

Dependence between infiltration capacity and karst processes in river catchments

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Abstract. The article shows the empirical dependence between the cavern volume filled with water and infiltration capacity. This dependence makes it possible to estimate how karst influences infiltration capacity and run-off and water balance as well.

1 Introduction

The main problem in studying karst influence on hydrological parameters is heterogeneity of karst areas.

Many scientists investigated how karst influences run-off. The work [1] is based on studying karst influence on minimum run-off. Increasing or decreasing minimum run-off in karst rivers in comparison with the rivers without karst is a consequence of karst influence on run-off. The work [2] made a significant contribution to karst studies suggesting and defining four main eras of reservoir rock development throughout the hydrogeological history of Earth: fractured, pored, karstic and anthropogenic. Many Cuban scientists investigate the problems of karst: [3], [4] and others.

2 Materials and methods

Observation data from the Cuban rivers, especially from western regions where karst is widely spread, are used to study how karst changes river run-off. There is karst in eastern Cuban regions too but it is considered to be covered (i.e. karsting rocks are covered by comminute insoluble precipitate on the surface).

3 Karst types description

The study describes western Cuba areas presented in Fig. 1. The description is based on [4] where the author distinguishes five karst areas.

The material of the study is annual average streamflow of the rivers in eastern and western Cuba: 21 water stage gauges of the key hydrologic network in eastern Cuba and 14 water stage gauges in western Cuba. The observation period is 42-50 years and short-term records concerning precipitation within the multiyear period.

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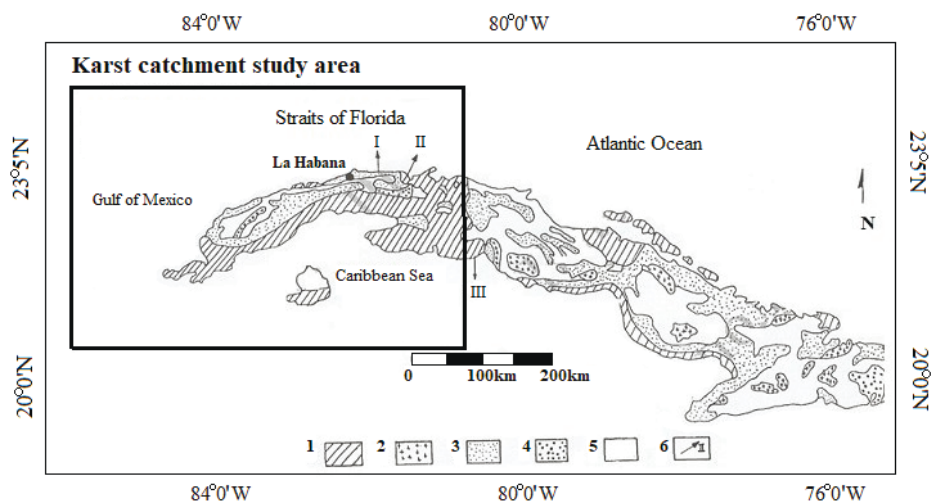


Fig. 1. Karst areas distributions in Cuba (engineering-geological classification [3]): 1 – karst with drainage into underlying strata, 2 – karst with local drainage, 3 – karst with adjacent drainage, 4 – non-karstic rocks, 5 – study areas (I – Sants Cruz Thermal Power Plant, II – Matanzas Thermal Power Plant, Juragua Nuclear Power Plant).

The linear-correlation model of water balance [5, 6] is used to carry out a qualitative and quantitative analysis of karst influence on river run-off.

4 Results and discussion

Among other parameters this model includes R_0 – depth of absorption in closed depressions after the period of water formation. This will be used later to evaluate the influence of karst on infiltration, run-off and water balance. The method of calculation of depth of absorption R_0 is described in the work [5] and uses the geomorphologic factor Φ [7], which is the ratio of slope length of the catchment area l to the square root of watershed slope $I_{\text{ср.д.}}$. As the parameter b includes:

$$b = R_l + R_0,$$

we have to make the dependence graph $\frac{b}{P} = f(\Phi)$ (Fig. 2) which consists of seven groups of points, with various slopes.

R_0 can be also easily calculated with the tangent of an angle of the lines on the dependence graph $\frac{b}{P} = f(\Phi)$.

R_0 is used to make the dependence graph to $\frac{U}{P} = f\left(\frac{R_0}{P}\right)$ calculate the degree of karst influence on infiltration capacity. It is presented in Fig. 3.

The graph of the correction factor of infiltration capacity change is presented in Fig. 4.

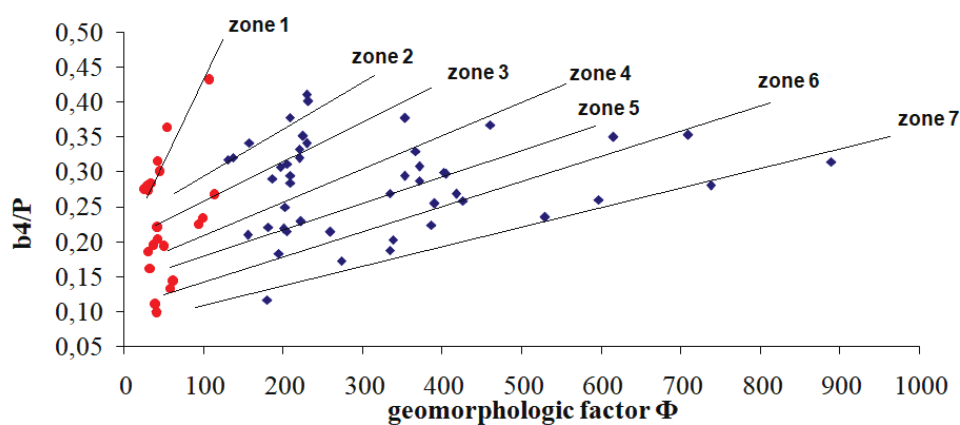


Fig 2. Dependence between relative absorption capacity and ruggedness of terrain.

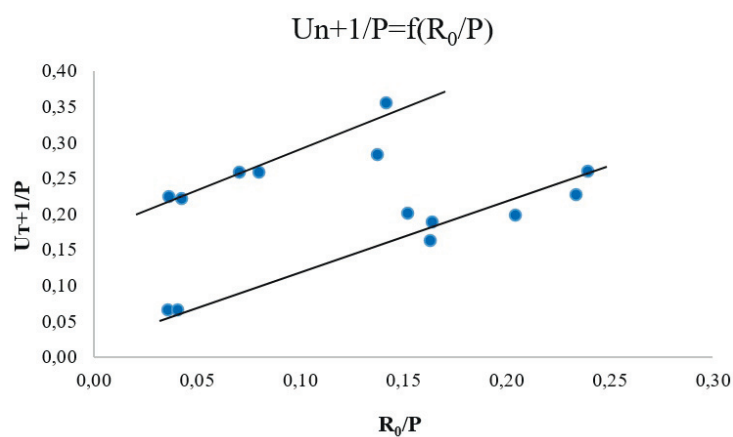


Fig. 3. Dependence between relative infiltration capacity and layer of run-off accumulation in the catchment area.

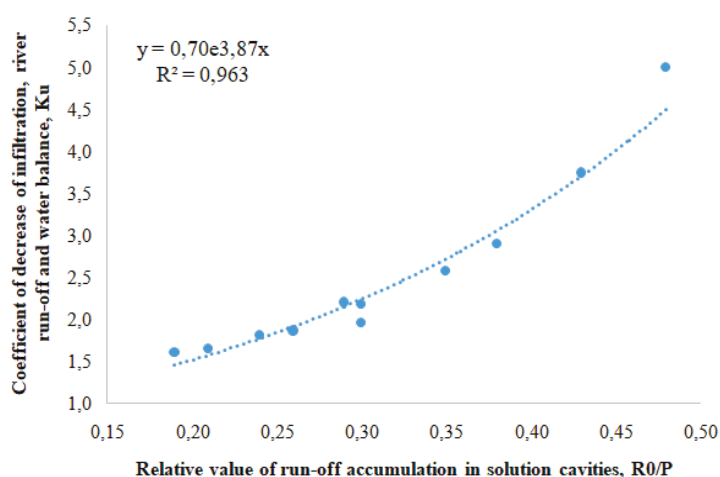


Fig. 4. Dependence for the coefficient of karst influence on infiltration capacity.

To estimate the scale of this influence it is necessary to study the expression for infiltration capacity from other works [5, 6]:

$$U = \frac{Y(1-k)}{k},$$

where Y – depth of streamflow, mm; k – regression coefficient of the correlation dependence between streamflow and precipitation depth.

5 Conclusion

The study suggests the method to consider karst influence on infiltration capacity, as well as on river run-off and water balance. The method can prove accurate if additional observation data from adjacent catchment areas with karst is taken into account.

Reference

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