

# DEPENDENCE OF LITHUANIAN RIVER RUNOFF EXTREMES ON CATCHMENT AREA

J. Kriauciuniene, M. Kovalenkoviėnė

*Lithuanian Energy Institute, Kaunas, Lithuania  
hydro@mail.lei.lt*

There are more than 22 thousand rivers with total length of 76.8 thousand km in Lithuania. The small rivers with the length less than 3 km are prevailing (80.1% of all rivers). The rivers with the length more than 3 km are classified according to catchment area (Table 1). There are 4953 rivers with the catchment area less than 50 km<sup>2</sup> and only 4 rivers with the area more than 6000 km<sup>2</sup> (Gailiušis *et al.*, 2001). Measurements of river discharge have been done in 102 hydrological stations during different periods. Large rivers with the catchment area of more than 500 km<sup>2</sup> are thoroughly investigated (Table 1), while investigations of small river runoff are insignificant (only 15 hydrological stations for 4983 rivers).

Table 1. Distribution of Lithuanian rivers according to catchment area [km<sup>2</sup>]

Catchment area	<50	50 - 100	100 - 200	200 - 500	500 - 1000	1000 - 3000	3000 - 6000	>6000
Number of rivers	4983	249	114	73	23	10	5	4
Number of hydrological stations	15	11	21	19	16	9	5	4

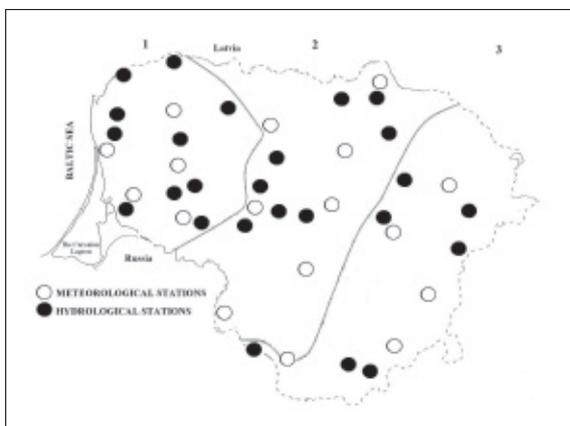


Figure 1. Network of meteorological and hydrological stations in Lithuania (hydrological regions of Lithuania: 1 – Western, 2 - Central, 3 - Southeastern)

The consistent patterns of variations of the river runoff depend on climate and local physical-geographic factors. According to different characters of rivers feeding Lithuania is divided into three hydrological regions (Reihan *et al.*, 2007): Western, Central and Southeastern (Figure 1).

In Western Lithuania the main source of river feeding is precipitation (40-70% of the annual runoff). The type of the river feeding is mixed in Central Lithuania. The snowmelt and rain contributions are from 35% to 50% of the whole runoff. The rivers of Southeastern Lithuania have a prevailing subsurface feeding (40-60% of the annual runoff). The annual runoff of Southeastern Lithuanian rivers is distributed rather equally. The extremes of Lithuanian rivers runoff depend on the hydrological regions (Kriauciūnienė *et al.*, 2007).

Measurements of hydrological regime in small rivers are not sufficient. Analogue method could be applied for the evaluation of non-measured small river runoff. For this purpose hydrological data from the larger rivers could be used. The task of this study is to investigate the dependence of the Lithuanian river runoff characteristics on the catchment area. The annual, maximum and minimum discharges of rivers are analyzed. All characteristics are expressed by specific discharges in order to compare together. Additionally the coefficients of uneven run-off distribution  $d$  (deficit volume) are analyzed.

## Methods and data

Representative historical daily data series from 24 hydrological stations are used for the analysis of specific discharge characteristics and coefficients of uneven run-off distribution in the Lithuanian rivers (6 stations in Western, 6 – in Central and 6 – in Southeastern region).

The coefficient of uneven run-off distribution  $d$  describes the annual run-off distribution between water and dry seasons.  $d$  is calculated as deficit to the average annual discharge  $Q$ , that corresponds to the run-off surplus over the average annual discharge. The coefficient  $d$  is calculated according to the formula:

$$d = \frac{\sum Q_p - Q \cdot t_p}{365 Q}, \quad (1)$$

where:

$\sum Q_p$  - sum of water discharges during time  $t_p$  when discharge  $Q_p$  exceeds the average annual discharge  $Q$ .

The minimal specific discharge series were calculated according to series of the 30-day minimum discharge ( $Q_{30}$ ) for the summer low flow period. It was evident that the daily minimum flow data series contained many casual errors. Therefore 30-day minimum discharge averages were used for the minimum flow regime analysis in order to obtain more reliable calculation results. The maximum specific discharge series were calculated according to series of the spring flood peak discharge.

## Results

The annual runoff in Lithuania varies from 4.2 to 14.2  $\text{dm}^3\text{s}^{-1}\text{km}^{-2}$ . The rivers of Western Lithuania are water abundant with specific discharge of 7.6-14.2  $\text{dm}^3\text{s}^{-1}\text{km}^{-2}$  (Figure 2a). The rivers of Central Lithuania have the least water abundance (4.2-6.0  $\text{dm}^3\text{s}^{-1}\text{km}^{-2}$ ). In Southeastern Lithuania annual runoff reaches 7.6-9.0  $\text{dm}^3\text{s}^{-1}\text{km}^{-2}$ . Most variation of annual runoff from catchment area is fixed in Western Lithuania. The reason of that variation is “marine” type climate in Western Lithuania. The main source of feeding of marine type rivers is precipitation, which exceeds 50 %. Due to the frequent thaws of the wintertime “marine” rivers often have winter floods, some of which are higher than spring floods. This is the reason that specific discharges in smaller catchments are larger then in bigger catchments.

The coefficient of uneven runoff distribution  $d$  has expressed the distribution of river runoff per year. Most even distribution of river runoff is in Southeastern Lithuania ( $d < 0.2$ ). The rivers of this region are “continental” type rivers where the snow melt water rate is almost equal to the groundwater. This is the reason of even runoff distribution. Variation of  $d$  is small and independent from the catchments’ area (Figure 2-b). More uneven distributions of runoff are fixed in Central and Western Lithuania ( $0.4 < d < 0.6$ ). The variation of  $d$  is bigger in the catchments with areas less then 1200  $\text{km}^2$ .

Maximum discharges of spring flood in Lithuanian rivers generally take place in March-April, but sometimes this event happens earlier, when strong snowbreaks raise floods. Maximum discharges occur in the rivers of Western Lithuania in the first months (January-February) of the year. In the small rivers (basin area up 100  $\text{km}^2$ ) discharges are observed 3-4 days earlier. Maximum discharges in the rivers of Central and Southeastern Lithuania are often observed on 27-30<sup>th</sup> of March. In the smaller rivers this process takes place a couple of days earlier. The largest maximum discharge (Figure 2-c) is in the rivers of Western Lithuania

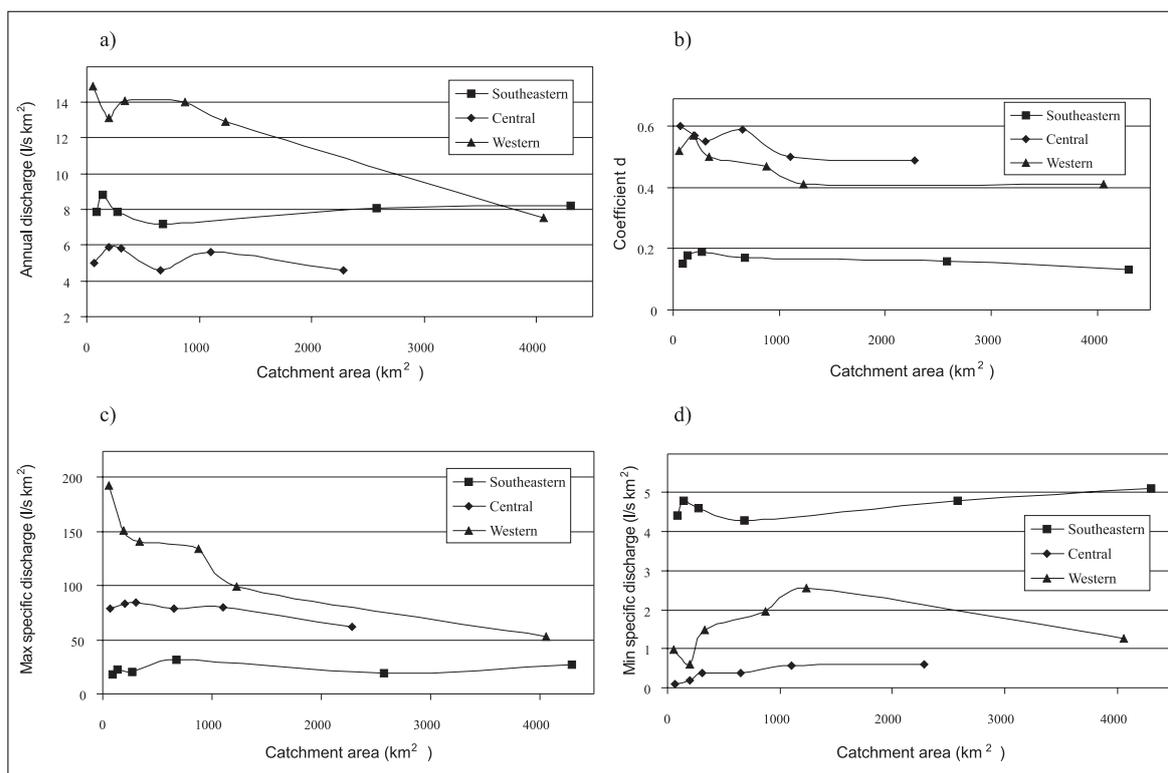


Figure 2. Dependence of runoff characteristics on the catchment area in Western, Central and Southeastern regions: a) annual specific discharge, b) coefficient d, c) maximum specific discharge, d) minimum specific discharge

(50-200  $\text{dm}^3\cdot\text{s}^{-1}\cdot\text{km}^{-2}$ ) and the least one – in the rivers of Southeastern Lithuania (20-35  $\text{dm}^3\cdot\text{s}^{-1}\cdot\text{km}^{-2}$ ). The largest dependence of annual runoff on catchment area is fixed in Western Lithuania. There are bigger specific maximum discharges in smaller rivers.

In Lithuanian rivers, a rather long period of drought begins after the end of spring flood. It finishes with the beginning of autumn rainfalls. Other period of drought in rivers exists during winter season. In Lithuanian rivers the summer-autumn drought period is significantly deeper and longer. On average in the whole Lithuania it begins at the end of April – at the beginning of May. The runoff of the most dry 30-day summer period in Western Lithuania is 0.4-2.5  $\text{dm}^3\cdot\text{s}^{-1}\cdot\text{km}^{-2}$ , in Central Lithuania – 0.1-0.8  $\text{dm}^3\cdot\text{s}^{-1}\cdot\text{km}^{-2}$  and in Southeastern Lithuania – 4.2-5.2  $\text{dm}^3\cdot\text{s}^{-1}\cdot\text{km}^{-2}$  (Figure 2d). In the Central region small rivers could dry out in summer periods.

## Conclusions

Characteristics of river runoff are different in three hydrological regions of Lithuania. There are no significant variations of runoff characteristics depending on the catchment area in the Central and Southeastern regions (“continental” type rivers). Stability of these characteristics is determined by natural runoff formation factors (percentage of lakes, forests and sand in river catchments). The analogue method could be applied for the evaluation of non-measured small river runoff applying hydrological data from the larger rivers in the Central and Southeastern regions. There is a significant relation between the runoff characteristics and the catchment area in the Western region of Lithuania. The reason of that variation is “marine” type climate in Western Lithuania. Heavy precipitation has influenced the river runoff in different way. The specific annual and maximum discharges have been decreasing as the catchment area has been increasing.

## Acknowledgements

This research was supported by the project “Climate and Energy Systems” (CES) funded by Nordic Energy Research.

## References

- Gailiušis B., Jablonskis J., Kovalenkoviene M., 2001: *Lithuanian rivers. Hydrographs and runoff*. Lithuanian Energy Institute, Kaunas: 792 pp.
- Kriauciūnienė J., Kovalenkoviene M., Meilutyte-Barauskienė D., 2007: *Changes of the low flow in Lithuanian rivers*. Environmental research, engineering and management, 4(42): 5-12.
- Reihan A., Koltsova T., Kriauciuniene J., Lizuma L., Meilutyte-Barauskienė D., 2007: *Changes in water discharges of the Baltic States rivers in 20th century and its relation to climate change*. Nordic Hydrology, 38(4-5): 401-412.