearity was found to be weak for rainfalls of greater than 100.0 mm. The results of this study can be used as data for water balance analysis and for formulating q water supply plan to establishing water resource management of Andong dam.

- This research is a reorganization of the doctoral dissertation

REFERENCES

Chang, H. J., Lee, H. S., 2015, “Assesment of continuous simulations of rainfall runoff models based on soil moisture accounting models at Guem River catchments, Korea”, *J. KOSHAM*, 15, 231-242.

Cho, H. J., Kim, J. S., Lee, K. B., 2000, “Long-term runoff analysis using the TOPMODEL”, *J. KWRA*, 33,

393-405.

Gawk, Y. S., Kim, S. J., Lee, E. H., Hamm, S. Y., Kim, S. H., 2016, "Soil water storage and antecedent precipitation index at Gwangneung Humid-Forested Hillslope", *J. Kor. Agri. and Forest met*. 18, 30-41.

Im, S. S., Yoo, D. G., Kim, J. H., 2012, "Improvement of GR4J model applying soil moisture accounting process and its application in Korea Basin", *J. KOSHAM*, 12, 255-262.

Jung, Y. Y., Koh, D. C., Han, H. S., Kwon, H. I., Kim, E. K., 2016, "Estimation of stream discharge using antecedent precipitation index models in a small mountainous forested catchment : Upper Reach of Yongsucheon Stream, Gyeryongsan Mountain", *J. soil and groundwater envi*., 21, 36-45.

Kang, H. Y., Lee, S. H., Kim, J. S., 2015, "Characteristics changes of hydrologic variability at multi-purpose dams in Korea", *J. KOSHAM*, 15, 123-130.

Kim, T. C., Ahn, B. K., Park, S. K., 1989, "Estimation of effective rainfall for daily streamflow", *J. KSAE*, 31, 116-124.

Lee, M. W., Yi, C. S., Kim, H. S., Shim, M. P., 2005, "Determination of suitable antecedent precipitation day for the application of NRCS method in the Korean Basin", *J. Kor. Wet. Soc.*, 7, 41-48.

Richard, B. D., Baumgather, J. V., Wigniton, R. Braunm, D, P., 1997, "How much water does a river need?", *Freshwater Biologyy*, 37, 231-249.

Saxon, K. E., Lenz, A. T., 1967, "Antecedent retention indexes predict soil moisture", *J. Hydrau. Div*. 93, 223-244.

www.wamis.go.kr

Yang, S. K., Kim, D. S., Jung, W. Y., 2014, "Rainfall -runoff characteristics in a Jeju Stream considering antecedent precipitation", *J. Envir. Sci. Inter*., 23, 553-560.

Yoon, G. N., Shin, H. S., Kim, Y. T., 2015, "Effect of antecedent rainfall on infiltration characteristics in unsaturated Soil", *J. Kor. Geoth. Soc*., 31, 5-15.

Zhao, Y., F, Wei., H, Yang., Jiang, Y., 2011, "Discussion on using antecedent precipitation index to supplement relative soil moisture data series", *Proce. Envi. Sci*. 10, 1489-1495.